Oral Hard Tissue Lesions: A Radiographic Diagnostic Decision Tree

Hamed Mortazavi1*, Yaser Safi1, Somayeh Rahmani2, Kosar Rezaiefar3

1Department of Oral Medicine, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran; 2Department of Oral and Maxillofacial Radiology, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran; 3Department of Oral Medicine, School of Dentistry, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

Abstract

BACKGROUND: Focusing on history taking and an analytical approach to patient’s radiographs, help to narrow the differential diagnoses.

AIM: This narrative review article aimed to introduce an updated radiographical diagnostic decision tree for oral hard tissue lesions according to their radiographic features.

METHODS: General search engines and specialized databases including PubMed, PubMed Central, Scopus, Embase, EBSCO, ScienceDirect, and authenticated textbooks were used to find relevant topics by means of MeSH keywords such as “jaw diseases,” “maxilla,” “mandible,” “radiolucent,” “radiopaque,” “odontogenic,” “nonodontogenic,” “cysts,” and “tumors.” Related English-language articles published from 1973 to 2020, including reviews, meta-analyses, and original papers (randomized or non-randomized clinical trials; prospective; or retrospective cohort studies), case reports, and case series about oral hard tissue lesions were appraised.

RESULTS: In this regard, bony lesions have been classified according to their radiographic pattern (radiolucent, mixed, radiopaque, and rarified), position (periapical, pericoronal and interradicular), margins (well and ill-defined), relation to dentition (with and without dental association), and number (solitary and multiple). In total, 50 entities were organized in the form of a decision tree.

CONCLUSION: In this paper, an updated decision tree was proposed to help dental practitioners to make more accurate diagnoses and better treatment plans on the basis of radiographic characteristics.

Introduction

Oral pathologies can be generally categorized into two major groups as soft-tissue and hard-tissue lesions. For proper diagnosis of any case in the oral cavity, especially in hard-tissue lesions, radiographs have a very important key role [1]. They enable the dentist to identify many conditions that may otherwise go undetected and to find conditions that cannot be seen clinically [2]. Many lesions that occur in the jawbones have a similar radiographic feature and it is often difficult to distinguish among them [1], [3]. Radiographic evaluation of the central lesion characteristic, which includes location, margin, cortical integrity, density, relation to dentition, effect on surrounding structures, and along with knowledge of clinical data, helps in narrowing the differential diagnosis [1]. Review of the literature showed that some authors have developed guidelines and classifications to help dental practitioners evaluate radiographs more precisely [1], [2], [3]. In this regard, we propose an updated radiographical diagnostic decision tree (Figure 1), this will help clinicians make more accurate diagnoses and better treatment plans according to the patient’s radiographs.

Methods

Search strategy

General search engines and specialized databases including PubMed, PubMed Central, Scopus, Embase, EBSCO, ScienceDirect, and authenticated textbooks were used to find relevant topics using MeSH keywords such as “jaw diseases,” “maxilla,” “mandible,” “radiolucent,” “radiopaque,” “odontogenic,” “nonodontogenic,” “cysts,” and “tumors.” Related articles published from 1973 to 2020, including reviews, original papers (randomized or non-randomized clinical trials; prospective or retrospective cohort studies), case reports, and case series were reviewed. Out of more than 500 articles and textbooks, of which about 200 articles were relevant to the topic. We ultimately included 84 articles and one textbook that were more closely related to the topic of interest. Other papers were excluded due to a lack of full texts, being written in languages other than English or containing repetitive material.
Results

In this regard, we described 50 most common oral bony lesions (Table 1), based on their pattern (radiolucent, mixed-opaque, and rarified), position (periapical, pericoronal, and interradicular), margin (well or ill-defined), location (anterior or posterior portion of jaws), dental association (with or without dental association), and number (solitary or multiple).

- **A) Radiolucent lesions**

  A-1-1) Well-defined → Unilocular → Periapical → With dental association

  • **Radicular cyst**

  The radicular or periapical cyst/granuloma is the most common odontogenic cyst which is in association with necrotic tooth or faulty root canal therapy [4], [5]. There is a slight sex predilection in men and most cases have been reported in the third and fourth decades of life [5]. It is usually asymptomatic and discovered when the periapical radiograph is taken from a non-vital tooth [5]. Radiographically, it appears as periapical or lateral round to oval well-defined radiolucent lesion with cortical margins [4]. It also can cause expansion, invaginate into the maxillary sinus, or depress the mandibular canal [4].

  A-1-2) Well-defined → Unilocular → Periapical → Without dental association → Anteriorly → Solitary
### Table 1: Characteristics of oral hard-tissue lesions by alphabetical order

