Introduction

Mandibular lesions are relatively common imaging findings. They can be encountered by head and neck-dedicated radiologists or by general radiologists. These lesions can be incidentally detected or actively searched for secondarily to patient’s symptoms or signs. They usually represent a diagnostic challenge. Knowledge of prevalence, imaging patterns and secondary signs that point to a specific diagnosis are essential for a thorough evaluation.

Imaging can have a significant impact on treatment, supporting clinical decisions and avoiding unnecessary and invasive procedures. Panoramic radiograph (PR), computed tomography (CT) and magnetic resonance imaging (MRI) are most useful. The World Health Organization (WHO) classification of odontogenic tumors, published in 2005, is still used worldwide and will be applied in this article.

This article intends to accomplish a pictorial review of the most common benign mandibular lesions, emphasizing on anatomical, epidemiological and imaging aspects that are crucial for narrowing the differential diagnosis.

Benign Cystic Lesions

Cystic mandibular lesions are most often odontogenic. Their anatomic relationship with teeth is an important diagnostic clue. Usually they appear as lucent, well-defined, uni or multilocular lesions. Cysts can predispose to infection or pathologic fractures1,2.

Periapical (Radicular) Cyst

Periapical cysts are the most common type of odontogenic cysts. They are slightly more common in men and have an incidence peak between 30 and 60 years. They result from infectious processes (abscess or granuloma) caused by chronic apical periodontitis, usually associated with dental cavities1,3.

PR and CT (Fig. 1) show a lucent unilocular area around the root of a non-vital tooth, generally measuring less than 1 cm in diameter. Dental root resorption or deviation and cortical expansion are possible complications. MRI demonstrates lesions with high signal on T2-weighted images (T2WI) and only peripheral enhancement. The term residual cyst should be used when referring to a lesion that persists after tooth extraction (Fig. 2)1,3.

Abstract

Mandibular lesions are a common imaging finding and they usually represent a diagnostic challenge. This article intends to make a pictorial review of the most frequent benign mandibular lesions categorizing them according to their nature (cystic or solid) and also according to their origin (odontogenic/non-odontogenic and osseous/non-osseous). Odontogenic lesions will be designated accordingly to the World Health Organization (WHO) classification of odontogenic tumors, published in 2005. The main objectives of this article are to describe the epidemiologic, anatomic and imaging characteristics of the most common benign mandibular lesions, emphasizing the aspects that aid in the differential diagnosis; and to present some illustrative examples of these lesions in orthopantomography, computed tomography and magnetic resonance.

Key-words

Mandibula; Benign lesions; Orthopantomography; Computed tomography; Magnetic resonance.

Resumo

As lesões mandibulares constituem um achado imagiológico frequente, representando habitualmente um desafio diagnóstico. Este artigo pretende realizar uma revisão pictórica das lesões benignas mais comuns da mandíbula, estratificando-as de acordo com a sua natureza (quística ou sólida) e também de acordo com a sua origem (odontogénica/não odontogénica e óssea/não óssea). As lesões odontogénicas serão denominadas tendo por base a classificação da Organização Mundial de Saúde (OMS) dos tumores odontogénicos, publicada em 2005. Os principais objectivos deste artigo são descrever as características epidemiológicas, anatômicas e imagiológicas das lesões benignas mais comuns da mandíbula, com ênfase nos aspectos que permitem realizar o diagnóstico diferencial; e apresentar alguns exemplos ilustrativos destas lesões em ortopantomografia, tomografia computorizada e ressonância magnética.

Palavras-chave

Mandíbula; Lesões benignas; Ortopantomografia; Tomografia Computorizada; Ressonância Magnética
Figure 1 – Periapical cyst. PR (A) shows a lucent rounded image around the root of 4.1 (arrow). The tooth is fragmented. Bone window CT images in the coronal (B) and sagittal (C) planes demonstrate a hypodense lesion in the mandibular body, surrounding the 4.1 root (white arrows). The tooth is fragmented and has a cavity (black arrow).

Figure 2 – Residual cyst. Bone window axial CT image shows a well-defined hypodense image in the left mandibular body (arrow). Teeth are absent (extracted).

