



Evaluation of Incidental Findings on Cone Beam Computed Tomography

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Abstract

Objective: To assess the prevalence of incidental findings in relation to the side of a patient's face, location, and age group on cone beam computed tomography. **Material and Methods:** 175 CBCT examinations were performed on patients aged between 12 and 77 years, consisting of recordings of the anatomical location and findings following each examination. For standardization of tomographic evaluations, acquired images were analyzed by two previously trained expert radiologists. After positional adjustment of the multi-dimensional images on the monitor screen, examination of each scan was conducted simultaneously on the coronal, axial, and sagittal planes. Fisher's exact tests and Chi-square tests were used to compare the frequencies of incidental findings using a significance level of 0.05. **Results:** The most frequent incidental finding was maxillary sinus mucosal thickening, which occurred on the right and left side in 46.3% and 46.9% of the patients, respectively. The second most frequent incidental finding was flattening of the mandibular condyle, occurring on the right and left side in 29.7% and 24% of the patients, respectively. No significant difference was observed among the individual age groups. The number of incidental findings per patient varied from 0 to 5 on the right side and left side and from 0 to 12 in total. The Kendall correlation coefficient for the number of incidental findings between the sides was 0.25 ($p < 0.0001$), indicating a weak but significant and positive association between the sides in relation to the number of incidental findings. The mean total number of incidental findings was 4.07. **Conclusion:** The prevalence of the individual incidental findings and the total number of findings were not statistically different. However, some alterations were more likely to be observed bilaterally.

Keywords: Diagnostic Imaging; Cone-Beam Computed Tomography; Stomatognathic System.

Introduction

An “incidental finding” is a term applied in radiology to describe the unexpected discovery of a hidden entity during an imaging test. These findings are typically unrelated to the indication for the test [1].

Cone beam computed tomography (CBCT) is a method used for the diagnostic imaging of the craniofacial region. The examination provides high contrast images of maxillofacial bone anatomy and teeth. It is widely used in all areas of odontology, for dentomaxillofacial diagnosis and surgical planning. It also enables the viewing of structures in three dimensions, allowing the dental surgeon access to images that were not possible with older two-dimensional X-rays. However, a lack of understanding of CBCT can result in misinterpretation, particularly due to the inability to recognize specific structures and pathological conditions.

A study involving nearly 1000 CT scans of children with a blunt trauma reported that 4% of children had incidental findings unrelated to their injury following a CT scan [2]. Of these, 4% required immediate attention (tumors), 26% required monitoring (mostly sinus conditions), and the remaining 70% had little clinical importance. With the increasing use of CBCT in odontology and the considerable improvements in the images, an increase in incidental findings from CBCT examinations is expected [3].

Incidental findings are relatively frequent in CBCT images. They vary considerably in nature and frequency, and most apply to areas outside of the dental region and the alveoli. The need to watch for incidental findings increases a radiologist's responsibility with respect to the imaging and interpretation of an entire set of volumetric data. Moreover, even though radiologists may have a specific area of specialization, they are still responsible for evaluating the entirety of the data [4].

Incidental findings can alter the treatment plan. In many situations dental treatment must be postponed because the patient needs to be referred to a specialist for evaluation or monitoring of the finding before continuing treatment. Atheromas, for example, may be indicators of stroke or metabolic potential for disease [5].

Therefore, CBCT can contribute to the development of guidelines on the use and interpretation of the images obtained in odontology. Incidental findings increase the amount of information available for diagnosis and may help to direct the planning and proactive realization of patient care.

In this context, the current study examined the prevalence of incidental findings detected on CBCT examinations and related this prevalence to whether each finding was on the right or left side of the face, its location, and the age group and sex of the patient.

Material and Methods

Study Design

This research is classified as a cross-sectional and observational study. Were selected exams from 175 patients who were referred for CBCT for treatment planning or maxillofacial diagnosis. The patients' ages ranged from 12 to 77 years, with an equal distribution of sexes.

Data Collection

The computed tomographic (CT) scans were acquired using an i-CAT™ brand volumetric acquisition apparatus with a conical beam (Imaging Sciences International, Hatfield, PA, USA). The scans were examined by a single evaluator who is a specialist in oral radiology, using a 17" flat-screen LCD monitor, model 5000:1 (LG, Seoul, Korea), with 1280 x 1024 pixels resolution and maximum color quality (12 bits).

To evaluate the incidental findings, a pilot study was conducted using 10% of the CBCT images for software recognition, along with tools for expansion and measurement. Furthermore, in this initial phase, a datasheet for data collection was developed. We evaluated 175 CT scans (n=175), examining each region listed in Table 1 for each of the potential findings listed. For standardization of tomographic evaluations, acquired images were analyzed by two previously trained expert radiologists using an intraclass correlation coefficient (ICC) test. Results revealed that intraexaminer reproducibility was excellent both for linear measurements (ICC>0.9; p<0.0001) and nominal measurements (Kappa = 1.0) obtained at two different time points.

Table 1. Evaluation of the incidental findings according to specific locations.

Location		Incidental Findings
Maxillary Sinuses		Mucus Retention Phenomenon
		Sinus Opacification
		Mucosal Thickening
		Antrolith
Nasal Cavity		Deviated Septum
		Turbinate Hypertrophy
		Rhinolith
TMJ		Flattening
		Osteophyte
		Erosion
		Subchondral Sclerosis
		Subchondral Pseudocyst
Salivary Gland		Bifid Mandibular Condyle
	Parotid	Sialolith
	Submandibular	Sialolith
	Sublingual	Sialolith
Region Cervical	Styloid Process	Elongation
	Styloid Process	Ossification
	Carotid Artery	Atheroma
	Palatine Tonsil	Tonsillolith
	Lymph Node	Calcification

After positional adjustment of the multi-dimensional images on the monitor screen, examination of each scan was conducted simultaneously on the coronal, axial, and sagittal planes (Figures 1 and 2).

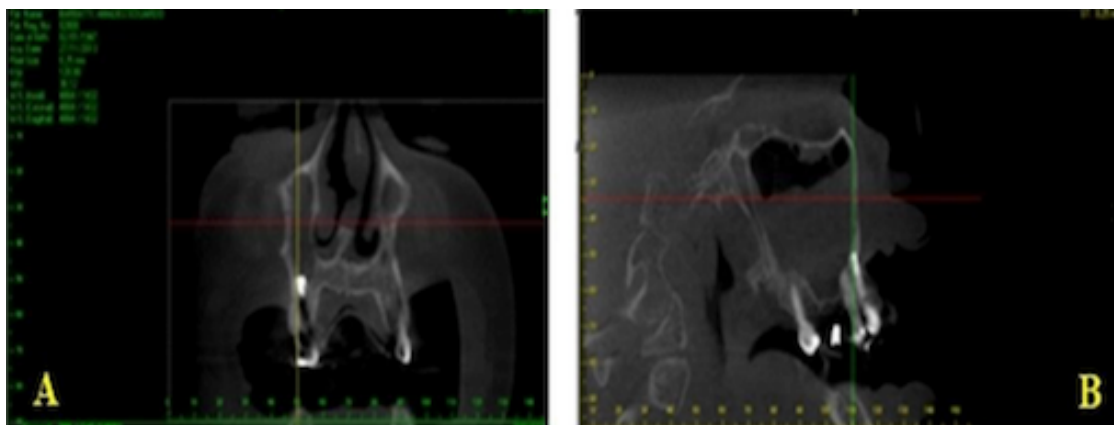


Figure 1. Multi-dimensional reconstructed images, showing findings of A) nasal septum deviation; B) opacification of the maxillary sinus.

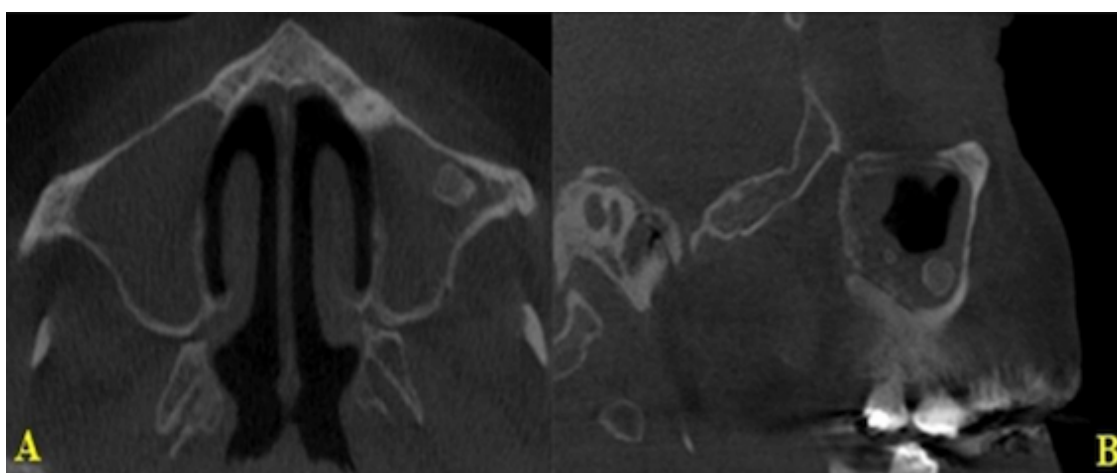


Figure 2. Axial (A) and sagittal (B) images, showing opacification of the right and left maxillary sinus and the presence of an antrolith.

Data Analysis

The data were presented as absolute and relative frequencies. Fisher's exact test and the Chi-square test were used to compare the incidental findings with respect to the side of the face, location, and age, using a significance level of 5%. The Kendall correlation coefficient for the number of incidental findings between the sides ($p < 0.0001$) was evaluated. The Odds Ratios were also calculated. All analyses were conducted using R software, version 3.2.2 (www.r-project.org).

Ethical Aspects

This study protocol was submitted to and approved by the Committee for Research Ethics of an institution of higher education in accordance with regulation number 559,660.

Results

The most prevalent incidental finding was thickening of the mucosa of the maxillary sinuses on the right and left side in 43.9% and 46.9% of the patients, respectively. The second most common finding was the flattening of the condylar head, occurring on the right side in 29.7% of the patients and on the left in 24%.

Table 2 shows the odds ratios obtained by measuring the fractional change in probability of an incidental finding on one side of the face given that the same finding was observed on the opposite side. For example, for the incidental finding of opacification of the maxillary sinus, the OR (1.72 [95% CI, 1.55-1.91]) was 58. This means that, for a given patient, if sinusitis is observed on one side, there is a 58 times greater probability that it will be observed on the opposite side. The p-value shown in Table 2 tests whether the OR is statistically different from 1. The last column of Table 2 shows the correlation coefficient, which measures the ratio of the number of patients who present a given incidental finding on both sides and the number of patients who present the same finding on at least one side.

Table 2. Absolute frequency and relative frequency of each of the incidental findings according to side, odds ratio (OR), p-value and correlation coefficient (CC).

Location	Incidental Findings	Right Side		Left Side		OR*	p-value**	CC***
		N	%	N	%			
Maxillary Sinuses	Mucus Retention Phenomenon	26	14.9	19	10.9	7.2	0.0003	25.0
	Opacification	12	6.9	13	7.4	58.0	<0.0001	47.1
	Mucosal Thickening	81	46.3	82	46.9	10.4	<0.0001	59.8
	Antrolith	4	2.3	3	1.7	25.8	0.0674	16.7
Nasal Cavity	Deviated Septum	43	24.6	32	18.3	0.1	0.0011	1.4
	Turbinate Hypertrophy	39	22.3	43	24.6	0.6	0.3985	9.3
	Rhinolith	0	0.0	0	0.0	-	-	-
TMJ	Flattening	52	29.7	42	24.0	3.3	0.0017	28.8
	Osteophyte	22	12.6	22	12.6	4.2	0.0094	18.9
	Erosion	13	7.4	16	9.1	8.4	0.0028	20.8
	Subchondral Sclerosis	6	3.4	12	6.9	37.6	0.0002	28.6
	Subchondral Pseudocyst	1	0.6	4	2.3	-	0.0229	25.0
	Bifid Mandibular Condyle	1	0.6	0	0.0	-	-	0.0
Salivary Gland	Parotid / Sialolith	0	0.0	0	0.0	-	-	-
	Submandibular / Sialolith	1	0.6	1	0.6	-	-	0.0
	Sublingual / Sialolith	1	0.6	0	0.0	-	-	0.0
Cervical Region	Styloid Process / Elongation	0	0.0	0	0.0	-	-	-
	Styloid Process / Ossification	3	1.7	4	2.3	-	1.0000	0.0
	Carotid Artery / Atheroma	4	2.3	10	5.7	5.9	0.2114	7.7
	Palatine Tonsil / Tonsillolith	21	12.0	24	13.7	27.6	<0.0001	45.2
	Lymph Node / Calcification	0	0.0	0	0.0	-	-	-

*Tests the alternative hypothesis that the OR is different from 1; **Chi-square test; ***Correlation coefficient.

Table 3 shows the frequency of each incidental finding for the right side of the face, split by age group. The age of the patients ranged from 12 to 77 years. Table 4 shows the same information, for findings on the left side of the face. Tables 3 and 4 also show the p-values resulting from Fisher's exact test, thus comparing the incidences among the different age groups. In general, no significant difference was observed among the individual age groups ($p > 0.05$).

The number of incidental findings per patient varied from 0 to 5 on the right side and left side and from 0 to 12 in total. The Kendall correlation coefficient for the number of incidental findings between the sides was 0.25 ($p < 0.0001$), indicating a weak but significant and positive association between the sides in relation to the number of incidental findings. The mean total number of incidental findings was 4.07.

Table 3. Percentage distribution of incidental findings to the right side, according to age group.

Location	Incidental Findings	Right Side – Age Group					p-value*
		Up to 29	30 to 39	40 to 49	50 to 59	≥ 60	
Maxillary Sinuses	Mucus Retention Phenomenon	18.2	16.7	17.9	13.7	11.1	0.8717
	Opacification	4.5	11.1	5.1	2.0	13.3	0.1898
	Mucosal Thickening	59.1	50.0	41.0	49.0	40.0	0.5897
Nasal Cavity	Antrolith	0.0	0.0	0.0	2.0	6.7	0.3486
	Deviated Septum	22.7	16.7	30.8	21.6	26.7	0.7983
	Turbinate Hypertrophy	27.3	33.3	17.9	15.7	26.7	0.4097
TMJ	Rhinolith	0.0	0.0	0.0	0.0	0.0	-
	Flattening	27.3	22.2	35.9	25.5	33.3	0.7642
	Osteophyte	18.2	16.7	7.7	9.8	15.6	0.6059
	Erosion	22.7	5.6	0.0	7.8	6.7	0.0299
	Sclerosis Subchondral	4.5	0.0	5.1	0.0	6.7	0.3122
	Pseudocyst Subchondral	0.0	0.0	2.6	0.0	0.0	0.4514
Salivary Gland	Bifid Mandibular Condyle	0.0	0.0	0.0	0.0	2.2	0.7086
	Parotid / Sialolith	0.0	0.0	0.0	0.0	0.0	-
	Submandibular / Sialolith	0.0	0.0	0.0	0.0	2.2	0.7086
Cervical Region	Sublingual / Sialolith	0.0	0.0	0.0	2.0	0.0	1.0000
	Styloid Process / Elongation	0.0	0.0	0.0	0.0	0.0	-
	Styloid Process / Ossification	0.0	0.0	0.0	5.9	0.0	0.2355
	Carotid Artery / Atheroma	0.0	0.0	5.1	2.0	2.2	0.8364
	Palatine Tonsil / Tonsillolith	13.6	0.0	20.5	7.8	13.3	0.1866
Lymph Node / Calcification	0.0	0.0	0.0	0.0	0.0	-	

*Fisher's exact test.

Table 4. Percentage distribution of incidental findings to the left side, according to age group.

Location	Incidental Findings	Right Side – Age Group					p-value*
		Up to 29	30 to 39	40 to 49	50 to 59	≥ 60	
Maxillary Sinuses	Mucus Retention Phenomenon	13.6	11.1	10.3	7.8	13.3	0.8923
	Opacification	9.1	11.1	7.7	3.9	8.9	0.7527
	Mucosal Thickening	50.0	44.4	43.6	43.1	53.3	0.8599
Nasal Cavity	Antrolith	0.0	0.0	0.0	5.9	0.0	0.2355
	Deviated Septum	18.2	38.9	7.7	15.7	22.2	0.0719
	Turbinate Hypertrophy	22.7	27.8	25.6	23.5	24.4	0.9929
TMJ	Rhinolith	0.0	0.0	0.0	0.0	0.0	-
	Flattening	4.5	27.8	25.6	27.5	26.7	0.1922
	Osteophyte	13.6	0.0	12.8	11.8	17.8	0.4231
	Erosion	18.2	5.6	0.0	7.8	15.6	0.0364
	Sclerosis Subchondral	4.5	5.6	10.3	5.9	6.7	0.9429
	Pseudocyst Subchondral	0.0	0.0	2.6	3.9	2.2	1.0000
Salivary Gland	Bifid Mandibular Condyle	0.0	0.0	0.0	0.0	0.0	-
	Parotid / Sialolith	0.0	0.0	0.0	0.0	0.0	-
	Submandibular / Sialolith	4.5	0.0	0.0	0.0	0.0	0.2286
Cervical Region	Sublingual / Sialolith	0.0	0.0	0.0	0.0	0.0	-
	Styloid Process / Elongation	0.0	0.0	0.0	0.0	0.0	-
	Styloid Process / Ossification	4.5	0.0	0.0	3.9	2.2	0.7487
	Carotid Artery / Atheroma	0.0	5.6	10.3	5.9	4.4	0.6248
	Palatine Tonsil / Tonsillolith	18.2	16.7	15.4	11.8	11.1	0.8772
Lymph Node / Calcification	0.0	0.0	0.0	0.0	0.0	-	

*Fisher's exact test.

Discussion

Many incidental findings are not related to the teeth or to a radiologist's area of specialization [6]. In the present study, of the 175 images that were analyzed, 99.1% presented some type of incidental finding not related to the teeth, a result that was similar to those in previous studies [4,7-10].

A comparison of the sample size of this study with that of other studies [6,11] indicates that this study provides better information about incidental findings that are relatively rare, since rare findings have a better chance of appearing in a larger sample, as in the example of antrolith. Accordingly, this study examined 19 different types of incidental findings.

Studies that evaluated examinations with orthodontic indications [12,13] showed a much lower average age than that in the present study. In our research, the average age was 49.4 years, similar to that of previous studies [14,15]. The age of the patients at the time of the examination ranged from 12 to 77 years, with the highest number of cases occurring in patients between the age of 50 and 59 years. Additionally, one study reports that most pathological findings were observed in individuals over 50 years old [16].

In this study, the most frequent incidental finding was mucosal thickening of the maxillary sinuses, occurring on the right side in 46.3% of patients and on the left side in 46.9%. Thickening of the mucosa in a maxillary sinus may be related to acute inflammation or to chronic disease resulting from infectious or immunological processes. When planning dental or orthodontic mini-implants, it is important to identify and treat the factors involved. A procedure can be performed safely only after resolution of the pathological condition [17].

The second most common finding in this study was the flattening of the mandibular condyle, occurring on the right and left side in 29.7% and 24% of the patients, respectively. This information is especially important, as it indicates remodeling of the bone to allow for the distribution pressure over a larger surface area, and thus involves other structures that must be evaluated, such as the articular eminence [8]. This high frequency may be related to the severe occlusal problems encountered in most of our patients. It is worrisome because such alterations are irreversible and can lead to pain and temporomandibular dysfunction. When the incidence was compared between the sexes, there was no significant difference, but when compared across age groups, the flattening was greatest in the 40-49 year age group and in the group of patients aged 60 years or more. Incidental findings in the temporomandibular joint region (TMJ) were also prevalent and included erosion of the condyles (4.8%), osteophytes (3.4%), and bifid condyle (2.9%) [10].

It has been shown that the progression and severity of bone alterations related to the TMJ increases with age [18]. Thus, the high rates found in our study may be explained by the high mean age of 49.4 years. Other study had a lower prevalence of findings in their samples, probably because they were based on orthodontic CBCT indications, and because of the younger population investigated [7].

In this study, only one case of bifid condyle was found in the TMJ region, representing 0.6% of the total sample. Another authors found a larger percentage, that is, 2.7% [6]. This difference may be due to the indications for the CBCT examinations in the present study, since in the other study, 36.7% involved cases of maxillofacial pathology and 28.5% involved TMJ conditions. The above studies reported that a 60-year-old patient who had a CBCT indication for implant planning presented a unilateral incidental finding of bifid condyle in the TMJ. Therefore, the proposed treatment was not indicated for that patient [4].

The third most frequent finding was a deviated septum, occurring on the right side in 24.6% of patients and on the left side in 18.3%. This result is similar to that described in the literature, which varies from 50% [17] to 83.2% of patients with a deviated septum developed sinusitis or some evidence of sinus mucosal thickening, on the right and left side, respectively [18]. This is especially important, since the diagnosis of sinus inflammation may be a constraining factor for implant installation. Therefore, patients with a nasal septum deviation must be carefully analyzed for the presence or absence of opacifications of the maxillary sinus, especially in patients with indications for implants [10,11].

Another incidental finding identified in our study was pseudocysts (occurring on the right side in 14.9% of patients and on the left side in 10.9%). In previous CBCT studies, the occurrence of pseudocysts ranged from 2.9% to 16.4% [4,8-10,18]. This difference in prevalence may be explained by the clinical features of the disease. Pseudocysts usually regress spontaneously, may not show significant changes in size over the long term [19], and rarely lead to symptoms. Owing to these characteristics, conservative monitoring is suggested in the absence of complications associated with pseudocysts [7].

Atheromas or calcifications found in the internal carotid artery were identified in 2.3% of cases on the right side and 5.7% on the left side, with no significant differences based on age or sex. This result represents a significantly lower prevalence than that reported in another study [8], which reported the finding in 23.6% of the sample, but is closer to the findings of several other studies [4,6,9]. Despite the lower prevalence in our study, it is of fundamental importance to consider this finding carefully, since a dental surgeon can be an important participant in the diagnosis of coronary diseases.

In our results, the frequency of tonsilloliths was 11.6% for the right side and 15.7% for the left side. This finding is similar to the observations of a previous study, reporting a rate of 10% [8], but different from the observations of another study, with a reported rate of 30% [20,21].

The high rate of incidental findings in this sample could lead to concerns regarding the frequency and response to such incidental findings in diagnostic imaging [22,23]. It is particularly important to note the absence of guidelines for professionals on how to proceed when such findings are encountered. It is also true that of all the incidental findings investigated in our experiment, some may be related to pathological conditions that were already established without a concrete diagnosis, which may contribute to an increase in morbidity or even mortality of the patient [22,23].

In this study we presented the OR of each incidental finding evaluated in our sample. The OR measures the change in probability of a particular incidental finding on one side of the face given that it was observed on the opposite side. Opacification had the highest OR, 58, followed by subchondral sclerosis with an OR of 37.6 and tonsilloliths with an OR of 27.6. These results are consistent with the clinical characteristics of these findings. Opacification of the sinus is usually associated with an inflammatory condition and would therefore likely reach both sides of the sinus. Subchondral sclerosis is related to age, and tonsilloliths are linked to the anatomical condition of the tonsils, and also to metabolism. These results are important in that they can guide the radiologist in assessing certain important findings such as atheromas, which in our sample presented an OR of 5.9.

As limiting factors to the development of the present study, it was considered that the CBCT exams were evaluated by a single observer, as well as the use of a single software to evaluate the images, making it impossible to work with different image filters for better interpretation of the findings.

This study is important in that it alerts the radiologist to observe innumerable alterations that are not related to the reason for the initial examination. It also points out the necessity of rigorous observation of both sides of the patient, since a greater probability of bilateral incidental findings was noted. It is also important to note that incidental findings should be considered independently of the indication for examination. After the identification of any alterations, the symptoms should be assessed, so that a specialized professional can proceed with the treatment or proactive patient care.

Conclusion

Although no significant difference was observed with regard to age and side of the face observed, or the prevalence and total number of each of the incidental findings, we noted that some changes are more likely to be observed bilaterally.

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Conflict of Interest: The authors declare no conflicts of interest.

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