<table>
<thead>
<tr>
<th>Entity</th>
<th>Gender predominance</th>
<th>Age predominance (decades)</th>
<th>Common location</th>
<th>Common radiographic feature</th>
<th>Clinical feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adenomatoid odontogenic tumor</td>
<td>Female</td>
<td>2</td>
<td>Maxilla</td>
<td>Well-defined mixed lesion</td>
<td>NA</td>
</tr>
<tr>
<td>Ameloblastic fibroma</td>
<td>Male</td>
<td>1 – 2</td>
<td>Mandible</td>
<td>Well-defined radioluent lesion</td>
<td>Asymptomatic swelling</td>
</tr>
<tr>
<td>Ameloblastic fibro-odontoma</td>
<td>Male/Female</td>
<td>1 – 2</td>
<td>Mandible</td>
<td>Well-Defined Mixed lesion</td>
<td>Asymptomatic swelling</td>
</tr>
<tr>
<td>Ameloblastoma</td>
<td>Male</td>
<td>3 – 5</td>
<td>Mandible</td>
<td>Well-defined radioluent/radiopaque lesion</td>
<td>Asymptomatic swelling</td>
</tr>
<tr>
<td>Aneurysmal Bone cyst</td>
<td>Male/Female</td>
<td>1 – 2</td>
<td>Mandible</td>
<td>Well-defined Radioluent lesion</td>
<td>Symptomatic swelling</td>
</tr>
<tr>
<td>Calcifying epithelial odontogenic tumor</td>
<td>Female</td>
<td>4 – 5</td>
<td>Mandible</td>
<td>Well-defined mixed lesion</td>
<td>Asymptomatic swelling</td>
</tr>
<tr>
<td>Calcifying odontogenic cyst</td>
<td>Male/Female</td>
<td>2 – 6</td>
<td>Mandible</td>
<td>Well-defined Mixed lesion</td>
<td>NA</td>
</tr>
<tr>
<td>Cementoblastoma</td>
<td>Female</td>
<td>2 – 3</td>
<td>Mandible</td>
<td>Radiopaque lesion with radiolucent rim</td>
<td>Symptomatic swelling</td>
</tr>
<tr>
<td>Cemento-osifying fibroma</td>
<td>Female</td>
<td>2 – 4</td>
<td>Mandible</td>
<td>Radiolucent/radiopaque lesion with a radiolucent rim</td>
<td>Asymptomatic swelling</td>
</tr>
<tr>
<td>Central giant cell granuloma</td>
<td>Female</td>
<td>1 – 2</td>
<td>Mandible</td>
<td>Well-defined radioluent lesion</td>
<td>Asymptomatic swelling</td>
</tr>
<tr>
<td>Chorubitus</td>
<td>Male/Female</td>
<td>2 – 7 years</td>
<td>Mandible and Maxilla</td>
<td>Radiolucent lesion</td>
<td>Asymptomatic swelling</td>
</tr>
<tr>
<td>Chondrosarcoma</td>
<td>Female</td>
<td>4 – 7</td>
<td>Maxilla</td>
<td>Ill-defined radioluent/mixed lesion</td>
<td>Symptomatic swelling</td>
</tr>
<tr>
<td>Condensing osteitis</td>
<td>Female</td>
<td>4</td>
<td>Mandible</td>
<td>Well-defined radioluent lesion</td>
<td>NA</td>
</tr>
<tr>
<td>Dentigerous Cyst</td>
<td>Male</td>
<td>2 – 3</td>
<td>Mandible</td>
<td>Well-defined radioluent lesion</td>
<td>NA</td>
</tr>
<tr>
<td>Ewing’s sarcoma</td>
<td>Female</td>
<td>15 years</td>
<td>Mandible</td>
<td>Ill-defined radioluent lesion</td>
<td>Symptomatic swelling</td>
</tr>
<tr>
<td>Fibrous dysplasia</td>
<td>Female</td>
<td>1 – 3</td>
<td>Maxilla</td>
<td>Ill-defined radioluent/mixed lesion</td>
<td>Asymptomatic swelling</td>
</tr>
<tr>
<td>Florid cement-osseous dysplasia</td>
<td>Female</td>
<td>4 – 5</td>
<td>Mandible</td>
<td>Radiolucent/radiopaque lesion with a radiolucent rim</td>
<td>NA</td>
</tr>
<tr>
<td>Focal cement-osseous dysplasia</td>
<td>Female</td>
<td>4 – 5</td>
<td>Mandible</td>
<td>Radiolucent/radiopaque lesion with a radiolucent rim</td>
<td>NA</td>
</tr>
<tr>
<td>Glanular odontogenic cyst</td>
<td>Male/Female</td>
<td>Middle-aged</td>
<td>Mandible</td>
<td>Well-defined radioluent lesion</td>
<td>Asymptomatic swelling</td>
</tr>
<tr>
<td>Hypoparathyroidism</td>
<td>Female</td>
<td>Middle-aged</td>
<td>-</td>
<td>Radiolucent lesion</td>
<td>Symptomatic swelling</td>
</tr>
<tr>
<td>Idiopathic osteosclerosis</td>
<td>Female</td>
<td>3</td>
<td>Mandible</td>
<td>Well-defined radioluent lesion</td>
<td>NA</td>
</tr>
<tr>
<td>Incisive canal cyst</td>
<td>Male</td>
<td>4 – 6</td>
<td>Maxilla</td>
<td>Well-defined radioluent lesion</td>
<td>NA</td>
</tr>
<tr>
<td>Intracapsular hemangiomata</td>
<td>Female</td>
<td>2 – 5</td>
<td>Mandible</td>
<td>Well-defined radioluent/mixed lesions</td>
<td>Asymptomatic swelling</td>
</tr>
<tr>
<td>Langerhans cell histiocytosis</td>
<td>Male</td>
<td>1 – 2</td>
<td>Mandible</td>
<td>Ill-defined radioluent lesion</td>
<td>Symptomatic swelling</td>
</tr>
<tr>
<td>Lateral periodontal cyst</td>
<td>Male/Female</td>
<td>5 – 7</td>
<td>Mandible</td>
<td>Well-defined radioluent lesion</td>
<td>Asymptomatic swelling</td>
</tr>
<tr>
<td>Leukemia</td>
<td>-</td>
<td>Young</td>
<td>-</td>
<td>Generalized rarefaction</td>
<td>Asymptomatic swelling</td>
</tr>
<tr>
<td>Multiple myeloma</td>
<td>Male/Female</td>
<td>40 – 70 years</td>
<td>Mandible</td>
<td>Well-defined radioluent lesion</td>
<td>Symptomatic swelling</td>
</tr>
<tr>
<td>Osteogenic keratocyst</td>
<td>Male</td>
<td>2 – 5</td>
<td>Mandible</td>
<td>Well-defined Radioluent lesion</td>
<td>NA</td>
</tr>
<tr>
<td>Odontogenic myxoma</td>
<td>Female</td>
<td>2 – 3</td>
<td>Mandible</td>
<td>Well-defined Radioluent lesion</td>
<td>Symptomatic/asymptomatic swelling</td>
</tr>
<tr>
<td>Odontoma complex compound</td>
<td>Male/Female</td>
<td>The first two</td>
<td>-</td>
<td>Well-defined radioluent lesion</td>
<td>NA</td>
</tr>
<tr>
<td>Osteoblastic Metastatic Cancer</td>
<td>Male/Female</td>
<td>40 – 70 years</td>
<td>Mandible</td>
<td>Well-defined radioluent lesion</td>
<td>Symptomatic swelling</td>
</tr>
<tr>
<td>Osteoklastoma</td>
<td>Male</td>
<td>2 – 3</td>
<td>Mandible</td>
<td>Mixed with radioluent rim</td>
<td>Symptomatic swelling</td>
</tr>
<tr>
<td>Osteoid ostoma</td>
<td>Female</td>
<td>2 – 3</td>
<td>Mandible</td>
<td>Radiolucent/radiopaque lesion with a radiolucent rim</td>
<td>Pain</td>
</tr>
<tr>
<td>Osteoporoic bone marrow defect</td>
<td>Female</td>
<td>4 – 6</td>
<td>Mandible</td>
<td>Well-defined, radioluent lesion</td>
<td>NA</td>
</tr>
<tr>
<td>Osteomyelitis</td>
<td>Male</td>
<td>Wide age range</td>
<td>Mandible</td>
<td>Ill-defined Mixed lesion</td>
<td>Symptomatic/asymptomatic swelling</td>
</tr>
<tr>
<td>Osteoporosis and osteomalacia</td>
<td>Female</td>
<td>50 years</td>
<td>Mandible</td>
<td>Radioluent lesion</td>
<td>NA</td>
</tr>
<tr>
<td>Osteosarcoma</td>
<td>Male/Female</td>
<td>5 – 25 years</td>
<td>Mandible</td>
<td>Ill-defined mixed lesion</td>
<td>Symptomatic swelling</td>
</tr>
<tr>
<td>Paget’s disease</td>
<td>Male</td>
<td>5 – 6</td>
<td>Mandible</td>
<td>Radiolucent lesion</td>
<td>Symptomatic swelling</td>
</tr>
<tr>
<td>Preapical cement-osseous dysplasia</td>
<td>Females</td>
<td>30 years</td>
<td>Mandible</td>
<td>Radiolucent/radiopaque lesion with a radiolucent rim</td>
<td>NA</td>
</tr>
<tr>
<td>Primary intracapsular carcinoma</td>
<td>Male</td>
<td>6 – 7</td>
<td>Mandible</td>
<td>Ill-defined radioluent lesions</td>
<td>Symptomatic swelling</td>
</tr>
<tr>
<td>Radicular cyst</td>
<td>Male</td>
<td>3 – 4</td>
<td>Mandible</td>
<td>Well-defined radioluent lesion</td>
<td>NA</td>
</tr>
<tr>
<td>Residual cyst</td>
<td>Male</td>
<td>3 – 4</td>
<td>Maxilla</td>
<td>Well-defined radioluent lesion</td>
<td>NA</td>
</tr>
<tr>
<td>Sickle cell anemia</td>
<td>-</td>
<td>Childhood</td>
<td>-</td>
<td>Generalized rarefaction</td>
<td>Pain</td>
</tr>
<tr>
<td>Socket sclerosis</td>
<td>Male/Female</td>
<td>-</td>
<td>-</td>
<td>Radiolucent lesion</td>
<td>NA</td>
</tr>
<tr>
<td>Statile bone cyst</td>
<td>Male</td>
<td>5 – 6</td>
<td>Mandible</td>
<td>Well-defined radioluent lesion</td>
<td>NA</td>
</tr>
<tr>
<td>Surgical defect</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Well-defined radioluent lesion</td>
<td>NA</td>
</tr>
<tr>
<td>Thalasssemia</td>
<td>-</td>
<td>Young</td>
<td>-</td>
<td>Generalized rarefaction</td>
<td>Asymptomatic swelling</td>
</tr>
<tr>
<td>Traumatic bone cyst</td>
<td>Male</td>
<td>2 – 3</td>
<td>Mandible</td>
<td>Well-defined radioluent lesion</td>
<td>NA</td>
</tr>
<tr>
<td>Unicystic ameloblastoma</td>
<td>Male</td>
<td>2</td>
<td>Mandible</td>
<td>Well-defined radioluent lesion</td>
<td>Asymptomatic swelling</td>
</tr>
</tbody>
</table>