Dentigerous (Follicular) Cyst
Dentigerous cysts are the second most common type of odontogenic cyst (after periapical cysts) but are the most common developmental (non-acquired) odontogenic cyst. These lesions form around the crown of an unerupted tooth (usually the 3rd molar). They have an incidence peak at 20-40 years. PR (Fig. 3) and CT show well-defined unilocular lucent areas around the crown of the 3rd molar (the root of the tooth is not involved). The tooth follicular space should be greater than 5 mm.

Unlike periapical cysts, dentigerous cysts can grow to a large size and induce teeth deviation and osseous remodeling, although the cortex is usually preserved. CT imaging is important to determine cortical integrity and relationship with adjacent structures (mainly the mandibular canal), prior to surgical intervention. MRI shows a lesion with signal characteristics similar to periapical cysts and is used only in atypical cases.

Periodontal Lateral Cyst
These are less common odontogenic cysts. They form between the roots of teeth, usually in the premolar region and appear as well-circumscribed lytic lesions. They commonly affect men aged 50 years or older.

Odontogenic Keratocystic Tumor
Odontogenic keratocystic tumors (OKT) are intraosseous benign lesions. Most are localized in the mandibular body or rami. These lesions can induce dental impaction but tooth involvement is not necessary (absent in one third of cases). They are more common in men and have an incidence peak between the 2nd and 4th decades of life. Imaging appearance consists of uni or multilocular lesions that can extend through “daughter cysts”. The walls of the lesion are thin but the contour may be lobulated owing to the coalescence of satellite lesions. Osseous expansion and cortical erosion can be evident, especially in large lesions. The internal content is cheese-like in consistency, which is responsible for the CT density as high as 50HU and for the variable signal on MRI T1WI and T2WI (Fig. 4 e 5). OKTs can have a locally aggressive behavior and the local recurrence rate after surgery is high (up to 60%). Squamous cell carcinoma malignant transformation is rare.

Basocellular Nevus (Gorlin-Goltz) syndrome should be suspected when multiple lesions are found in a young patient. Other hereditary syndromes such as Ehler-Danlos can be associated with multiple OKTs.

Simple Osseous Cyst
Simple osseous cysts are pseudocysts that result from previous traumatic episodes, such as dental extractions, associated with bone bleeding. They are more common in women and tend to occur before 20 years. These lesions are commonly located in the posterior mandibular medulla. They are generally asymptomatic and found incidentally.

Imaging studies demonstrate unilocular radiolucent lesions of variable dimensions that do not induce erosion nor change teeth position. The internal content can be serous, associated with high T2WI signal or hemorrhagic, associated with variable spontaneous CT density and MRI signal (that depends on the age of blood). These lesions do not enhance.

Static Bone Cavity (Stafne Cyst)
Stafne cysts are pseudocysts located in the lingual border of the mandibular angle, caudally to the mandibular canal. They result from osseous remodeling due to the adjacent submandibular gland and are more common in men. They are well-defined radiolucent lesions, less than 2 cm in diameter, and represent cortical defects. Imaging evaluation is usually limited to panoramic radiograph.
Solid Benign Lesions

Odontogenic Tumors

Odontomas are the most common odontogenic tumors (approximately 67%). They are hamartomatous lesions where a variety of dental components can be identified, including enamel. They occur more frequently in children and adolescents and have an incidence peak in the 2nd decade of life. About half are associated with unerupted teeth and occur around the crown.

The radiographic appearance of odontomas changes with time. Initially these lesions are radiolucent but tend to progressively calcify until they become radiopaque. In the last stages the margins are well defined, usually surrounded by a lucent halo. They can deviate and erode teeth.

The WHO classification comprises two types of odontomas: compound (Fig. 6), occurring more commonly in the anterior maxilla and demonstrating some dental components (denticles); and complex (Fig. 7), that normally occur in the molar region of the mandible, showing only amorphous calcifications.

Ameloblastoma

Ameloblastomas constitute 10% of odontogenic tumors and originate in the enamel-producing epithelial cells. They are equally common in both genders and have an incidence peak between the 3rd and 5th decades of life. These are classically benign, slow-growing tumors but locally aggressive.

