RESEARCH ARTICLE

Characteristic features of the adenomatoid odontogenic tumour on cone beam CT

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Objectives: To illustrate characteristic features of adenomatoid odontogenic tumour (AOT) on CBCT.

Methods: The archived CBCT and panoramic radiographs of eight patients histopathologically diagnosed as AOT were analysed. The radiographic features displayed on both radiographic images were carefully described and compared.

Results: All eight AOT cases presented as unilocular and well-demarcated lesions on both CBCT and panoramic images. CBCT images displayed three-dimensional interpretation of AOT lesions, especially the detailed intralesional radiopacities. Numerous discrete radiopaque foci scattered in the lesion with evident contrast to the radiolucent background could be considered as one of the characteristic features of AOT on CBCT.

Conclusions: Compared with panoramic radiography, CBCT seems to possess better potential in diagnosing AOT.

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Introduction

Adenomatoid odontogenic tumour (AOT) was generally considered as an uncommon disease that occurred in the maxillofacial region, accounting for 2.2–7.1% of all odontogenic tumours in various literature.^{1–3} It was reported that the lesion was more likely to occur in the maxilla in 64.3% of cases, and the involvement of a canine tooth was commonly found in around 60.1% of cases. According to its location and tooth association, AOT can be further classified into three categories of follicular, extrafollicular and peripheral AOTs. Approximately 70% of AOTs were identified as follicular, which characteristically presented as a well-defined, unilocular radiolucent lesion associated with an impacted permanent or supernumerary tooth on the radiographic images.^{4–6} Therefore, the radiographic differential diagnosis of AOT,

especially the pre-dominant follicular type, from other cystic lesions associated with teeth, such as dentigerous cyst, unicystic ameloblastoma, keratocystic odontogenic tumour or calcifying cystic odontogenic tumour (CCOT), might be difficult.⁷

The intralesional radiopaque calcification was considered as one of the distinct features of AOT, which can assist its differential diagnosis from other bone cystic lesions. However, the frequency of AOT cases observed with radiopacities varied among different studies. Philipsen and Reichart² found that approximately two-thirds of AOTs had radiopaque foci inside. Arotiba et al⁸ proposed that 7.1% of cases were observed with radiopaque calcifications inside the lesion. Mohamed et al,⁹ however, reported none of their 33 cases had intralesional calcification. The radiographic modality used to acquire the image was speculated to have an effect on the perception of radiopacities, particularly

Figure 1 Case 1 with numerous calcified foci scattered around the tooth. The lesion embeds the entire associated tooth, and the adjacent teeth are displaced. The radiographic features showed on CBCT (a) and panoramic radiographs (b) are consistent. The calcifications around the associated tooth are obviously displayed on CBCT (a).

for the cases with minimal intralesional calcifications. Therefore, the capability of radiographic modality in detecting the intralesional calcifications was critical for the diagnosis of AOT.^{5,10}

CBCT has been increasingly utilized in the fields of oral maxillofacial surgery, implantology, orthodontics and endodontics. CBCT is advantageous in displaying the extent, border, surrounding structures and detailed intralesion content (*i.e.* calcifications) of lesions in a three-dimensional way, particularly when the lesion is overlapped by adjacent bony structures on plain radiographs.¹¹

However, the application of CBCT in the diagnosis of AOT has never been specifically evaluated. The purpose of this study was to illustrate the characteristic features of AOT presented on CBCT radiographs, which may provide great value for its differential diagnosis.

Methods and materials

Cases analysed in this study were retrospectively screened from the patient database of the Department of Oral Pathology in West China Hospital of Stomatology (Chengdu, China) from 2010–13. The selected cases were all histopathologically diagnosed as AOT with both panoramic and CBCT radiographic records archived in the Department of Oral Radiology, West China Hospital of Stomatology. Age, gender and general clinical features, including lesion location, associated impacted tooth, lesion expansion and disease duration of all subjects were analysed. The lesion location was defined by the anterior and posterior margins of the lesion marked by its corresponding tooth.