- **Glandular odontogenic cyst (GOC)**

GOC is a developmental odontogenic cyst [6]. There is no sex predilection and mostly affects middle-aged persons [7]. It presents clinically as a slow-growing, asymptomatic swelling generally occurring in the anterior portion of jaws especially the mandible. Few bilateral cases have been also reported [6]. Radiographically, it represents as an unicellular or multilocular, well-defined radiolucent lesion with scalloped and sclerotic border. Root resorption, tooth displacement, and association with impacted teeth and some lesions such as dentigerous cyst (DC) and lateral periodontal cyst (LPC) have been also found in some cases [7]. In addition to radiographic findings, a clear and low viscosity fluid content on aspiration may be helpful in the diagnosis of GOC [6].

- **Invasive canal cyst (ICC)**

ICC is the most common non-odontogenic, developmental cyst, arising from the degeneration of nasopalatine ducts [8]. There is a sex predilection in men with the peak incidence in the fourth to sixth decades of life [8], [9]. It clinically represents an asymptomatic lesion that develops in the midline of anterior maxilla near the incisive foramen [8]. In some cases, patients may suffer from swelling, drainage, and pain [10]. Radiographically, it appears as a well-defined, unicellular, round, oval, and heart-shaped radiolucency with cortical margin in the midline and between the central incisors [8], [9]. Furthermore, tooth displacement, root resorption, nasal septum deviation, thinning, and perforation of the buccal cortical plates have been also reported in some cases [8], [9]. In the large lesions, it might show the roots of the adjacent incisors to be within the cyst cavity; however, the lamina dura is an intact and dental pulp is vital [8].
• **Periapical cement-osseous dysplasia (PCOD)**

PCOD, also known as periapical fibrous dysplasia (FD), is considered as a benign fibro-osseous lesion originated from undifferentiated cells of the periodontal ligament (PDL) tissue [11]. There is a sex predilection in women with age over 30 years [1]. The most affected site in the oral cavity is the anterior portion of the mandible (incisor and canine region) and the teeth involved remain vital [11]. The lesions may be solitary or multiple, asymptomatic and do not involve alteration to the periodontal tissues [11], [12]. Radiographically, in the osteolytic phase, a well-defined radiolucent lesion is seen at the apex of the root; in the cementoblastic stage, the radiolucent lesion assumes a mixed appearance and in the final or mature stage gives rise to a completely radiopaque lesion [1], [11]. During the time, the lesion becomes a calcified mass that can reach 10 cm in diameter and is often surrounded by a radiolucent rim [1], [11].

• **Residual cyst (RC)**

RC is an inflammatory cyst that persists after the removal of its associated tooth [13]. There is sex predilection in men and it is more common in the third to fourth decades of life [4], [13]. The maxilla is more commonly involved than mandible and the lesions usually occur in the alveolar process and body of the jawbones in edentulous areas, it may also be found in lower ramus [13]. It is an asymptomatic lesion and radiographically appears as a well-defined radiolucent lesion with cortical margins. Occasionally, in longstanding lesions, calcified particles may be seen [4], [13]. Furthermore, the same findings to the radicular cyst can be found in the RC [4].

• **Surgical defect**

The surgical defect is a structural alteration that is in association with a surgical procedure, accounts for 3% of all periapical radiolucencies [14]. It is clinically asymptomatic and radiographically represents as a round or oval, well-defined radiolucent lesion with <1 cm in diameter. In 45% of cases, it is completely healed but in 25% of cases, it remains unhealed for a long time [14]. If changing the angle of radiation leads to change the position of the radiolucent lesion around the periapical region, it is demonstrated that the lesion is not periapically, whereas it is located in the buccal or lingual cortical plates such as a surgical defect [14].

A-1-3) Well-defined → Unilocular → Periapical → Without dental association → Anteriorly → Multiple

• **PCOD**
   (See the section A-1-2).

• **RC**
   (See the section A-1-2).

A-1-4) Well-defined → Unilocular → Periapical → Without dental association → Posteriorly → Solitary

• **Central giant cell granuloma (CGCG)**

CGCG is a proliferative intra-osseous lesion [4]. There is a slight sex predilection in women with the peak incidence in the first to second decades of life [4], [15]. This entity can be divided into two subgroups as aggressive and non-aggressive. The aggressive type of lesion tends to present in younger patients with more discrepancies [15]. It occurs with a higher frequency in the mandible than maxilla and most cases are found in the anterior portion of the jaws than in the posterior portion [4]. Clinically, it can reach to a swelling >5 cm in diameter and cross the midline in 50% of mandibular cases [4], [15]. Radiographically, it is characterized by a unilocular to multilocular radiolucent lesion with well-defined margins. A stubble granular pattern of calcification has been also reported. In some cases, the septae are located perpendicular to the periphery and creating a honeycomb pattern [4]. CGCG can cause tooth displacement, root resorption, as well as bone perforation [15]. The lamina dura of the teeth within the lesion is usually missing [4], [15].

• **Focal cemento-osseous dysplasia (FCOD)**

FCOD is a benign fibro-osseous lesion with PDL cell origin [10]. It is more frequent in women than men with a peak incidence in the fourth and fifth decades [1], [10]. The majority of cases occur in the periapical area of posterior mandibular teeth with vital pulps or in regions of dental extractions [10], [11]. It is linked to one tooth and causes no symptoms and is detected only on routine radiographic examinations [1], [12]. Radiographically, in the early stage, it is seen as a well-defined radiolucency, in the intermediate stage also is seen as a radiolucent-opaque lesion with a well-defined radiolucent halo and in the late stage, the lesion is characterized by a definite radiopacity surrounded by a uniform radiolucent rim [1], [10]. It is also mentioned that FCOD can be transformed into FCOD and therefore emphasized the importance of recall visits [10].