There are ameloblastoma variants that demonstrate metastatic potential while preserving benign histological characteristics – “malignant ameloblastomas”; and other variants that have malignant histological characteristics (with or without metastatic potential) – “ameloblastic carcinomas”.

Ameloblastomas most commonly arise in the mandible (80%), frequently in the posterior body (3rd molar region) or in the rami. Symptoms are usually non-specific and the most common complaint is painless swelling. Most of the time the detection is incidental.

Four types of ameloblastoma exist: multicystic (Fig. 8 and 9), unicystic (Fig. 10), extraosseous and desmoplastic. The multicystic type is the most frequent (85% of tumors) and also the most aggressive. The imaging appearance varies with the histologic type but their differentiation based solely on imaging patterns is not possible. The multicystic type is generally a multilocular lucent lesion (“soap bubble-like”) and can display thick septa, solid components or papillary projections that enhance after contrast administration. The desmoplastic type is noticeable for the presence of coarse calcifications.

Locally aggressive behavior is demonstrated by dental root erosion and significant osseous expansion. CT and MRI are important to evaluate for malignant degeneration, cortical integrity, extension of osseous and soft tissue involvement and relationship with the mandibular canal. MRI shows lesions with low signal on T1WI and high signal on T2WI.
T2WI. Positron emission tomography in conjunction with CT (PET/CT) shows benefit in detection of malignant variants\(^1,4,7,10\).

Cementoblastoma
Cementoblastomas are rare benign tumors (less than 1% of odontogenic tumors). They commonly occur in the premolar or molar regions of the mandible and are usually periapical. The majority of patients are younger than 25 years, and these tumors occur more frequently in men\(^1-3,9\).

The most common imaging pattern is a sclerotic periapical rounded lesion that tends to fuse with the tooth root and possibly invade the tooth root canal\(^1-3\).

Cemento-Osseous Dysplasia
Cemento-osseous dysplasia originates from a connective tissue proliferation of the periodontal membrane. These lesions are frequently multifocal and occur among tooth roots of the anterior mandible, usually in the region of the canines. They affect preferentially African or Asian women and have an incidence peak during the 4th and 5th decades of life\(^3,9\).

The initial imaging appearance is a lucent periapical lesion that tends to become more opaque with time, turning into a sclerotic well-marginated lesion (Fig. 11). Unlike cementoblastomas they are not prone to fuse with teeth roots. A diffuse form, affecting two or more maxillary quadrants, is called florid cemento-osseous dysplasia\(^3\).

Ameloblastic Fibroma
Ameloblastic fibromas are rare lesions affecting primarily unerupted teeth in the posterior mandible. Their aspect is similar to unilocular ameloblastomas and entails lucent pericoronal well-defined lesions (Fig. 12)\(^11\).

---

Figure 7 – Complex odontoma. PR (A) and bone window axial CT image (B) of the same patient demonstrate a sclerotic lesion in the right mandibular ramus (arrows) adjacent to the crown of an unerupted tooth. Only amorphous tissue is visible, without evidence of odontogenic elements.

Figure 8 – Multilocular ameloblastoma. PRs (A and B) show multilocular lucent lesions (arrows) demonstrating the classic “soap bubble-like” pattern.

Figure 9 – Multilocular ameloblastoma. Soft-tissue window axial CT image (A) shows a bilocular lesion in the right mandibular body (arrow) demonstrating cortical disruption anteriorly, where an enhancing septum is visible (arrowhead). Bone window sagittal CT image (B) showing a lucent lesion in the right mandibular body/ramus transition, with osseous expansion, cortical disruption and fine septa (arrow).

Figure 10 – Unilocular ameloblastoma. PR (A) presents a unilocular lucent lesion in the right mandibular body (arrow). A barely visible fine septum is discernible (arrowhead). Bone window axial CT image (B) of the same patient shows a unilocular lucent lesion (arrow) with osseous expansion and anterior cortical disruption (arrowhead).
Condensing Osteitis

Condensing osteitis is a periapical reactive osteitis, usually secondary to an inflammatory process (pulpitis) and associated with other inflammatory lesions such as granulomas, cysts or abscesses. Children and young adults are usually affected and the lesions predominate in the premolar or molar regions of the mandible. On imaging they feature as sclerotic, ill-defined and non-expansible lesions, adjacent to a non-vital tooth.