The panoramic radiographs were performed with Orthoceph[®] OC200D (Instrumentarium Dental, Tuusula,

Figure 2 Case 2 with different radiopaque patterns on CBCT and panoramic images. CBCT images (a–c) display numerous radiopacities scattered around the associated canine, while only a few thin radiopaque lines are perceived on panoramic image (d).

Figure 3 Case 3 with irregular lesion heavily intruded into maxillary sinus. Lateral incisor is directly associated and canine is adjacent to the lesion. Plenty of calcified spots are found scattered mainly in the periphery region in all three views of CBCT (a–c). The characteristic feature of calcifications is well displayed on CBCT. The features shown on the panoramic image are relatively obscure (d).

Finland) at 60 kV, 8.0 mA. We followed the advisory statement from the American Dental Association Council on Scientific Affairs to use CBCT only when the diagnostic yield will benefit patient care, enhance patient safety or improve clinical outcomes significantly.¹² All the CBCT images were performed with 3D Accuitomo (J Morita Mfg. Corp., Kyoto, Japan)

in its standard mode. Since the majority of subjects in this study were young patients who might be more sensitive to radiation, the radiation dose (75–78 kV; 2–3 mA) was optimized properly, and radiation protection was performed regularly.

All radiographs were studied on the same liquid-crystal display monitor by three senior radiologists individually,

Figure 4 Case 4 with dissimilar radiographic features on CBCT and panoramic radiographs. The radiopacities are mainly scattered at the periphery region shown on the CBCT images (a–c). The associated pre-molar is completely enclosed in the lesion (c). However, only a few calcification spots can be perceived on the panoramic radiograph, and the relationship between the lesion and the pre-molar root is not clearly displayed (d).

Figure 5 Case 5 with the adjacent teeth root resorbed. On CBCT images, numerous calcified deposits distribute around the impacted incisor, which is totally emerged in the lesion (a–c). Although the calcifications are minimal and thin, CBCT can still show the characteristic feature. However, the calcification features are barely shown in the panoramic radiography, and the apex of the root is not clearly displayed (d).

without the case details provided. The following radiographic features were evaluated and compared between the panoramic and CBCT images: detailed intralesional content, pattern of radiopacities, border of the lesion, displacement of adjacent tooth, root resorption and the relationship between the lesion and the associated impacted tooth. More specifically, the border of the lesion was identified as well defined or

partly diffused. As for the pattern of intralesional radiopacities, a four-level system was proposed: + + +, numerous discrete radiopaque foci scattered in the lesion, with evident contrast to the radiolucent background; + +, a few discrete radiopaque spots; +, several vague or thin radiopaque lines; –, no radiopacity perceived. Displacement and root resorption of the adjacent tooth were recorded as presence or absence.

Figure 6 Case 6 with numerous calcifications. On CBCT images, numerous calcified foci are scattered in the circular lesion with the permanent canine unruptured (a–c). The panoramic radiography, however, only shows a few thin radiopacities in the radiolucent lesion (d).

Figure 7 Case 7 with huge lesions occurring in the mandible. CBCT images show the lesion expand heavily to the buccal and lingual side of the mandible (a–c), which cannot be observed in the two-dimensional panoramic radiograph (d). The scattered calcifications are clearly shown on CBCT images (a–c). The calcified foci at the bottom of the lesion, however, are found to fuse together and transform into a calcified mass, which may be related to the more than 10 years disease duration.