• **Odontogenic kerato cyst (OKC)**

OKC is an odontogenic cyst representing the third most common cyst of the jaw bones [16]. There is a slight sex predilection in males with a peak incidence in the second and fifth decades of life [17], [18]. More than 80% of cases have been reported in the mandible, especially in the body followed by angle and vertical ramus [17]. Maxillary lesions are most frequently seen between canine and lateral incisor,
and the third molar region [18]. Larger size lesions are more common at the angle and ramus of the mandible. OKC can be presented as a periapical, pericoronal, and interradicular lesion [17], [18]. Radiographically, it is characterized by a well-defined unilocular or multilocular radiolucency with smooth or scalloped and often corticated margins. It tends to grow in an anteroposterior direction within the jawbone without causing considerable expansion [17], [18]. In some cases, dystrophic calcifications may develop in longstanding cysts as radiopaque particles [17].

- **RC**
  (See the section A-1-2) (Figure 2).

![Figure 2: Panoramic reconstructed cone-beam computed radiographic image shows residual cyst; a well-defined radiolucent, unilocular solitary lesion in left mandible in the edentulous area of 34, 35](image)

- **Stafne bone cyst (SBC)**

  SBC is an asymptomatic congenital cyst-like bone defect due to entrapment of a glandular tissue portion (submandibular or submental salivary glands) during mandibular development [19], [20]. There is a sex preilection in men with a peak incidence in the fifth and sixth decades of life [19]. Most cases have been detected in the posterior portion of the mandible; however, anterior variant of the disease is usually found periapical, interradicular, or at the previous sites of tooth extraction [19]. Radiographically, it appears as a circumscribed, unilocular, radiolucent lesion with different sizes from 0.5 cm to 2 cm [19], [20].

- **Surgical defect**
  (See the section A-1-2).

- **Traumatic bone cyst (TBC)**

  TBC also known as a simple bone cyst, idiopathic bone cyst, and primary bone cyst is a pseudocyst that mostly occurs in the second and third decades of life and has a slight male predominance or no sex predilection [21], [22]. Clinically, it often presents as an asymptomatic lesion without any bone expansion and most cases have been located in the posterior portion of the mandible [21]. In addition, presence of pain, buccal cortical expansion, and lower lip paresthesia are rare but possible chief complaint of patients with TBC [22]. There is no evidence of tooth mobility and they are barely sensitive to percussion [22]. The mandible is more affected than maxilla and the majority of cases have been located in the body and symphysis of the mandible [23]. Radiographically, it presents as solitary/multiple, unilocular/multilocular radiolucent lesion with well-defined borders that can be either scalloped or irregular [21], [22] (Figure 3).

![Figure 3: Panoramic reconstructed cone-beam computed radiographic image shows traumatic bone cyst; well-defined radiolucent, posterior unilocular lesion in the left side of the mandible](image)

- **A-1-5** Well-defined → Unilocular → Periapical → Without dental association → Posteriori → Multiple

  - **CGCG**
    (See the section A-1-4).
  - **Florid cemento-osseous dysplasia (FLCOD)**
  - **FCOD**

  FLCOD also known as multiple enostosis is a reactive fibro-osseous lesion with PDL cell origin [1]. It is more common in females than males with a peak incidence in the fourth and fifth decades [24]. This entity usually appears as symmetrical, bilateral, asymptomatic, and extensive lesions in all four quadrants of the jaws mostly in the molar and premolar regions [1], [25]. The uncommon clinical symptoms observed are swelling, pain, and local drainage but these are only encountered in cases of secondary infection when the lesions are exposed in the oral cavity [25]. The diagnosis of FLCOD is based on its typical radiographic appearances which are described in three stages as the osteolytic stage (well-defined radiolucent areas), the cementoblastic stage (mixed radiolucent-radiopaque appearance), and osteogenic stage (lobular radiopacity throughout the lesion, and surrounded by a radiolucent rim) [1], [25].

- **Langerhans cell histiocytosis (LCH)**

  LCH is a rare hematologic disorder divided into three types [26]. There is as sex predilection in men with the peak incidence in the first to second decades of life, generally, LCH is considered a pediatric disease [27]. The mandible is more affected than maxilla especially in the premolar and molar regions [26]. It appears clinically as uni-focal or multi-focal painful swelling, tooth mobility, gingival enlargement, and mucosal ulcerations [26]. Radiographically, it characterized by sharply punched out or ill-defined radiolucencies without corticated borders. Alveolar bone involvement may leads to a tooth floating appearance, causing tooth mobility and thereby mimicking the periodontitis feature [26], [27]. Corticosteroid therapy, surgery, and chemotherapy have been suggested as the treatment of choice [26].
• **OKC**  
(See the section A-1-4).
• **Osteoporotic bone marrow defect (OBMD)**  
OBMD is an osteolytic lesion of the jawbones. There is a sex predilection in women with a peak incidence in the fourth to sixth decades of life [28], [29]. The mandible is affected more than maxilla especially in the premolar/molar region [29]. It is an asymptomatic condition and may be related to some underlying diseases such as sickle cell anemia, rheumatoid arthritis, and osteoporosis [28], [29]. Because most patients had previous root canal therapy in the affected sites, it is noted that NaOCl or Ca(OH)$_2$ apical extrusion may be an etiologic factor for this defect [29]. Radiographically, it appears as well-defined or ill-defined, unilateral or bilateral, focal or multifocal radiolucencies with different sizes and shapes, they may not be visible on plain X-rays and in some cases, neither on computed tomography [29].
• **RC**  
(See the section A-1-2).
• **TBC**  
(See the section A-1-4).

**A-1-6) Well-defined → Unilocular → Interradicular**
• **OBMD**  
(See the section A-1-5).
• **ICC**  
(See the section A-1-2) (Figure 4).

![Figure 4: Panoramic reconstructed cone-beam computed radiographic image shows incisive canal cyst; a well-defined radiolucent, anterior unilocular inter-radicular lesion in midline of maxilla](image)

• **Lateral periodontal cyst (LPC)**
LPC is a non-inflammatory, developmental odontogenic cyst, arising on the lateral surface of vital tooth roots [30], [31]. There is no sex predilection and most cases have been reported in the fifth and seven decades of life [31]. It occurs most frequently in the mandibular canine/premolar or maxillary anterior regions [30]. It presents clinically as an asymptomatic gingival swelling on the facial aspect between two teeth [30], [31]. Radiographically, it appears as a round or oval unilocular well-defined radiolucent lesion. This radiographic feature is not pathognomonic for LPC and can resemble an OKC or lateral radicular cyst [31]. Root resorption, tooth displacement, pain, and expansion have also been reported [31].
• **Multiple myeloma (MM)**
MM is the most commonly affecting patients between the fourth and seventh decades of life. The mandible is involved more frequently than the maxilla and the most common affected sites are the premolar region, angle, and ascending ramus. When the mandible is involved, paresthesia or numbness of the lip, as well as looseness, migration of the teeth and swelling may be complaints. Radiographically, it appears as small, circular, multiple but separate, and well-defined (punched-out) radiolucencies. In advanced cases, it may appear as a generalized rarefaction of the skeleton or as numerous radiolucencies with ill-defined and ragged borders [13].
• **OKC**  
(See the section A-1-4).
• **TBC**  
(See the section A-1-4).