Osseous Non-Odontogenic Tumors

Ossifying Fibroma

Ossifying fibromas are composed of fibrous tissue and variable amounts of osseous trabeculae. There are several subtypes including cementifying, cemento-ossifying and juvenile. Most of these tumors occur in the posterior mandible (premolar and molar regions). They are more common in women and have an incidence peak during the 3rd and 4th decades of life. The main radiographic characteristic is ground glass attenuation. Their appearance can change over time from radiolucent to radiopaque or mixed lesions. Usually they are unilocular and locally expansive. Dislocation and erosion of teeth are frequent. The most important differential diagnosis is fibrous dysplasia. The narrow zone of transition typical of ossifying fibromas, sometimes associated with a radiolucent border, is useful in this distinction.

Fibrous Dysplasia

Fibrous dysplasia is a congenital defect in the differentiation and maturation of osteoblast that induces normal bone transformation into fibrous stroma and immature bone. Craniofacial fibrous dysplasia commonly affects young adults and is usually monostotic. Craniofacial bones are involved in about half the cases of polyostotic fibrous dysplasia. Mandible involvement is possible although not very common. These lesions grow along the longitudinal axis of the involved bone, which they expand. They are less focal lesions than ossifying fibromas. Typically fibrous dysplasia becomes quiescent in adults but some growth can be seen in this age group.

On imaging they display heterogeneous ground glass attenuation and show a wide and ill-defined transition zone, a feature that is useful to distinguish them from ossifying fibromas. The bony cortex is commonly thickened but not disrupted and teeth dislocation is not usual.

MRI shows lesions of variable signal intensity that is influenced by the degree of lucency vs. ground glass attenuation that they possess. On T1WI lesions demonstrate low to intermediate signal intensity. On T2WI lesions demonstrate high signal intensity.
Figure 14 – Monostotic fibrous dysplasia. PR (A) and bone window axial CT image (B) demonstrate an expansible and homogeneous lesion with ground glass attenuation in the right mandibular ramus (arrows). There is an ill-defined transition zone but the lesion does not erode adjacent teeth. Axial MR T1WI (C), T2WI (D) and T1WI after gadolinium (E) demonstrate low T1 signal, areas of high T2 signal and heterogeneous enhancement (arrows).

Fig. 15 – Monostotic fibrous dysplasia. PR (A) and bone window axial CT image (B) show an expansible lesion with heterogeneous ground glass attenuation (arrows) in the left mandibular body. CT tridimensional image after volumetric reconstruction (volume-rendered) illustrates the predominant growth of these lesions along the longitudinal axis (arrows).

are usually hypointense although they can show some focal areas of hyperintensity (Fig. 14D). After gadolinium administration there is a strong and heterogeneous enhancement (Fig. 14E)\(^9,14\).

**Idiopathic Osteosclerosis**

Idiopathic osteosclerosis is an osseous developmental variant of unknown cause and not related to local stimuli. In 90% of cases it occurs in the mandible (usually in the premolar or molar regions) and is frequently asymptomatic. A peak incidence occurs between the 1st and 2nd decades of life. There is a uniform distribution in both genders\(^9,15\). Radiograph and CT demonstrate sclerotic, focal and rounded lesions, well margined and usually periapical (80% of cases) (Fig. 16). Spiculated margins can be seen. They can grow slowly until skeletal maturation is complete but do not induce osseous expansion. Sometimes they are multifocal\(^9,15\).

**Osteochondroma**

Osteochondromas are the most common bone tumors. They are composed of cortical and medullary bone and covered by a hyaline cartilaginous cap. Continuity with the parent cortical bone and medullary canal is considered pathognomonic (Fig. 17). Lesions can be solitary or multiple, the latter being related to the autosomal dominant syndrome named hereditary multiple exostoses. Malignant transformation occurs in about 1% of solitary and 3-5% of multiple hereditary osteochondromas\(^7,9,16\).

Imaging features that are associated with malignancy include continuous growth and thick cartilaginous cap (>1.5 cm) after skeletal maturity\(^7,9,16\).

**Osteoradionecrosis**

Approximately 15-37% of patients treated with radiation therapy for tumors in the head and neck region experience osseous necrosis, secondary to hypoxia and hypovascularization caused by radiation. These events lead to cell death and fibrosis. Osteoradionecrosis is dose-dependent and more common with radiation doses above 60 Gy. Evidence of bone necrosis can arise months or years (usually between 5-15 years) after the conclusion of radiation therapy. The mandible is more susceptible than the maxilla and the vestibular cortex is more vulnerable than the lingual cortex. The body of the mandible is most frequently affected (around the molar region). The chin and mandibular angles are usually spared\(^3,4,9\).
Osteoradionecrosis features on CT as an ill-defined area of mixed attenuation (lytic and sclerotic foci), loss of normal bone trabeculation, cortical disruption, fragmentation and bony sequestrum (Fig. 18). Soft tissue masses and periosteal reaction are characteristically absent, findings that are useful in the differential with tumor relapse.

MRI shows areas of bone edema and sclerosis with heterogeneous enhancement. Diffusion weighted images (DWI) are useful in the differentiation with tumor relapse (low ADC values) from osteoradionecrosis (high ADC values)\(^3,4,9\).

**Bisphosphonate-related Osteoradionecrosis**

Bisphosphonates are frequently used in oncologic patients and improve their quality of life. The benefits result from osteoclastic activity inhibition and consequent reduction in the growth of bone lesions and prevention of pathologic fractures. This drug can also be used in non-oncologic diseases, such as osteoporosis. A potential side effect of this treatment is bone necrosis. Bisphosphonate-related osteonecrosis occurs preferentially in the mandible (more than in the maxilla), usually in the molar region. Focal lesions and traumatic events (such as dental extractions) can facilitate it\(^4,9\).

Imaging features are similar to osteoradionecrosis. Clinical factors are very important in the differential diagnosis that implies absence of previous radiotherapy\(^4,9\).

**Osteomyelitis**

Osteomyelitis is a bone infection (usually bacterial) with medullary involvement. It is rare in healthy subjects due to antibiotic treatment. The mandible is commonly affected (more than the maxilla). Most patients have dental cavities or previous dental extractions. Mandibular or dental fractures and osteonecrosis are other possible predisposing factors. Chronic osteomyelitis (>1 month) may have complications such as sinus tracts, fistulae, bone sequestra or pathologic fractures. The most common risk factors are diabetes mellitus, alcoholism, malnutrition, radiation therapy and bisphosphonate treatment\(^3,4,9\).

Common imaging findings consist of focal disturbance of bone trabeculation with mixed attenuation (lytic and opaque areas), cortical disruption, bone sequestra, gas attenuation and periosteal reaction (Fig. 20). CT is useful to define the extension and severity of bone and soft tissue involvement (abscesses, myositis, fasciitis or cellulitis). MRI shows greater sensitivity in the detection of osteomyelitis, allowing earlier diagnosis. This entity demonstrates low signal intensity on T1WI, high signal on liquid-sensitive sequences and enhancement of adjacent soft tissues. Bone sequestra show marked hypointensity on all sequences\(^3,4,9\).
Figure 18 – Osteoradionecrosis. PR (A) and bone window axial CT images (B and C) show the classic features of this entity (arrows), disclosed by an ill-defined lytic area with bone destruction, cortical disruption and sequestrum (arrowheads).

Figure 19 – Bisphosphonate-related osteonecrosis. Bone window axial CT image of a patient with mandibular osteonecrosis after bisphosphonate treatment demonstrates several lytic areas (arrows) and a bone sequestrum (arrowhead).

Non-Odontogenic Non-Osseous Tumors

Giant Cell Granuloma

Giant cell granulomas are composed of fibrous and hemorrhagic tissue as well as giant osteoclastic cells. They are rare, benign but locally aggressive tumors. Children and young adults are most affected, especially women. They have an incidence peak in the 2nd and 3rd decades of life. These lesions tend to occur in the posterior mandible.

