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RESEARCH ARTICLE

Evaluation of mandibular odontogenic keratocyst and ameloblastoma by panoramic radiograph and computed tomography

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Objectives: The purpose of this study was to describe and compare the main imagenological features of mandibular ameloblastomas and odontogenic keratocyst (OKC) using panoramic radiograph (PR) and CT.
Methods: The sample consisted of nine cases of ameloblastomas and nine cases of OKC. PR and CT images were analyzed according to shape, internal structure, borders, associated unerupted tooth, root resorption, expansion and perforation of cortical bones.
Results: PR evaluation allowed the identification of the lesion's location, presence of sclerosis in the periphery, presence of associated non-erupted tooth and expansion of the mandible's lower border cortical bone. CT was more accurate than PR in the assessment of the lesion shape, presence of inner bone septa, root resorption, buccolingual expansion and rupture of cortical bone. Most cases of ameloblastoma and OKC presented buccolingual expansion and erosion of cortical bone. Only ameloblastomas showed tooth root resorption.
Conclusions: Although PR is very helpful and widely used, CT provides more precise information on buccolingual expansion, calcification, bone septa, perforation of cortical bones and tooth resorption, features that are frequently underdescribed in the literature, particularly in OKC.
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Keywords: Computed tomography; panoramic radiography; ameloblastoma; odontogenic keratocyst; odontogenic tumour; odontogenic cyst

Introduction

Imaging exams are extremely important for managing intraosseous lesions, with panoramic radiography (PR) being used most frequently.[1,2] CT has become increasingly common in dental practice, especially with the advent of cone beam CT.[3–12] In addition, CT enables the observer to manipulate and reconstruct high-resolution images, providing more resources than other radiographic methods.[10,12]

Previous studies have demonstrated that PR has a similar accuracy to CT when measuring well-defined lesions located in the posterior region of the mandible. PR is also considered a suitable method for evaluating odontogenic cystic lesions in the mandible.[13,14] However, in the maxilla, it is difficult to assess lesions that are close to the maxillary sinus using a two-dimensional (2D) image. CT assesses the exact dimension of

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the lesion and its proximity to the adjacent anatomical structures. Therefore, the internal structure of the lesion can be more accurately evaluated and the bone cortical expansion can be determined.[14,15]

Ameloblastoma is the most common odontogenic tumour characterized by expansion and a tendency for local recurrence. Odontogenic keratocyst (OKC) is an odontogenic cyst representing the third most common cyst of the jaws. In 2005, OKC was classified by World Health Organization (WHO) as a tumour (keratocystic odontogenic tumour) due to its aggressive behaviour, recurrence and mutations in PTCH gene. However, the most recent WHO classification in 2017 considered these evidences were insufficient to support the neoplastic origin and classified it again as a cyst.[2,16]

In dentistry, CT studies mainly focus on implantology, orthodontics, endodontics and surgery.[10,17–26] Few studies have focused on oral diagnosis.[12,27–31] According to MacDonald-Jankowsky,[32] although ameloblastoma images and OKC present similarities, there are a number of differences, the main one related to the pattern of progression. MacDonald-Jankowsky stated that OKC has a fusiform growth pattern due to a smaller buccolingual expansion while ameloblastoma shows a balloon-like pattern of expansion (ballooning). However, for many years, the description of these odontogenic tumours has mainly been based on 2D images and little data regarding CT scans has been reported.[33,34]

The purpose of this study was to describe and compare the main features of ameloblastomas and OKC using PR and CT.

Methods and materials

The files of oral diagnosis clinic were reviewed and the cases were randomly selected. However, only cases with confirmed histopathological diagnosis, good image quality and complete Digital Imaging and Communications in Medicine file or panoramic radiograph image were included. The sample consisted of nine cases of ameloblastomas and nine cases of OKC. Ameloblastomas were located in the mandible (five females, four males; mean age, 31.8 years; range: 13–51 years). OKC were located in the mandible (five females, male males; mean age, 34.4 years; range: 8–80 years).