**A-1-7) Well-defined → Unilocular → Pericoronal → Anteriorly**
• **Adenomatoid odontogenic tumor (AOT)**
AOT is a benign odontogenic tumor that is more common in women than men with the peak incidence in the second decades of life [17], [32]. The lesions are more prevalent in the maxilla and 90% of them occur in the anterior portion of the jaws [17], [33]. In more than 70% of cases, AOT is in association with an impacted or un-erupted tooth, mostly maxillary canine followed by lateral incisors and mandibular premolars [17]. It is usually asymptomatic and does not exceed 3 cm in diameter and displacement of adjacent teeth may be seen [17], [33]. Radiographically, it frequently looks like a DC and characterized by a corticated circumscribed unilocular radiolucency surrounding an impacted tooth. In addition, internal radiopaque foci develop in two-thirds of cases [17], [32]. Multilocular appearance, bone perforation, ill-defined borders, and root resorption have been reported in few cases [33].
• **Dentigerous cyst (DC)**
DC is the second most common odontogenic cyst after radicular cyst enclosing the crown of an unerupted tooth at the cemento enamel junction [17]. Most of the cases have been found in the second to third decades of life and there is a sex predilection in males [17], [34]. The most frequently affected teeth are the mandibular third molars, followed by the maxillary canines, maxillary third molars, and mandibular second premolars [17]. This lesion is usually asymptomatic and is generally detected by a radiographic examination to find the reason for the delayed eruption [34], [35].
Radiographically, DC typically shows a well-defined unilocular, pericoronal radiolucent area close to an un-erupted tooth. The radiolucent space should be at least 3 to 4 mm in diameter [17]. The relationship between DCs and the crown of the impacted tooth shows three types of radiographic patterns: central, lateral, and circumferential [17]. Displacement of the involved tooth and root resorption of the adjacent erupted tooth have been reported [17], [34], [35].

• **Unicystic ameloblastoma (UA)**

UA is a variant of ameloblastoma, accounts for about 6% of all intraosseous ameloblastomas [36]. There is a sex predilection in men and about 50% of the cases occur in the second decade of life [17], [36]. More than 90% of lesions have been reported in the posterior portion of the mandible, followed by the parasympysis region, anterior maxilla, and the posterior maxilla [17]. The lesion typically found in association with an impacted mandibular third molar but can be seen also in interradicular, periapical, and edentulous areas as well [36]. It can also arise from other bone lesions such as residual, radicular, and primordial cysts [17]. Radiographically, it presents as unilocular, scalloped macromultilocular, pericoronal, interradicular, or periapical expansive [17], [36]. Cortical perforation and root resorption have been reported in radiographic views of UA [17].

A-1-8) Well-defined → Unilocular → Pericoronal → Posteriorly

• **Ameloblastic fibroma (AF)**

AF is a rare, benign slow-growing neoplasm, constitutes 2% of odontogenic tumors [37]. It is reported that this lesion has a propensity to affect men more than women with a peak incidence in the first to second decades of life [17], [37]. The most commonly affected site is the posterior mandible (premolar and molar regions) and 75% of cases are in association with impacted teeth [17]. It presents clinically as a unilateral painless swelling, delayed/failure of tooth eruption, tooth mobility, displacement of the involved teeth, pathological fracture, and paresthesia [37]. Radiographically, it is usually seen as well-defined, corticated, pericoronal radiolucency, and may vary from a small unilocular lesion to an extensive multilocular lesion. Root resorption and expansion of buccal and lingual cortices have also been reported in some cases [17], [37].

• **DC**

(See the section A-1-7) (Figure 5).
• **Aneurismal bone cyst (ABC)**

ABC is a rare pseudocyst filled with blood [4]. There is no sex predilection and most of the patients are in the first to second decades of life [39]. This entity is more common in mandible than maxilla and frequently has been reported in the body of the mandible, followed by mandibular ramus, angle, coronoid process, and condyle [4], [39]. It is clinically represented as a tender, painful, and rapidly growing lesion that causes bone swelling [4]. Their radiographic features may vary from unilocular radiolucency to a "ballooned-out" multilocular radiolucency with a honeycomb or soap-bubble pattern. Aneurysmal bone cysts can cause expansion, destruction, periosteal reaction, root resorption and perforation of bone, and soft-tissue herniation [4], [39].

• **CGCG**  
(See the section A-1-4).

• **Intraosseous hemangioma (IH)**

IH is a vascular malformation/tumor, comprises about 1% of all bone tumors [40], [41]. There is a sex predilection in women with the peak incidence in the second to fifth decades of life [41]. The mandible is more affected than maxilla especially in the premolar/molar region, some condylar lesions have also been reported [40], [41]. Swelling, tooth mobility, mucosal discoloration at the affected site, massive bleeding after dental extraction, pain and paresthesia of the lip, or mental region are most clinical findings [40], [41], [42]. Radiographically, it can appear as unilocular/multilocular, well-defined/ill-defined, radiolucent/mixed cystic lesions. In addition, honeycomb, soap-bubble, sun-burst, and tennis racket appearances have been reported in some cases [40], [41].

• **OKC**  
(See the section A-1-4).

• **Odontogenic myxoma (OM)**

OM is an uncommon benign but locally aggressive tumor [43], [44]. It most frequently occurs in the second to third decades of life with a slight sex predilection in women [43]. Clinically, it represents as a painful/painless lesion that grows slowly, which may cause tooth mobility, bone expansion, paresthesia, and pain or facial distortion [43], [44]. The mandible is more frequently involved than maxilla, especially in the premolar/molar region [44]. It can cross the midline when occurring in the mandible [44]. Radiographically, it is characterized by a well-defined multilocular radiolucency, consisting of fine trabeculae, arranged at right angles, known as “tennis racquet” or “step-ladder” pattern. A “sun-ray,” “sun-burst,” “soap bubble,” and “honeycomb” appearances have also been reported [43], [44]. The “honeycomb” appearance seems to be characteristic to mandibular lesions [44].

• **TBC**  
(See the section A-1-4).

• **A-1) Well-defined → Multilocular → Periapical → Multiple**

• **CGCG**  
(See the section A-1-4).

• **Cherubism**

Cherubism is a rare hereditary non-neoplastic bone lesion that affects only the jaw bones that typically appears in the age of 2–7 years [45]. There is no sex predilection and the hallmark of cherubism is the development of symmetrical expansile lesions in the mandible and/or the maxilla that begins to regress with the onset of puberty [23]. Clinically, it is presented as a hard and asymptomatic swelling in the affected areas. In addition, submandibular and upper cervical lymphadenopathy has been also reported [23], [45]. Radiographically, it is characterized by bilateral, multilocular radiolucent lesions in the mandible. Bone lesions generally start at the mandible and ascending ramus of the mandible. Involvements of the mandibular body, coronoid process, and mandibular canal displacement have been also found in some cases [45]. Maxillary involvement is rare and less extensive [23], [45]. In mild forms of disease, no treatment is required to regress spontaneously after puberty [23].

• **OKC**  
(See the section A-1-4).

• **TBC**  
(See the section A-1-4).

• **A-2) Ill-Defined**

• **Chondrosarcoma**

Chondrosarcoma is the third most common bone tumor after MM and osteosarcoma [46]. There is a slight sex predilection in women and it may present at any age; however, primarily occurs in the fourth to seventh decades of life [47]. Clinically, it represents as painful or painless swelling associated with loosening of the involved tooth, especially in the maxilla [46]. In the mandibular lesions, paresthesia of the lower lip, as well as tooth mobility, has been also reported [47]. Radiographically, it may mimic osteosarcoma and there is no pathognomonic image finding for this entity [46]. Solitary or multiple radioluencies with irregular/indistinct borders, ground-glass or sun-ray/sun-burst appearance, uniform widening of the PDL, endosteal scalloping, and bone destruction associated with calcifications may occasionally be present. In tooth-bearing areas, a widened PDL may be noticed as an early sign of chondrosarcoma [46], [47].
ES is the fourth most frequent bone malignancy after MM, osteosarcoma, and chondrosarcoma; it also is the second most common bone tumor in infancy and childhood, after osteosarcoma [48]. Head and neck are affected only in 1–4% of all cases and there is a sex predilection in the female with a mean age of 15 years [48], [49]. Clinically, it usually represents as a symptomatic swelling and it is more common in the mandible than maxilla [48], [49]. Few patients reported conditions of fever, neck adenopathies, tooth mobility, and paresthesia [48], [49]. Radiographically, more than 50% of cases showed an osteolytic, ill-defined lesion with cortical destruction [49].