Results

Clinical features

Eight cases histopathologically diagnosed as AOT were carefully analysed. The mean age of the patients was 17 years and ranged from 12 to 26 years. The female to

male ratio was 7:1. Lesions of six cases (Cases 1–6) occurred in the maxillary region (Figures 1–6), whereas in the other two cases (Cases 7 and 8), they were found in the mandible (Figures 7 and 8). As for the tooth associated with the lesions, four cases (Cases 1, 2, 5 and 6) were associated with the canine (Figures 1, 2, 5 and 6)

Figure 8 Case 8 with different radiographic features on CBCT and panoramic images. The lesion (white arrows) is not clearly displayed in the panoramic radiograph (d). On CBCT images (a–c), however, the buccal expanded lesion and the intralesional calcifications (black arrows) are optimally displayed.

and another three cases were associated with the lateral incisor (Case 3) (Figure 3), pre-molar (Case 4) (Figure 4) and central incisor (Case 7) (Figure 7). There was no associated impacted tooth observed in Case 8 (Figure 8). The recorded duration of disease recognized by patients ranged from 1 month to 10 years. The expansion of lesion was physically examined in all cases. The disease duration of Case 7 was more than 10 years, which was the only one that presented a huge lesion crossing the midline in the series. Table 1 shows the clinical features of each patient.

Radiographic findings

As shown in Table 2, the patterns of intralesional calcifications were inconsistent between panoramic radiographs and CBCT images for some cases. On CBCT images, all cases were evaluated as level +++, that is, numerous discrete radiopaque foci were perceived in the lesions with a good contrasting background. However, the radiopacity patterns observed on the panoramic radiographs were different among the eight cases, with numerous scattered radiopacities in Cases 1, 3 and 7 (level +++) (Figures 1, 7 and 8), a few discrete calcified spots in Cases 4–6 (level ++) (Figures 4–6), several thin radiopaque lines found gathered only at the root side of the impacted tooth in Case 2 (level +) (Figure 2) and no calcification perceived in Case 8 (level –) (Figure 8). CBCT images further provided detailed distribution of intralesional radiopacities and their relationship with the impacted tooth. In Cases 1, 2 and 5–7, the calcified foci were mainly distributed around the crown and root of the associated impacted tooth, with a constant radiolucent area delineated in the periphery region. In Cases 3 and 4, the discrete radiopacities, which were mainly found at the periphery region of the radiolucency, showed no special relationship with the associated tooth. The discrete radiopacities of Case 8, which were hardly found on the panoramic radiograph, were visually perceived on CBCT images.

Other radiographic features on both panoramic and CBCT images are shown in Table 3. In detail, six cases (Cases 1–6) were observed as a unilocular and well-demarcated lesion, which extruded into the maxillary sinus at the involved side. Among them, five cases (Cases 1, 2 and 4–6) presented as a teardrop shape with the associated tooth apex as the tip on the panoramic images.

On CBCT images of these five cases, the affected maxillary sinuses were occupied by tumour lesions with less than one-third of the total sinus volume. In Case 3, however, the tumour shape was irregular and the left maxillary sinus was tremendously compressed, in which more than two-thirds of the original volume was occupied by the intruded mass.

In seven cases (Cases 1–7), one impacted tooth was observed directly associated and spatially related to the lesion. Case 3 has one more permanent tooth, the left canine, involved and spatially adjacent to the lesion. On the panoramic radiographs, a radiolucent lesion enclosing the entire impacted tooth was clearly perceived in Cases 1–3 and 6. By contrast, the relationship of the lesion and the impacted tooth root failed to be clearly displayed on the panoramic radiographs, and it seemed only part of the tooth root was enclosed in the radiolucent lesion for Cases 4 and 5. The CBCT images of these two cases, however, precisely displayed the impacted tooth that was totally submerged within the lesion. In Cases 1–4, the adjacent teeth were displaced by the lesion where no root resorption occurred. In comparison, the adjacent teeth in Cases 5–7 were not displaced but heavily absorbed at the root side. In Case 8, however, no impacted tooth was observed in the lesion.

Histopathological findings

The typical configuration observed in our AOT cases was the duct-like spaces in the lesion tissue (Figure 9a,b). Intralesional calcifications, which presented as eosinophilic amorphous materials, were also detected among the epithelial cells or in the centre of the rosette-like structures in all eight cases. The amount of those calcific deposits varied from small foci to extensive calcification areas (Figure 9c,d).

Discussion

In this study, we analysed the clinical and radiographic features of eight AOT cases. We mainly emphasized the great diagnostic value of CBCT in presenting the characteristic features of AOT by studying and comparing the radiographic performances of CBCT and conventional panoramic images. In agreement with previous studies, the majority of cases (6/8) in our study occurred in the

Table 1 Clinical features of each case

Case number	Age (years)	Sex	Location ^a	Impacted tooth ^a	Expansion	Duration (months)
1	12	F	Maxilla (12–15)	13	Y	2
2	13	M	Maxilla (11–15)	13	Y	1
3	15	F	Maxilla (21–26)	22	Y	4
4	14	F	Maxilla (13–16)	14	Y	2
5	21	F	Maxilla (21–25)	23	Y	3
6	15	F	Maxilla (22–25)	23	Y	4
7	26	F	Mandible (34–44)	41	Y	120+
8	20	F	Mandible (33)	None	Y	3

F, female; M, male; Y, yes.

^aIndividual teeth are identified using the FDI two-digit system.

Table 2 Different radiographic features of adenomatoid odontogenic tumour on panoramic and CBCT images of each case

Case number	Radiographic techniques	Pattern of radiopacities	Associated tooth relationship
1	Pano	+++	Entire root
	CBCT	+++	Entire root
2	Pano	+	Entire root
	CBCT	+++	Entire root
3	Pano	+++	Entire root
	CBCT	+++	Entire root
4	Pano	++	Partial root
	CBCT	+++	Entire root
5	Pano	++	Partial root
	CBCT	+++	Entire root
6	Pano	++	Entire root
	CBCT	+++	Entire root
7	Pano	+++	Entire root
	CBCT	+++	Entire root
8	Pano	–	Not sure
	CBCT	+	None

+, several vague or thin radiopaque lines; ++, a few discrete radiopaque spots; +++, numerous discrete radiopaque foci scattered in the lesion, with good contrast to the radiolucent background; –, no radiopacity perceived; Pano, panoramic radiography.

anterior region of the maxilla, with part of the pre-molar or molar region being involved.⁵ The tumours of the other two cases occurred in the anterior mandibular region, which were not commonly found in previous studies.

The radiological differential diagnosis of AOT from a variety of odontogenic lesions is of great clinical importance. However, distinguishing AOT from dentigerous cysts is extraordinarily difficult especially when the AOT lesion is follicular and perceived as completely radiolucent. Intralesional calcification with characteristic pattern was proposed as a distinctive radiographic feature of AOT. Therefore, the capability to recognize the characteristic calcification on radiographs even in small amounts is highly meaningful for diagnosis. However, the frequency of characteristic radiopacities perceived on radiographic images varied among different AOT studies. Based on the study of hundreds of AOT cases, Philipsen *et al*^{1,2} reported approximately two-thirds of the intrabony AOTs possessed scattered radiopacities in the radiolucent lesions. By contrast, the frequency of radiopacities in some other studies was very low.^{8,9} Arotiba *et al*⁸ reported that only 2 of 56 intra-osseous AOTs displayed intralesional calcifications, while

Mohamed *et al*⁹ reported that none of 33 cases had radiopaque foci observed inside.

The perception of patterned calcifications on radiographs was mainly affected by the amount of calcifications and the radiographic technique adopted. The correlation between radiology and histology of AOT had been analysed in previous studies. The results indicated a positive correlation between the extent of calcifications evaluated histologically and the degree of radiopacities on radiographs.⁸ In many of the other AOT case studies, however, the radiographic technique and parameters had not been reported, which made the evaluation and comparison difficult. The principles of panoramic technique led to many limitations of the generated images, including superimposition, distortion of structures and the suboptimal imaging of structures out of the focal layer.^{13–15} The accuracy of maxillary anterior and pre-molar region on the panoramic images was poor because of the relatively severe superimposition in this area with complex anatomy.¹⁶ Therefore, the perception of calcified deposits could be difficult when the lesion was located at maxillary anterior and pre-molar areas. Earlier studies reported AOTs were twice as frequently found in the maxilla than in the mandible, and the canine and pre-molar regions were the most common locations.^{2,4} Six of our AOT cases were located at the maxillary anterior and pre-molar region. These areas with more severe superimposition could be partially responsible for the inaccurate evaluation of the degree of intralesional calcifications on the panoramic radiographs. The calcifications within the lesion of Case 8 were too small to observe on the panoramic radiograph. On the CBCT images, however, the thin and minimal calcifications could be clearly shown.

As an advanced imaging modality, CBCT has been widely applied to different fields of dentistry and oral maxillofacial surgery.¹⁷ The main advantage of CBCT radiography is the multiplanar cross-sectional images in various orientations and three-dimensional reconstructions based on a single scan of fields of view of interest, varying from a single tooth to the whole maxillofacial area. CBCT imaging is superior to panoramic radiography with regard to elimination of superimposition and excellent contrast resolution for mineralized tissue such as teeth, bones and calcified spots. Therefore, CBCT is advantageous in terms of demonstrating the detailed internal structures of lesions (*e.g.* radiopaque calcified deposits), particularly when the calcifications are minimal or the superimposition is serious in the maxillary region. Moreover, CBCT provides better display of the extent and complex spatial relationship of the lesions with the surrounding structures. In the study of Chindasombatjaroen *et al*,⁶ only two of eight AOT patients had CBCT images, and these two images illustrated numerous radiopaque foci dispersed in the lesions. The author indicated that CBCT was advantageous with regard to the perception of intralesional calcifications. The frequency of lesions with radiopaque foci might be higher if CBCT radiography was applied in all cases.

Table 3 Radiographic features of all cases on both panoramic and CBCT images

Case number	Well-defined border	Midline crossing	Adjacent teeth displacement	Root resorption
1	Y	N	Y	N
2	Y	N	Y	N
3	Y	N	Y	N
4	Y	N	Y	N
5	Y	N	N	Y
6	Y	N	N	Y
7	Y	Y	Y	Y
8	Y	N	N	N

N, no; Y, yes.

Figure 9 Similar histopathological findings in all cases. (a) Duct-like appearance of adenomatoid odontogenic tumours and minimal calcifications in the duct-like spaces; (b) characteristic rosette-like structures; while (c) and (d) demonstrate extensive calcifications in the lesion.

Previous studies of other odontogenic tumours with internal calcifications, CCOTs, for example, also showed that CBCT could better demonstrate the minimal calcification than plain radiographs by avoiding the superimposition of surrounding structures.¹⁸ The pattern of calcified deposits of CCOT was more likely a bigger mass calcification at the bottom or to one side of the lesion. The scattered calcified foci around the crown and neck of the associated impacted tooth as well as the constant radiolucent band that might be the fibrous capsule delineating the tumour were considered as distinctive radiographic features of AOT different from CCOT.⁶ In our eight AOT cases, however, CBCT images showed numerous

calcifications either scattered around the impacted teeth with a constant radiolucent region in the periphery of the lesions, or inversely clustered at the periphery region of the lesions. This discrepancy may need further studies with larger sample size for better clarification.

In conclusion, CBCT clearly displays AOT lesions in three-dimensional perspectives. Furthermore, the distinctive internal calcification features, shape of tumours, detailed relationship between surrounding structures and associated impacted tooth are well displayed on CBCT. The distribution pattern of the radiopaque calcified deposits shown on CBCT images is critical for the radiographic diagnosis of AOT.

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