

Use of Cone Beam Computed Tomography in the Differential Diagnosis of Jaw Bone Lesions

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Abstract

Background/Objective: This study aims to describe in detail the characteristics of the different jaw bone lesions seen in cone beam computed tomography examinations, from a retrospective analysis.

Methods: All the preoperative examinations of cone beam computed tomography of intraosseous lesions of the jaws were retrospectively reviewed from patients treated at the Department of Stomatology of a Brazilian University, from 2008 to 2017. The following data were collected: sex, age, location, density and size of the lesion, relation to an unerupted tooth, margins, cortical and/or perforation, tooth displacement, root resorption, presence of calcifications, and proximity to anatomical structures. Fisher's exact test was used to verify associations between the variables.

Results: We identified 28 lesions, all of which were benign: 14 odontogenic keratocysts, 5 odontomas, 3 dentigerous cysts, 2 ameloblastomas, 1 ameloblastic fibro-odontoma, 1 cementoblastoma, 1 adenomatoid odontogenic tumour, and 1 calcifying epithelial odontogenic cyst. Of these lesions, 23 affected the mandible, and 5 the maxilla. The lesions were subdivided into aggressive and non-aggressive, and when compared, there was a difference only for the cortical cone perforation variable ($p < 0.05$), which was more prevalent in aggressive lesions, suggesting that this characteristic is an important indicator of pathological behaviour.

Conclusions: An accurate identification of the characteristics of bone lesions of the buccomaxillofacial complex, using cone beam computed tomography, can guide diagnostic hypotheses, in addition to guiding the management, thus, providing a more appropriate treatment for each individualized case.

Introduction

The introduction of cone beam computed tomography (CBCT) has greatly changed the dentists' practice in diagnosing maxillofacial alterations, since access to sectional images has become faster and easier. Previously, multiplanar images were obtained mainly by multislice helical computed tomography (MHCT) and magnetic resonance imaging (MRI), which are costly equipment usually restricted to hospitals. However, CBCT units have the smallest physical dimension, lowest cost, lowest radiation dose, and easier operation, which led to their rapid acceptance [1].

Before the advent of CBCT, panoramic radiography (PR) was the most common imaging tool in oral and maxillofacial surgery [2]. Although surgical practice is successful in the vast majority of cases, the limitations of this technique include variable magnification, distortion, overlapping structures, air shadows, and inaccurate images of structures that are not within the focal plane [2–4]. CBCT has overcome these limitations due to its wide range of applications in dentistry, from diagnosis to treatment planning [1, 2]. Depending on the field of view (FOV), the CBCT exam covers a large focal area of the facial skeleton, as well as a small focal area of clinical interest [1].

For the evaluation of cysts or tumours, the CBCT originates three dimensions that are registered through multiplanar reformatting (axial, coronal, and sagittal) [5], which provides important information about the presence and buccal-lingual extension of bone pathologies, bone resorption, sclerosis of the adjacent bone, cortical expansion, presence of internal or external calcifications, and proximity to anatomical structures [6].

In addition, small cut thicknesses, such as 0.1 mm, allow a better visualization of the bone margins of a lesion [5, 7].

Although CBCT has been widely studied in recent years, studies on its applicability and diagnostic value in intraosseous lesions of the jaws are scarce. Some studies have reported isolated clinical cases [8, 9], specific pathologies [10–12], or are based on MHCT images [13–15]. Thus, the present study aims to describe in detail the imaging findings of CBCT examinations of patients with intraosseous lesions in the maxillofacial region.

Methods

The research was approved by the Human Research Ethics Committee (number 1,683,193/2016).

Sample

A retrospective study was carried out with a sample consisting of CBCT exams belonging to the Department of Stomatology of a Brazilian University. All preoperative images of intraosseous pathologies, odontogenic or not, confirmed via microscopic examination, of patients presented between 2008 and 2017 were reviewed. There were no age restrictions. Endodontic apical lesions and fibro-osseous lesions were excluded from the study.

CBCT

The patients were examined using two CBCT systems (3D Accuitomo® 170 – J. Morita Corp., Kyoto, Japan, and New Generation i-Cat® – Imaging Sciences International, Hatfield, PA, USA), according to the protocols recommended by the manufacturer and the specifications of each system (120 kVp, 3–8 mA, 0.3 mm voxel size and 80 kVp, 6 mA, 0.08 mm voxel size, respectively). The FOV varied according to the location and extension of the lesion. Images were obtained in different planes (sagittal, coronal, and axial) at 1 mm slice thickness and 0.5 mm slice interval in both devices.