• Fibrous Dysplasia (FD)

FD is a condition that normal bone is replaced with abnormal fibro-osseous tissue [50]. There is a sex predilection in women with the peak incidence in the first to third decades of life [50], [51]. The maxilla is affected 2 times more than mandible and most cases have been located unilaterally in the posterior regions of the jawbones [50]. It clinically appears as a slow-growing painless swelling that may become arrested at a time coinciding with the onset of puberty [51]. Radiographically, it presents as radiolucent, mixed radiolucent-radiopaque, an ill-defined lesion with ground glass, or orange peel appearance [50], [51]. In addition, upward displacement of the mandibular canal has been considered as pathognomonic for this lesion [4].

• Osteomyelitis (OM)

OM is an inflammatory process of the medullary portion of the affected bone [52]. The jaw lesions are predominantly seen in the mandible, whereas, the maxilla by virtue of its laxity and the thin cortical plate is less frequently involved [53]. In the mandible, the most affected site is the body which is followed by the symphysis, angle, ascending ramus, and condyle [52]. There is a sex predilection in men with a wide reported age range [52]. It presents clinically as fever, tenderness, painful/painless swelling, intra-oral/extra-oral fistula, purulent discharge, hypoesthesia/paresthesia, and pathologic fractures [52]. Radiographically, it is typically seen as a mixed radiolucent-radiopaque, ill-defined lesion. Lamination of periosteal new bone and sequestra is characteristic features of OM. Periosteal bone reaction and onion-skin appearance have also been reported [52], [53].

• Osteosarcoma

Osteosarcoma is the most common malignant bone tumor after MM; however, it is a rare entity in the jaw [42], [46]. There is no sex predilection and over 80% of cases occurred in patients between 5 and 25 years, a second peak incidence has been also reported in the fifth and sixth decades of life [46]. Clinically, it is usually represented as a rapidly growing mass and it is more common in the mandible than maxilla [46], [54]. Pain, paresthesia, tooth mobility, and facial asymmetry have been found in some cases [42]. Radiographically, it manifests as an ill-defined mixed radiolucent-radiopaque lesion. A radiopaque lesion with moth-eaten pattern, a codman triangle, sun-burst appearance, (PDL) widening, fusiform, or tube-like widening of the mandibular canal is among other findings of osteosarcoma [42], [46]. The triad of widening of PDL, mandibular canal, and a sunburst appearance are pathognomonic for this phenomenon [42] (Figure 7).

• Primary intraosseous carcinoma (PIOC)

PIOC is a unique tumor of the jaws that is classified in four subtypes as follows: (Type 1) PIOC ex-odontogenic cyst, (Type 2a) malignant ameloblastoma, (Type 2b) ameloblastic carcinoma arising de novo, ex-ameloblastoma or exoodontogenic cyst, and (Type 3) PIOC arising de novo: (a) Keratinizing, (b) non-keratinizing types, and (Type 4) intraosseous mucoepidermoid carcinoma [55]. Thomas et al. in a pooled analysis of world literature about PIOC reported that majority of PIOC were keratinizing, the tumor affects males more than females with the peak incidence in the sixth or seventh decades of life [56]. The mandible is more affected than maxilla and most cases arise in the posterior portion where remnants of dental lamina can be the source of epithelium. In addition, anterior lesions may have arisen from epithelial remnants in line of fusion of facial processes [55]. Clinically, patients may experience painful swelling, tooth mobility, paresthesia, and numbness, mimicking facial neurological problems [55]. There is no diagnostic feature in radiographs and they usually appear as destructive unilocular, ill-define radiolucent lesions [55], [56].

B) Mixed-opaque lesions

B-1-1) Periapical → With dental association → Solitary
Cementoblastoma

Cementoblastoma is a rare slow-growing, benign odontogenic tumor, accounting for about 6% of all odontogenic tumors [1]. It is predominantly seen in the second to third decades of life and there is a slight sex predilection in women [57]. It occurs most commonly in the premolar/molar region of the mandible and in 50% of cases, mandibular first molar is affected, which remains vital [1], [57], [58]. Patients may experience swelling, pain, jaw deformity, and adjacent tooth displacement [57]. Radiographically, it is presented as a well-defined radiopaque lesion surrounded by a thin, radiolucent rim of non-mineralized tissue, in close association with roots of the involved tooth. Loss of usual outline and obliteration of the PDL are common radiographic features. Attachment of the lesion to the roots of the involved tooth is nearly pathognomonic [1] (Figure 8).

Figure 8: Panoramic reconstructed cone-beam computed radiographic image shows cementoblastoma a posterior periapical opaque lesion in the right side of mandible at the apex of 46 teeth

Condensing osteitis (CO)

CO or chronic focal sclerosing OM is pathologic bone that grows due to mild infection of the dental pulp [59]. It is an asymptomatic lesion that only can be detected on radiographs. There is no sex predilection with the peak incidence in the fourth decade of life [60]. The mandible is more affected than maxilla and it is most commonly localized adjacent to the second premolars (60%), followed by first molars (22%) [60]. Radiographically, it usually appears as a uniform dense well-defined radiopaque lesion near the apex of the necrotic tooth, with the mean distance 5 mm [59], [60]. It can find in different sizes and shapes such as round, irregular, and U-shape [59], [60].

Hypercementosis

Hypercementosis is a phenomenon in which non-neoplastic cementum is deposited along the root portion, affecting one tooth or more and changing dental morphology [61]. It was detected in 1.7% of dental patients and being predominant in adults [61], [62]. Mandibular molars are the most affected teeth, followed by mandibular premolar and maxillary second premolars [61]. Most of the cases are unilateral; however, bilateral involvement is not uncommon [62]. In most cases, it is found as an idiopathic or age-related entity [62]. Radiographically, it is presented as an excessive buildup of cementum around all or part of a root. The outline of the lesion is usually smooth but in some cases, it can be irregular and the continuity of the lamina dura and PDL space is observed around the lesion [61], [62].

B-1-2) Periapical → With dental association → Multiple
- Multiple CO
  (See the section B-1-1).
- Multiple hypercementosis
  (See the section B-1-1).

B-1-3) Periapical → Without dental association → Anteriorly
- PCOD
  (See the section A-1-2).

B-1-4) Periapical → Without dental association → Posteriorly → Solitary
- Calcifying odontogenic cyst (COC)
  COC is a benign odontogenic cyst [63]. There is no sex predilection and most cases have been reported in the second and sixth decades of life [17]. The lesion is usually asymptomatic and can occur also in extrasosseous regions such as gingival [63]. In general, the mandible is more affected than maxilla; however, a predilection for the upper jaw has been noted in Asians [17], [57]. More than 60% of the lesions have been found to be associated with an impacted tooth, mostly canines [17]. Radiographically, it appears as a well-defined unilocular/multilocular, periapical/pericoronal radiolucency containing small irregular calcified bodies. Dental impaction or displacement, which is more common in the posterior segment of the jaw and root resorption of neighboring teeth have been also reported with some frequency [17].