PR was carried out using analogue and digital equipment. The analogue images were digitalized [600 dpi spatial resolution, 256 shades of grey (8 bit) contrast resolution]. The CT scans were carried out using cone beam equipment (four cases, i-Cat 3D Dental Imaging System, Hatfield, USA, 120 kV, 36 mA, 0.25 mm slice thickness; 11 cases, Sirona XG3D, Sirona Dental Systems, Bensheim, Germany, 85 Kv, 5 mA, 0.16 mm slice thickness) and medical equipment with helical acquisition (three cases, Philips, Koninklijke Philips N.V, Amsterdam, Netherlands,120 kV, 146 mA, 1.6 mm slice thickness). The software e-Film Workstation, v. 4.1 (Merge Healthcare Inc., Chicago, USA) was used to visualize CT Digital Imaging and Communications in Medicine files. Images were described in terms of shape, internal structure, borders, associated unerupted tooth, root resorption, expansion and perforation of cortical bones.

Results

Table 1 describes the main imaging characteristics of this sample. The panoramic radiograph evaluation allowed, without prejudicing the analysis, the identification of the lesion's location, presence of sclerosis in the periphery, the presence of an associated non-erupted tooth and expansion of the mandible's lower border cortical bone. The CT scan analysis showed the same characteristics. In addition, this technique was more accurate than PR in the assessment of the lesion shape (multi or unilocular), the presence of inner bone septa, the presence of root resorption, in delimiting the margins of the lesion, and in the buccolingual expansion and the rupture of cortical bone.

Eight cases of ameloblastoma presented ballooning expansion of the cortical bone (Figure 1), four cases showed expansion of the lower cortical jawbone and six out of the nine cases presented disruption of the cortical bone. Six cases showed expansion of the cortical bone, both buccal and lingual, showing a characteristic pattern. Two cases showed obvious cortical bone expansion on only one side (buccal or lingual) associated with cortical bone resorption. In Case 1, the lesion located in the posterior area of the mandible presented lingual cortical expansion, while in Case 6, the lesion located in the right mandibular body showed expansion of buccal cortical bone. At the same time, Case 9 showed no evidence of cortical bone expansion, while CT showed disruption of the lingual cortical bone.

Seven out of nine OKC cases showed cortical bone expansion, six of them presented disruption of cortical bone and no case showed expansion of the lower cortical jawbone. Three cases showed the ballooning pattern of buccolingual expansion (Figure 2), while four cases showed the fusiform pattern of buccolingual expansion (Figure 3). Three cases showed expansion of only one of the cortical bones (buccal or lingual); when located in the anterior and mandibular body (cases 11 and 17) the expansion occurred in cortical buccal bone; and in the case located in the posterior part of the mandible (Case 14) the expansion occurred in the cortical lingual bone. Only two cases showed no expansion of cortical bone.

Six of nine cases of ameloblastoma presented root resorption, whereas only one of the OKC cases displayed this feature.

Four cases of ameloblastoma and OKC were associated with the presence of unerupted teeth. All teeth associated with cases of ameloblastoma were molars: 3 third molars and 1 second molar. In OKC cases, two cases were associated with the third molar, one case with

Table 1 Summary of the main features of ameloblastoma and odontogenic keratocystic

										Cortical bone expansion		
Case	*Year (gender)*	*HD*	*Location*	*Shape*	*Septae*	*Degree of marginal definition*	*Cortication or sclerosis of the periphery*	*Root resorption*	*Unerupted tooth?*	*Buccolingual (shape)*	*Lower border of the mandible displaced*	*Cortical bone resorption*
1	27 (M)	Amelo	Mandible	Unilocular	Yes	Well-defined	No	No	Yes	Yes (balloon)	No	Yes
2	13 (F)	Amelo	Mandible	Multilocular	Yes	Well-defined	Yes	Yes	Yes	Yes (balloon)	Yes	No
3	31 (M)	Amelo	Mandible	Unilocular	Yes	Well-defined	Yes	Yes	Yes	Yes (balloon)	Yes	No
4	31 (F)	Amelo	Mandible	Unilocular	Yes	Well-defined	Yes	Yes	No	Yes (balloon)	Yes	Yes
5	26 (M)	Amelo	Mandible	Unilocular	Yes	Well-defined	Yes	Yes	Yes	Yes (balloon)	Yes	No
6	37 (F)	Amelo	Mandible	Unilocular	No	Well-defined	No	[a]	No	Yes (balloon)	No	Yes
7	43 (F)	Amelo	Mandible	Unilocular	No	Poorly-defined	No	Yes	No	Yes (balloon)	No	Yes
8	27 (M)	Amelo	Mandible	Unilocular	Yes	Well-defined	Yes	Yes	No	Yes (balloon)	No	Yes
9	51 (F)	Amelo	Mandible	Multilocular	Yes	Well-defined	No	No	No	No (–)	No	Yes
10	80 (M)	OKC	Mandible	Multilocular	Yes	Well-defined	Yes	[a]	No	No (–)	No	Yes
11	52 (F)	OKC	Mandible	Unilocular	No	Well-defined	No	No	No	Yyes (balloon)	No	Yes
12	52 (F)	OKC	Mandible	Multilocular	Yes	Well-defined	Yes	Yes	No	Yes (balloon)	No	Yes
13	30 (F)	OKC	Mandible	Unilocular	No	Well-defined	Yes	No	Yes	Yes (fusiform)	No	No
14	36 (F)	OKC	Mandible	Unilocular	No	Well-defined	Yes	No	Yes	Yes (balloon)	No	Yes
15	27 (M)	OKC	Mandible	Unilocular	No	Well-defined	Yes	No	No	Yes (fusiform)	No	Yes
16	13 (M)	OKC	Mandible	Unilocular	No	Well-defined	No	No	Yes	Yes (fusiform)	No	No
17	8 (M)	OKC	Mandible	Unilocular	Yes	Well-defined	No	No	Yes	Yes (fusiform)	No	Yes
18	12 (F)	OKC	Mandible	Unilocular	No	Well-defined	No	No	No	No (–)	No	No

Amelo, ameloblastoma; F, female; HD, histopathological diagnosis; OKC, odontogenic keratocystic; M, male.
[a]Tooth absence.

Figure 1 Ameloblastoma. (A) PR showing displacement of mandibular low border. (B) CT image displaying tongue-shape crest (arrow) and ballooning expansion associated with resorption of cortical bones.

the canine and another one with the lateral incisor and canine.

In most cases, the lesion's edges had well-defined margins, with the exception of Case 7 (ameloblastoma), which had ill-defined margins. All cases produced a radiolucent image, except for case seven, which produced a radiolucent image with radiopaque points. The presence of bone septa was demonstrated in seven of the nine cases of ameloblastoma and three of the nine cases of OKC. The unilocular pattern was the most common feature for ameloblastoma and OKC. The cases considered multilocular had independent locus within the lesion, while the cases considered unilocular had a single lesion with or without bone septa. Such assessment was only possible with the help of the CT scan, and only two out of nine cases of ameloblastoma and OKC had the multilocular pattern.

Discussion

The OKC and ameloblastoma analyzed in this study were similar to most cases presented in the literature regarding the mean age of patients and the tumour location.[2,35] However, the cases of OKC showed no predilection for gender, while the literature indicates a predilection for males.[2,15]

In the evaluated cases, the features related to buccolingual expansion, disruption of cortical bone, presence of septa within the lesion and classification as uni- or multilocular, were confirmed only after evaluation of CT images. Being only 2D, the PR images do not allow this more detailed analysis.

Most cases of ameloblastoma and OKC in the current sample presented buccolingual expansion of cortical bone. However, the pattern of bone growth differed between the two groups. Eight ameloblastomas showed a ballooning pattern of buccolingual expansion, while only three OKC showed this feature. In addition, four of nine OKC showed fusiform expansion. These characteristics are consistent with the results of MacDonald-Jankowski,[32] MacDonald-Jankowski and Li,[36] Min et al[37] and Ariji et al[38] differing from the WHO[2] report that considered expansion of cortical bone to be unusual features of OKC. Disruption of cortical bone occurred in 67% of ameloblastomas and in 67% of OKCs in the current study. These results are consistent with Min et al[37] who identified this trait in 60.1% of OKC in their sample (n = 198). The currently available literature underestimates the prevalence of these characteristics (expansion and disruption of cortical bone), especially in OKC. And, while these characteristic are present in many cases reported in the literature, they have been little explored.[15,39–41] The more frequent use of CT in odontogenic cysts and tumours will allow the analysis of these aspects in more detail.

In this study, the expansion of the lower mandible cortical bone was observed in four ameloblastomas and

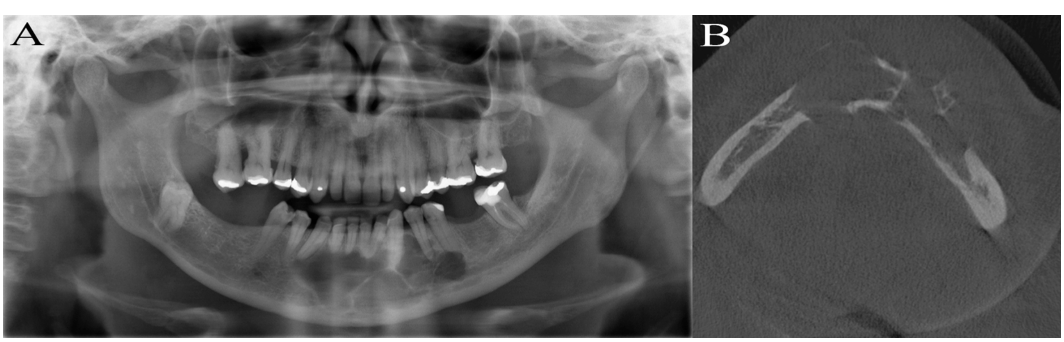

Figure 2 OKC. (A) PR illustrating the presence of septa within the tumour. (B) Buccolingual expansion associated with resorption and perforation of cortical bones in CT images. PR, panoramic radiography.

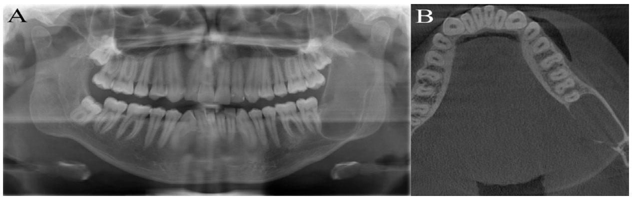

Figure 3 KCO. (A) PR showing a well-demarcated unilocular image. (B) CT allows the observation of buccolingual expansion and rupture of lingual cortical bone. PR, panoramic radiography.

no OKCs. Unlike in the current study, MacDonald-Jankowski[34] reported that this feature is ignored in most studies, but identified this feature in 71% of the OKCs.

The presence of root resorption was identified in six ameloblastomas, while only one case of OKC showed this characteristic. These data are consistent with the literature.[2,35,42,43] Although Ariji et al[38] did not observe statistically significant differences in the occurrence of this feature that would allow radiographic differentiation between these two lesions, the use of CT allowed us to analyze more accurately all faces and roots of the involved teeth, especially the upper molars, which have three roots and are commonly overlapping in 2D images.

In our sample, 78% of OKCs were classified as unilocular, corroborating the analysis of MacDonald-Jankowski[33] (73%), Shudou et al.[44] (66%), and Sanchez-Burgos et al.[45] (71%). As regards the ameloblastomas, 78% were classified as unilocular. These data differ from studies performed by Filizzola[42] More et al[43] and MacDonald-Jankowski and Li.[36] On the other hand, Ledesma-Montes[46] reported similar results. The presence of bone septa within the lesion does not necessarily mean that this corresponds to a multilocular pattern. An evaluation with the use of CT allows a detailed analysis of the internal structure of the lesion and helps to assess whether the septa is delimiting regardless of bone stores or if it shows only septation of a unilocular lesion. In four ameloblastoma of this sample, the ridges were identified in a tongue-shaped crest as described by Luo et al.[47] However, we disagree with these authors in their classification of this pattern of ameloblastoma as multilocular, because it represents the septation of a unilocular lesion. We also noticed that no OKC presented this internal structure of the lesion, which could thus be a way to radiographically differentiate the two lesions.

The accuracy of the interpretation of images of ameloblastoma and OKC may be critical to the decision of whether to take a more conservative approach or not.[48] Thus, professionals who manage patients with this type of tumour must be familiar with its imaging features. Conventional radiography remains the first choice in the initial evaluation of tumours of the gnathic bones, while CT can clearly show the borders of the tumour, which is helpful when choosing the best place to perform a biopsy, and enables accurate measurements for surgical planning, postoperative follow-up and evaluation of possible recurrences.[48–50] Cone beam CT is optimal for benign lesions, such as ameloblastoma and OKC, due to better spatial resolution, availability, and lower financial and radiation dose cost.[51]

In conclusion, our study shows subtle differences between ameloblastoma and OKC images. Although PR is a very useful method for evaluation of ameloblastoma and OKC, CT can more clearly show the presence or absence of buccolingual expansion, calcification, bone septa, perforation of cortical bones and tooth resorption, features that are commonly underdescribed in the literature, particularly in OKC. Further studies assessing large samples are advisable to allow better diagnosis of these jaw lesions.

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