Images were examined using the scanners' proprietary software (Xoran 3.1.62 version, Xoran Technologies, Ann Arbor, MI, USA, and One Volume Viewer, J. Morita MFG. Corporation, Kyoto, Japan) on an Intel® Core™ 2 Duo 1.86 Ghz-6300 (Intel Corporation, Santa Clara, CA, USA) PC workstation with an NVIDIA GeForce 6200 turbo cache video card (NVIDIA Corporation, Santa Clara, CA, USA) running Windows XP Professional SP-2 (Microsoft Corporation, Redmond, WA, USA) and with an EIZO-FlexScan S2000 monitor at a resolution of 1600 × 1200 pixels (EIZO NANA Corporation, Hakusan, Japan). All analyses were performed by a single examiner in a semi-dark and silent room with intervals between analyses to avoid eye fatigue. Software tools such as filter, zoom, and contrast could be used, allowing image optimization at the discretion of the examiner.

Data analysis

For all cases, coronal, sagittal, axial, and panoramic reconstructions were evaluated, as well as parasagittal cuts and 3D reconstruction. The following data were collected: sex, age, location of the lesion, density and

size of the lesion, relation to an unerupted tooth, margins, cortical expansion, cortical perforation, tooth displacement, root resorption, presence of calcifications, and proximity to anatomical structures. The assessed variables are shown in Table 1. In addition, Fig. 1 was designed to illustrate the main characteristics evaluated.

Table 1
Variables studied.

VARIABLE	CLASSIFICATION
Sex	⇒ Male ⇒ Female
Age	⇒ 7 to 81 years old
Lesion location	⇒ Mandible ⇒ Maxilla
Density	⇒ Hypodense ⇒ Hyperdense ⇒ Mixed
Lesion size (Apajalahti et al., 2011)	Larger diameter (in centimetres) in the axial plane, or large mandibular lesions involving the ascending branch in the sagittal plane
Relationship with unerupted tooth (Chindasombatjaroen et al., 2012)	⇒ Absent ⇒ Adjacent: tooth is adjacent to the lesion ⇒ Cementum–enamel junction (CEJ): injury which involves the tooth and is connected to at least the CEJ ⇒ Root: the lesion that surrounds the tooth and extends apically along the root beyond the CEJ ⇒ Whole tooth: injury involving the tooth completely
Borders	⇒ Well-defined - No halo - With halo - <i>Scalloping</i> ⇒ Poorly defined
Cortical expansion	Considered when there is an increase in volume resulting in expansion of the buccal or palatal/lingual bone cortex in any of the evaluated plans ⇒ Present ⇒ Absent
Cortical perforation	Considered when there is no evidence of cortical bone in any of the evaluated plans ⇒ Present ⇒ Absent

VARIABLE	CLASSIFICATION
Tooth displacement	⇒ Present
	⇒ Absent
Root resorption	Any degree of root resorption / shortening clearly visible
	⇒ Present
	⇒ Absent
Presence of calcifications (Chindasombatjaroen et al., 2012)	⇒ + presence of one or more thin hyperdense lines
	⇒ ++ some discrete hyperdense foci
	⇒ +++ numerous scattered or grouped hyperdense foci
Proximity to vital anatomical structures	

A database covering the variables and classifications was organized in a Microsoft Office Excel 2016 spreadsheet (Microsoft Corporation, Redmond, WA, USA) for the tabulation of statistical data. The data obtained were analysed using the *Statistica 8.0* software (Statsoft, Tulsa, USA). Frequency tables with percentages and graphs followed by Fisher's exact test were used to verify possible associations between the variables evaluated. The level of significance was 5%, and thus, associations with $p < 0.05$ were considered significant.

Subdivision of the lesions

The lesions found were categorized as aggressive and non-aggressive according to their behaviour. The proposed subdivision was based on proven findings related mainly to clinical behaviour and injury recurrence, based on the last classification proposed by the World Health Organization in 2017 [16, 17].

Results

Twenty-eight lesions were found, all of which were benign: 14 odontogenic keratocysts (50%), 5 odontomas (17.86%), 3 dentigerous cysts (10.71%), 2 ameloblastomas (7.15%), 1 fibro-ameloblastic odontoma (3.57%), 1 cementoblastoma (3.57%), 1 adenomatoid odontogenic tumour (3.57%), and 1 calcifying epithelial odontogenic cyst (3.57%). Of these lesions, 23 affected the mandible (82.1%), and 5 the maxilla (17.9%). The age of the patients ranged from 8 to 71 years, with an average of 29.3 years.