Cemento-ossifying fibroma (COF)

COF is a progressively growing neoplasm, consisting of fibrous tissue arising from the progenitor cells of the periodontium [1], [64]. There is a sex predilection in women and patients most affected in their second to fourth decades of life [1]. This lesion occurs much more frequently in the premolar/molar region of the mandible [1]. While 50% of all cases are asymptomatic, the growth of the lesion during the time may lead to expansion, facial asymmetry, and dental root displacement [64]. Although the main etiology of this entity is not known, most cases in the literature had a history of trauma in the affected site [64]. Radiographically, lesions in the early stage are small and radiolucent, they become mixed radiolucent-radiopaque and eventually become radiopaque with radiolucent rim [64].
- Chondrosarcoma
  (See the section A-2-1).
- FD
  (See the section A-2-1)
• FCOD
  (See the section A-1-4) (Figure 9).

Figure 9: Panoramic reconstructed cone-beam computed radiographic image shows focal cemento-osseous dysplasia; a posterior periapical mixed-opaque lesion in the right side of mandible

• Idiopathic osteosclerosis (IO)

IO is known as an intra-osseous anatomic variation that mostly found in routine radiographic evaluations [60]. There is a sex predilection in women with the peak incidence in the third decade of life [60], [65]. The mandible is more affected than maxilla and most cases have been detected in the premolar/molar region, at the periapical, inter radicular, away from the teeth, and in edentulous areas [65]. Radiographically, it usually appears as well-defined radiopaque areas with different sizes, mostly round or ovoid in shape but sometimes irregular. In some cases, it can be similar to a residual root [60], [65].

• IH
  (See the section A-1-9).

• Osteoblastic metastatic cancers (MCs)

MCs to the maxillofacial region are uncommon and may occur in the soft or hard tissues [66]. There is no sex predilection in jawbone metastases and generally, they are seen in patients between 40 and 70 years, in younger patients metastases are more common in jawbones than soft tissues [66], [67]. The mandible is more affected than maxilla especially in the premolar/molar region [66], [67].

The clinical manifestations of this phenomenon are included a bone swelling with tenderness, pain, hemorrhage, ulcer, paresthesia, and pathological fractures [66]. The breast, prostate, thyroid gland, kidney, and lungs are the most common primary sites for tumors that metastasize to the jawbones [66], [67]. Radiographically, it represents the absence of any manifestations to radiolucent or opaque lesion with ill-defined margins [66], [67]. Metastases from prostate cancer are osteoblastic whereas, bone metastases from kidney, lung, and breast are more often osteolytic [66].

• Osteoblastoma

Osteoblastoma is a rare benign tumor that accounts for about 1% of all bone tumors [68]. Patients in the second to third decades of life are most commonly affected and there is a sex predilection in men [1]. The involvement of mandible, especially the posterior segments, is more common than maxilla [1], [69]. Clinically, it is characterized by swelling, mild pain, and cortical expansion [1]. The size of the lesion does not usually exceed 4 cm in diameter and the pain does not relieve by aspirin or other nonsteroidal anti-inflammatory drugs [1]. A solitary mixed radiolucent-radiopaque circumscribed lesion is a common radiographic feature for osteoblastoma [1], [69]. The presence of a radiolucent rim or halo around the lesion has been also reported [1].

• Osteoid osteoma (OO)

OO is a low growth neoplasm of bone accounting for <1% in the jaws [70], [71]. It is more frequent in women than men and mostly observed in the second to third decades of life [1], [64]. Clinically, patients usually experience a dull, throbbing, intermittent, local, and nocturnal pain in the involved bone that alleviated by nonsteroidal anti-inflammatory drugs [1]. It can involve a single bone or several bones. The mandible is more affected than maxilla and the lingual surface and lower border of the body are the most common locations of the lesions [71]. The diagnosis of this phenomenon usually is obtained by radiographs confirmed by histopathological analysis [70]. Radiographically, it is described as a small radiolucent intracortical nidus, <1 cm in diameter, surrounded by a large, dense sclerotic zone of cortical thickening [71]. In the late stages mixed or high-density appearance can be detected in some cases. The presence of periosteal reaction and radiolucent rim around the mixed or radiopaque OO has been also reported [1].

• OM
  (See the section A-2-1).

• Osteosarcoma
  (See the section A-2-1).

• Socket sclerosis (SS)

SS is an abnormal bone healing after dental extraction, occurs in 2.7% of cases [72]. There is no sex predilection and it is characterized by deposition of sclerotic bone within the confines of lamina dura with a characteristic pattern [72], [73]. Radiographically, the density of the sclerotic bone is similar to the root dentin and the central area potentially mimics a root canal. At this point in the healing process, the dentist may be erroneously accused of having failed to extract the root [73]. It is demonstrated that this phenomenon can be related to some systemic diseases such as renal failure and digestive problems [72].

B-1-5) Periapical → Without dental association → Posteriorly → Multiple

• FLCOD
  (See the section A-1-5).

• Multiple IO
  (See the section B-1-4).
• Multiple SS  
  (See the section B-1-4).

• Paget’s disease (PD)

PD is a chronic progressive bone disorder [74]. There is a sex predilection in men with peak incidence in the fifth to sixth decades of life [74], [75]. Facial disfigurement may be a consequence of the enlargement of the maxilla and/or mandible; however, the maxilla is affected twice more than the mandible [74]. It usually presents as maxillofacial bone enlargement, pain, widened alveolar ridge, flattened palate, tooth mobility, tooth migration, poor healing in affected sites, excessive post-surgical bleeding, OM, and various infections [74]. Radiographically, in the early stage, it is characterized as a ground glass trabecular pattern, and with progression, diffuse sclerosis is seen as the cotton wool appearance of opacification [74], [75]. Other radiographic findings are also included a loss of lamina dura, root resorption, pulpal calcification, and hypercementosis [75]. It is mentioned that viral infection and Vitamin D deficiency in children may express later as PD [75].

B-2-1) Pericoronal

• AOT  
  (See the section A-1-7).

• Ameloblastic fibro-odontoma (AFO)

AFO is a benign mixed odontogenic tumor [76]. There is no sex predilection and this entity usually is seen in the first and second decades of life, which might also be a characteristic of the lesion [77]. It is clinically represented as an asymptomatic swelling, delayed tooth eruption and displacement of adjacent teeth [76], [77]. They are more frequent in the posterior areas of the mandible and the involved tooth is often displaced in an apical position, which demonstrated that the origin of the lesion is above the tooth [17], [76]. Radiographically, it presents as a well-defined unilocular or infrequently multilocular radiolucency containing various amounts of radiopaque material [17], [36], [76]. The malignant transformation of AFO into ameloblastic fibro-sarcoma has been reported, which can change the clinical and radiographical features of this entity [17].