Typical imaging characteristics consist of well-defined lucent and multilocular lesions (honeycomb-like) (Fig. 21). Thin bone septa can be discernible. Lesions can also be unilocular (particularly in an early stage) or present ill-defined borders. Sometimes there is bone expansion, teeth depositioning or erosion and cortical disruption. On MRI lesions show homogeneous intermediate signal on T1WI and T2WI and moderate/marked enhancement.

Figure 20 – Osteomyelitis. Bone window axial and coronal CT images (A and B) of a patient with a history of right partial pelviglossectomy demonstrate cortical thinning and gas attenuation in the right mandibular ramus (arrows), with associated cutaneous fistula (arrowheads). These findings are indicative of chronic osteomyelitis.
Brown tumors from hyperparathyroidism are an important differential diagnosis and denote identical imaging and pathologic features. Laboratory studies usually allow distinction.\textsuperscript{3,4}

**Eosinophilic Granuloma**

Eosinophilic granulomas are benign osseous lesions that represent the focal demonstration of a systemic disease named Langerhans Cell Histiocytosis (LCH). LCH is a disease caused by the clonal proliferation of dendritic cells and macrophages. Manifestations can be unifocal, multifocal but unisystem or multifocal and multi-system. About 79\% of cases occur in the mandible (usually in the body or the mandibular angle) but any bone can be affected. These lesions are more common in men and have an incidence peak between the 1\textsuperscript{st} and 3\textsuperscript{rd} decades of life.\textsuperscript{4,17}

Imaging reveals a lucent lesion generally associated with periosteal reaction (that may show a “sunburst” pattern) (Fig. 22). When the teeth arcade is involved, osseous destruction may induce a characteristic “floating tooth” appearance. Associated soft tissue masses around the mandible and muscles of mastication are frequent. On MRI these lesions demonstrate low signal on T1WI and high signal on T2WI. Marked enhancement and surrounding edema are typical. ADC values are usually higher than malignant lesions. Biopsy is crucial for a definitive diagnosis. PET/CT and PET/MR are useful in the detection of lesions in multifocal and multi-system disease and also in treatment monitoring.\textsuperscript{4,17}

**Nerve Sheath Tumors**

Nerve sheath tumors are benign and slow-growing lesions. They are rare tumors that show preference for the head and neck region. The mandible is the most commonly affected bone, usually in the ramus or posterior body. These lesions are more frequent in women and have an incidence peak between the 3\textsuperscript{rd} and 4\textsuperscript{th} decades of life.\textsuperscript{18}

Radiographs show lucent uni or multilocular lesions. Erosion of the adjacent teeth roots is frequent and enlargement of the mandibular canal or mental foramen may be the only findings. On CT they present as homogeneous masses of soft tissue density, sometimes with septa. MRI generally demonstrates high signal in liquid-sensitive sequences and enhancement after gadolinium administration (more striking in schwannomas) (Fig. 23). A central hypointense area surrounded by a hyperintense ring (“target sign”) is more frequent in neurofibromas (although not exclusive).\textsuperscript{18}

The relationship of the tumor with the inferior alveolar nerve is determinant. Neurofibromas tend to grow along the mandibular canal and have an ovoid shape. Schwannomas rarely grow inside the canal, having a more rounded morphology.\textsuperscript{18}

---

**Figure 21** – Giant cell granuloma. PR (A) and bone window sagittal CT image (B) demonstrate a lucent multilocular lesion in the right mandibular body (arrows). Note the idiopathic osteosclerosis adjacent to the root of 4.7 (arrowheads).

**Figure 22** – Eosinophilic granuloma. Bone window axial (A) and sagittal (B) CT images demonstrate several lytic foci in the mandibular body (arrows), with associated cortical disruption and bone sclerosis, regarding multifocal disease. Volumetric reconstruction image (C) demonstrates bone destruction caused by the lesions.
Conclusion

Knowledge of the more important epidemiologic and imaging characteristics of the benign mandibular lesions is essential for radiologic evaluation. The accurate diagnosis of these lesions is clinically useful because it can guide the therapeutic approach and follow-up, avoiding unnecessary procedures.

References