Odontogenic keratocyst, the most prevalent lesion, most frequently affected females (57.1%) with an average age of 33.2 years. The average lesion size was 3.42 cm, and the most common location was the mandible (12 cases, 85.7%). The lesion was hypodense in all cases and was mostly (57.1%) unrelated to an unerupted tooth. In addition, all of them had well-defined limits, and in 64.3% of the cases, there was no expansion of the cortices. There was no type of calcification in the lesions. Tooth displacement and root resorption were absent in 71.4% and 78.6% of cases, respectively. In 10 cases (71.4%), cortical bone perforation was present.

Odontoma (17.86%) was also more prevalent in females (60%) and in the mandibular region (80%), with a mean age of 20.4 years. The average lesion size was 1.3 cm. In 60% of the cases, the lesion was related to an unerupted tooth, and the lesion was hyperdense in all the cases, with well-defined hypodense halos. In addition, tooth displacement caused by the lesion was observed in 60% of cases. Cortical perforation, cortical expansion, and root resorption were not observed in any tomographic examinations. All lesions were diagnosed as complex odontomas.

The dentigerous cyst (10.71%) had an average size of 2.3 cm and occurred at an average age of 20.3 years in affected individuals. Females were more affected (66.7%) than males and the mandible was the only affected region (100%). All lesions were related to unerupted teeth and had well-defined limits. Cortical expansion was absent in most lesions (66.7%) and there was no cortical perforation or tooth displacement. Root resorption was present in two cases (66.7%).

Tomography revealed ameloblastomas (7.15%) with an average size of 4.14 cm, being more prevalent in females (57.1%), with an average age of 43.5 years, presenting in 100% of hypodense and multilocular cases, affecting exclusively the mandible. Additionally, in all the cases, there was a relationship between the lesion and an unerupted tooth, and an expansion of the bone cortices. The borders were well defined and half of the cases had a hyperdense halo. Perforation of the cortical bone, as well as root resorption, was present in 50% of the cases. It was not possible to observe calcifications or dental displacements in the analysed lesions. No cases of unicystic ameloblastoma were observed.

The prevalence of ameloblastic fibro-odontoma, cementoblastoma, adenomatoid odontogenic tumour, and calcifying epithelial odontogenic cyst lesions was 3.57% each. In cases of ameloblastic fibro-odontoma, adenomatoid odontogenic tumour, and calcifying epithelial odontogenic cyst, calcifications were observed, with some scattered hyperdense foci.

The lesions were subdivided into aggressive (odontogenic keratocyst and ameloblastoma) and non-aggressive (odontoma, ameloblastic fibro-odontoma, dentigerous cyst, cementoblastoma, adenomatoid odontogenic tumour, and calcifying epithelial odontogenic cyst), based mainly on findings related to clinical behaviour and recurrence of lesions. When compared, there was a statistically significant difference only for the bone cortex perforation variable, which was more prevalent in aggressive lesions. For the other variables, no statistically significant differences were observed (Table 2).

Table 2. Comparison between aggressive and non-aggressive lesions.

	Drilling		Expansion		Reabsorption		Displacement		Borders		
	Yes	No	Yes	No	Yes	No	Yes	No	Well defined with halo	Well defined without halo	Poorly defined
Aggressive lesion	12	5	8	9	4	13	4	13	8	8	1
Non-aggressive lesion	0	11	2	9	3	8	4	7	7	4	0
	p=0.0002*		p=0.2264		p=0.9999		p=0.6715		p=0.8154		

*Statistically significant difference. Fisher's exact test.

Discussion

CBCT images provide important information about the presence and extent of bone and/or tooth resorption, cortical expansion, presence of calcifications, tooth displacements, and involvement of anatomical structures [4, 6]. With the different reformats, it is possible to obtain a better view of the bone margins of the lesion in three dimensions [2, 5].

Measurements on CBCT images are acceptably accurate, in addition to revealing the direction in which the expansion is taking place, contributing to the planning of surgical treatment, especially in the early stages of expansion, when it may be difficult to observe the direction of growth by only clinical examination [4], in contrast to the PR where the image is enlarged [5].

In the present study, odontogenic keratocyst was more prevalent in the mandible than in the maxilla, in line with previous studies [18–23]. Likewise, ameloblastomas were also located in the mandibular region [18, 20, 22–24]. All dentigerous cysts occurred in the mandible; however, they may be common in the maxillary region [25]. For odontomas, 80% of the cases were observed in the mandible, contrary to previous studies that demonstrated a higher prevalence in the maxilla [18–20, 22, 23].

Among the lesions considered aggressive, odontogenic keratocyst and ameloblastoma caused cortical bone perforation in 71.4% and 50% of cases, respectively. Root resorption and displacement were observed in 22% and 29% of odontogenic keratocyst cases, respectively, and in half of ameloblastoma cases, root resorption of the teeth involved was observed. The main characteristic that differentiated both lesions was the association with unerupted teeth and the expansion of bone cortices, present in all cases of ameloblastoma. As for odontogenic keratocysts, in most cases (64.3%), there was no expansion of the cortices or association with an unerupted tooth (57.1%).

Among the non-aggressive lesions, the dentigerous cyst was not associated with cortical perforation or tooth displacement. However, most cases showed root resorption (66.7%). The margins have always been well

defined in non-aggressive lesions, as well as in odontomas, which in 60% of cases, were associated with unerupted teeth or caused tooth displacement without root resorption. Calcifications were observed in ameloblastic fibro-odontoma, adenomatoid odontogenic tumour, and calcifying epithelial odontogenic cyst. CBCT allows the detection of subtle hyperdensities, favouring the orientation of the hypotheses for the diagnosis of calcified lesions, which may also include the calcifying epithelial odontogenic tumour, cemento-ossifying fibroma, and fibro-osseous lesions.

On comparing aggressive and non-aggressive lesions, there was a statistically significant difference only for the perforation of cortical bone, which was more prevalent in aggressive lesions, suggesting that this characteristic is an important indicator of pathological behaviour, guiding the elaboration of diagnostic hypotheses and the plan of treatment.

Oral surgeons can rely on PR if the margins of benign lesions are well defined. However, when the margins are not well defined, CBCT is the best tool for diagnostic assistance [5]. A 'benign' lesion appearance in a PR can reveal characteristics of malignancy in thin slices scanned on CBCT. Tomographic images can identify such irregular margins and provide accurate and reliable information in the early stages of a malignant lesion [2, 7]. CBCT is as reliable as MHCT for detecting bone invasion by malignant lesions [26, 27]. However, they are not applicable for the analysis of soft tissue tumours, and in this case is more appropriate acquisition of MHCT in 'soft tissue windows' or MRI [7, 28].

The absence of cases of compound odontomas, simple bone cysts, or even the small number of cases of dentigerous cyst, can be justified by the fact that CBCT is not requested in all cases. Generally, the indication for the exam is in more extensive lesions or those close to anatomical structures, to assist in the diagnosis and treatment planning. It is important to note that CBCT, despite its advantages, should not be prescribed indiscriminately because of the relatively high radiation doses when compared to radiographic exams.

Conclusions

An accurate identification of the characteristics of bone lesions of the buccomaxillofacial complex, using CBCT, can guide diagnostic hypotheses, in addition to guiding the management, thus, providing a more appropriate treatment for each individualized case.

Declarations

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Conflicts of interest: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethics approval: The research was approved by the Human Research Ethics Committee (number 1,683,193/2016). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Consent to participate: Not applicable.

Consent for publication: Not applicable.

Availability of data and material: The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Code availability: Not applicable.

Authors' contributions: *Mailon Cury Carneiro:* Conceptualization, Formal analysis, Investigation, Methodology, Visualization, Writing-original draft, Writing-review & editing. *Elen de Souza Tolentino:* Conceptualization, Methodology, Project administration, Supervision, Visualization, Writing-original draft, Writing-review & editing. *Lorena Borgononi Aquaroni:* Conceptualization, Data curation, Formal analysis, Investigation, Writing-original draft, Writing-review & editing. *Milenka Gabriela Quenta Huayhua:* Conceptualization, Methodology, Writing-original draft, Writing-review & editing. *Bernardo da Fonseca Orcina:* Conceptualization, Methodology, Writing-original draft, Writing-review & editing. *Verônica Caroline Brito Reia:* Conceptualization, Investigation, Writing-original draft, Writing-review & editing. *Izabel Regina Fischer Rubira-Bullen:* Conceptualization, Project administration, Supervision, Writing-original draft, Writing-review & editing. All authors gave final approval of the work.

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Figures

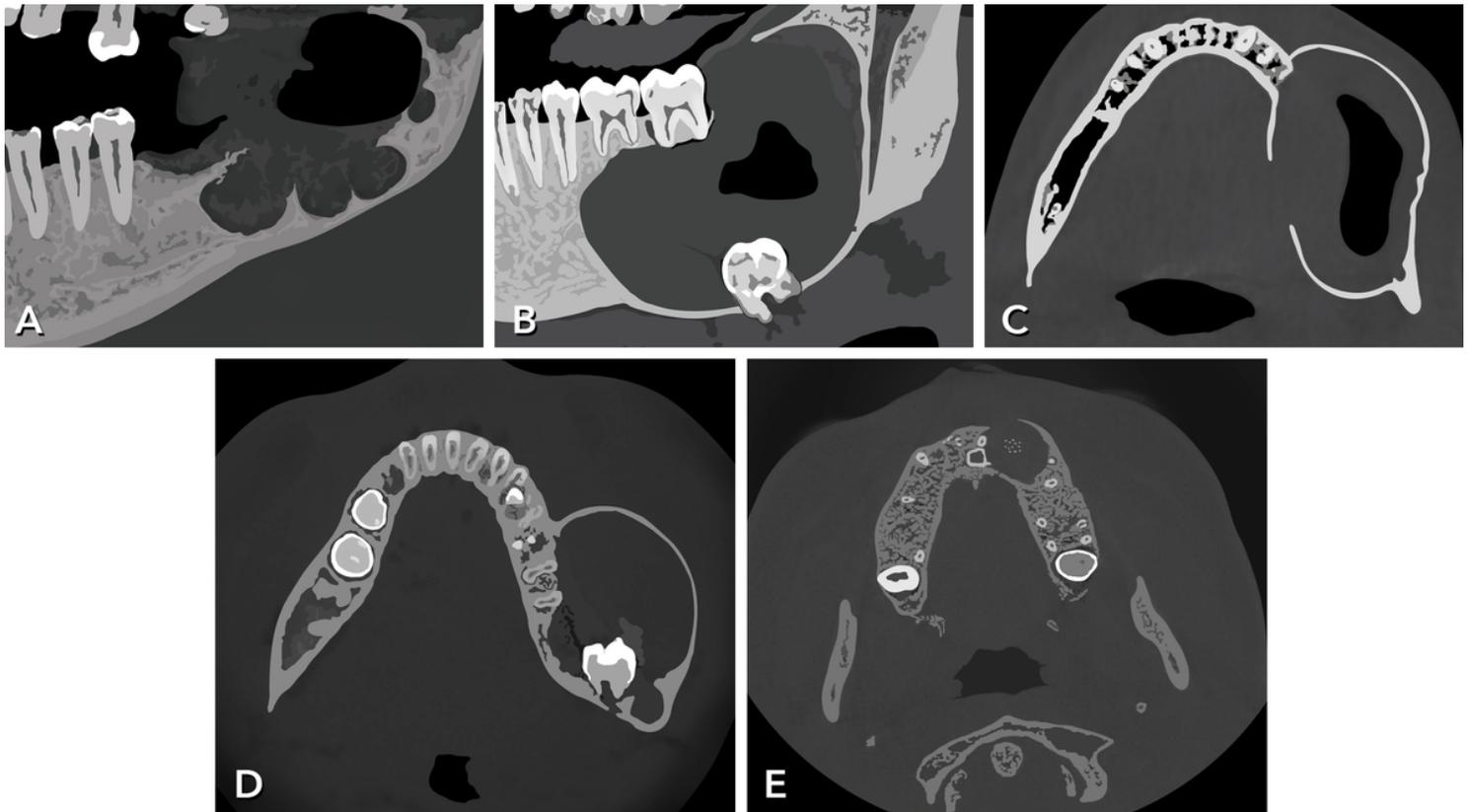


Figure 1

Illustrations of the main characteristics evaluated in CBCT. A: Multilocular lesion (panoramic reconstruction - mandible), B: Expansive and unilocular lesion, with displacement of the third molar and root resorption in the first and second molars (panoramic reconstruction - mandible), C: Expansive unilocular lesion with perforation of the lingual cortex (axial reconstruction - mandible), D: Expansive lesion involving an unerupted tooth (axial reconstruction - mandible), E: unilocular lesion, with perforation of the buccal cortex, and presence of hyperdensities (calcifications) inside (axial reconstruction - maxilla)