• Calcifying epithelial odontogenic tumor (CEOT)

CEOT or Pindborg tumor is a benign, locally aggressive odontogenic neoplasm [78]. The lesions are more common in women than men with the peak incidence in the fourth to fifth decades of life [17]. The most frequent location of the lesion is the mandibular premolar/molar region and half of the cases are associated with an impacted tooth, mostly the mandibular third molar or an odontoma [17], [79]. It is usually characterized by a pericoronal radiolucency, as well as radiolucent areas with diffuse opacities [17], [78]. A mixed well-defined, radiolucent-radiopaque pattern is the most common form of the lesion, followed by radiolucent and completely radiopaque cases [17]. Unilocular radiolucencies are more frequent in the maxilla than in the mandible and maxillary lesions might be more aggressive [78]. The appearance of radiopacities close to the crown of an un-erupted tooth has been mentioned as the most characteristic and pathognomonic feature in this entity [17]. In some cases, small, thin, and opaque trabeculae may cross the radiolucency in many directions [17]. Malignant transformation has been reported in some cases between 40 and 83 years [79].

• COC  
  (See the section B-1-4).

• Odontoma

Odontoma is the most frequent benign odontogenic tumor, accounting for 67% of jaw tumors and divided into two subgroups as complex and compound odontoma [1], [80]. There is no sex predilection and mostly manifests during the first two decades of life [80], [81]. Compound odontoma is more common than complex odontoma and is frequently seen in the anterior maxilla, whereas complex odontoma is seen most commonly in the posterior mandible, where it appears as a pericoronal lesion around un-erupted teeth or as an inter-radicular lesion [80]. Clinically, they are asymptomatic lesions that are associated with altered tooth eruption in the permanent or primary dentition [1]. Radiographically, compound odontomas present as well-defined lesion containing radiodense foci with a radiolucent rim. Several follicular structures contain denticles, which are separated by fibrous septae. However, in complex odontoma, opaque foci present as a haphazard mass with no similarity to dental structure [1] (Figure 10).
C) Generalized rarefaction

- Hyperparathyroidism (HPT)

HPT is an endocrinopathy with excessive secretion of parathyroid hormone [82]. There is a sex predilection in women and usually seen in middle-aged people [82], [83]. In the oral cavity, it represents as pain, swelling, tooth mobility, drifting of tooth, sensitive teeth in mastication and percussion, developmental dental anomalies, soft-tissue calcifications, alteration in dental eruption, and facial deformity [82], [83]. Malocclusion with definitive spacing of the teeth may be one of the first signs of disease [83]. Radiography, it is characterized by generalized rarefaction of the jawbone, ground glass appearance, floating teeth appearance, reduction of lamina dura, pulp stones, pulp chamber narrowing, lytic bone cysts (brown tumors), and loss of cortical thickness at the angle and inferior border of the mandible [83].

- Leukemia

Leukemia is a malignancy of the hematopoietic tissue that occurs primarily in young persons. The patient may exhibit pallor and weakness, as well as petechiae or ecchymoses in the mucous membrane or skin. Leukemic infiltration of the oral soft tissues may produce swelling of the palate and other regions of the jaws. Radiographic changes: Delayed or incomplete formation of tooth crowns and roots, destruction of cortices of the tooth crypts, enlargement of the crypts, rapid tooth eruption, and osteoporosis with the destruction of the apical portion of the cortex around the distal crypt of the developing mandibular molar [13].

- Osteoporosis and osteomalacia

Osteoporosis is a common metabolic disease characterized by low bone mass and density. It affects one in three women and one in four men over the age of 50 years [84]. In the maxillofacial region, the mandibular cortical bone undergoes resorptive activity in osteoporotic patients, leading to decreased thickness, deformity and more porous inferior border, characteristics that can be determined by panoramic radiographs [84]. The same bone changes can be seen in osteomalacia. Osteomalacia is a disease of bone caused by Vitamin D3 deficiency and most patients with this problem experience bone pain and muscle weakness [85]. These diseases radiographically appear as reduced bone opacity and pseudofractures. An increase in mandibular angle and maxillary micrognathia have been reported [85]. Periodontal disease and aplasia/hypoplasia of cementum have been also reported in these patients [85].

- Sickle cell anemia

Sickle cell anemia is a hereditary blood disease. The manifestations usually appear early in childhood. Oral pain occurs in sickle cell patients and is not related to common dental problems. Oral ulcers may also be present, particularly on the gingival. Radiographically, it is characterized by reduced in the number of trabeculae, coarsened and sharply defined trabeculae, presence of horizontal trabeculae between the teeth roots (stepladder appearance), generalized jawbone rarefaction, thinning of the inferior border of the mandible, and the alveolar crestal bone may be observed [14].

- Thalassemia

Thalassemia is recognized as a blood disorder that occurs primarily in young persons, mostly in the first 2 years of life. The most common clinical presentations are included as pallor, weakness, severe anemia, irritability, and lethargy. Patients with the minor type of the disease are usually asymptomatic or have barely perceptible symptoms. In severe cases, the maxillary bone enlargements resulting in prominent cheek bones and anterior displacement of the incisors produce a characteristic “rodent” faces. On radiographs, the cortices may be thinned and the tooth roots may be short and spike-shaped. There is a generalized rarefaction, and occasionally a honeycomb pattern is seen throughout the jaws. In addition, the sinus hypoplasia has been mentioned as pathognomonic of thalassemia [14].

Discussion

Any jaw lesions should be evaluated taking into consideration the following radiographical presentations:

Density, locularity, and borders: Jaw lesions can be explained as having a radiolucent, mixed, opaque or rarified appearance, relative to the density of the adjacent normal bone (Figure 1). More than 80% of bony lesions are radiolucent [2]. In terms of internal pattern, the lesions can be uni- or multi-locular. Unilocular and multilocular with well-defined borders indicate benign and benign with locally aggressive natures, respectively. In addition, mixed or radiopaque lesions with well-defined margins usually represent a benign or inflammatory process. In general, lesions with well-defined borders have a benign nature whereas; those with ill-defined borders represent the locally aggressive, inflammatory, or neoplastic phenomena. Mixed or opaque lesions can be related to metabolic abnormalities, inflammatory process, fibro-osseous entities, or less commonly malignant disorders. Rarified appearance is also related to a systemic disease such as endocrinopathies or blood dyscrasias [2], [3].
Specific location and relation to dentition: Certain lesions have a predilection for a particular position whereas others can occur anywhere in the jaw. Lesions below the mandibular canal are likely to be non-odontogenic such as SBC but the lesions over it is usually odontogenic in nature such as radicular cyst. Non-odontogenic lesions have no relationship to the dentition whereas odontogenic lesions typically involve teeth or a specific part of the tooth such as DC [2], [3].

Cortical integrity and periosteal reaction: Slow-growing lesions are usually benign and cause expansion with cortical bowing while cortical perforation without noticeable expansion denotes infected or malignant lesions, for example, infected odontogenic cysts or intraosseous carcinomas. The presence of periosteal reaction is also suggestive of an inflammatory or malignant process such as chronic OM or osteosarcoma [2], [3].

Effect on surrounding structures: Tooth displacement is usually related to a benign lesion. Lesions that are over the crown of the tooth can displace it apically and those are in the ramus such as cherubism may push the tooth in the anterior direction. Root resorption can occur in chronic, slow-growing benign lesions, however, malignant lesions also occasionally resorb teeth. PDL widening, inferior alveolar nerve canal widening, and displacement should also be mentioned in differential diagnosis such as malignancies, vascular, and neural lesions [4], [42].

Conclusion

This updated radiographical diagnostic decision tree allows dental practitioners to narrow the differential diagnosis and arrives at the most probable diagnosis through a systematic approach.

References

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The provided text appears to be a continuation of a scientific article, discussing various oral hard tissue lesions and conditions. Here is a structured representation of the content:


