ORIGINAL ARTICLE

Incidental findings in the maxillofacial region identified on cone-beam computed tomography scans

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ABSTRACT

Background: Cone beam computed tomography (CBCT) is a three-dimensional radiographic imaging technique that is commonly being used in diagnosis and treatment planning in various fields of dentistry. Incidental findings on CBCT images are frequently reported in the literature and are important to assess before treatment planning. **Aims:** To record types and prevalence of incidental findings in the maxillofacial region, identified on CBCT scans and described in radiologist's consultation reports. **Settings and Design:** A total of 147 CBCT scan reports on 59 males and 88 females between June 2007 and February 2012 at University of California, San Francisco, were analyzed retrospectively. Methods and Material: 147 patient reports by Board certified oral radiologists on CBCT scans taken with the Hitachi CB MercuRay. The incidental findings were categorized and analysed using descriptive statistics. **Statistical Analysis Used:** Logistic regression analysis was used to compare the rate of temporomandibular joint (TMJ) pathologies between females and males. **Results:** The overall rate of incidental findings was 40.1%. The age range of patients was from 8 years to 80 years. The highest rate of incidental findings was in the sinus region (51.7%), followed by dento-alveolar region (34.01%), TMJ region (26.53%), osseous region (15.64%), calcification of ligaments, pineal gland, and carotid artery (12.92%), dental anomalies (10.88%), nasal region (8.84%), and airway region (5.44%). According to logistic regression analysis, females were 2.58 times more likely to exhibit TMJ pathology compared to males (*P* value = 0.02). **Conclusions:** CBCT scans are beneficial in revealing incidental abnormalities in the head and neck region outside the scope of interest. Careful review of the entire CBCT image is essential to avoid under- or overestimation of potential complications in providing comprehensive health care.

Key Words: Cone-beam computed tomography, incidental findings, maxillofacial region

Introduction

Cone-beam computed tomography (CBCT) scanners were originally developed for angiography in the early 1980s.[1] Since then CBCT technology has been integrated into the field of dentistry for visualization of the maxillofacial region in three-dimensional cone-beam volumetric images.[1] Currently, the CBCT has various applications including evaluation of the temporomandibular joint (TMJ), visualization of impacted teeth and root resorption, assessment of the eruption path of the canine, virtual planning for implant placement, airway analysis, assessment of secondary alveolar bone grafting, and treatment planning for craniofacial/cleft lip and palate cases.[2-7] Using a cone-shaped x-ray beam, CBCT scanners perform a single rotation around the head of the patient at a constant angle, producing a volumetric data set that is later reconstructed into three-dimensional images.[1] The CBCT scan has two major advantages over two-dimensional conventional radiographs in that it eliminates geometric distortion and superimposition of surrounding anatomical structures.[8] Moreover, CBCTs use much lower radiation exposure, which ranges from 29 to 577 uSV, compared to conventional CT scanner with radiation exposure approximately 2000 uSV.[1] This is important especially in reducing the radiation burden in treatment of children and young adults.[9]

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American Dental Association (ADA) council of scientific affairs recommends utilizing techniques to reduce the amount of radiation received during dental radiography, as low as the reasonably achievable (ALARA) principle.[10]

Currently, only limited data are available regarding the occurrence of incidental findings with CBCT imaging in the craniofacial region,and most clinicians focus primarily on the teeth and jaws, even though other valuable information is often available in the image data sets.[1,9] As an example, one case report by Nair *et al*. describes the incidental encounter of a potentially life-threatening intracranial aneurysm in a CBCT performed for dental purposes.[11] In a case report by Popat*et al*, mid-line clefts of cervical vertebrae were diagnosed from a CBCT scan conducted for orthodontic diagnostic records.[12] Therefore, although there are a few studies that have found several incidental findings in the maxillofacial region, more studies are needed to acknowledge the types and frequencies of the incidental findings in order to avoid under- or overestimation of potential pathologies in the process of providing comprehensive health care.[13]According to American Academy of Oral and Maxillofacial Radiology (AAOMR) and the European Academy of Dento-Maxillo Facial Radiology (EADMFR), the entire CBCT data set needs to be fully interpreted, and if the clinician is not an expert in interpreting the entire data set, a referral is required for a review by oral and maxillofacial radiologists.[1]

The aim of this study was to evaluate the prevalence and types of incidental findings in the maxillofacial region from CBCT consultation reports obtained by the Orthodontic Division at University of California, San Francisco.

Materials and Methods

The CBCT scans were reviewed and interpreted by board certified oral and maxillofacial radiologists based on a preliminary indication of some pathology as assessed by the orthodontist(CHR approval number: 10-00564).

A total of 147 CBCT scan reports on 59 males and 88 females between June 2007 and February 2012 at University of California, San Francisco, were analyzed.The CBCT scans were completed on the Hitachi CB MercuRay (Hitachi Medical Corporation, Tokyo, Japan) and Care stream 9300 (Carestream Health Inc, Rochester, NY) with range of 18-200 uSV, 60 to 90 kvp, and 2-15 mA allowing for adjustments within each FOV and voxel size.The CBCT scans were ordered for various reasons such as the evaluation of maxillary or mandibular pathology, TMJ, sinus, orthodontic treatment, implant assessment, calcifications, and non-specified reasons [Table 1].The sample included 54 maxillary or mandibular pathology patients, 42 TMJ patients, 23 maxillary sinus patients, 4 orthodontic patients, 4 implant patients, 4 calcification of ligaments, pineal gland or carotid artery patients, and 16 non-specified patients (56 patients had CBCT's taken in conjunction with orthodontic assessment). Incidental findings were defined as abnormal findings that exist outside the specific region of interest that are detected by the CBCT covering the entire maxillofacial area. All incidental findings were categorized and analyzed using descriptive statistics. The incidental findings were categorized as Airway, Nasal, Sinus, Calcification, Dental abnormality, Osseous, Dentoalveolar and TMJ. Findings such as dental caries, missing teeth, eruption disturbance, altered tooth morphology, and periodontal bone loss, were not recorded.The age of the patients who received scans ranged from 8 to 80 years of age; the mean age for males was 24.75 (± 14.53) and for females was 30.43 (± 17.23). There was a preponderance of females (59.8%). Age distribution is described in Table 2.

Results

In our sample of 147 patients, there were incidental findings in 59, or 40.1% of the total sample.

Incidental findings were categorized into eight groups for analysis. Each group is listed in the order of the most frequent to the least in Table 3.The most frequent incidental findings were in the sinus region followed by dentoalveolar,

Table 1: Reasons for CBCT scan ordered and number of subjects

Reason for CBCT Scan	No. of Subjects	% of Subjects
Max. or mandib. pathology	54	36.73
TMJ evaluation	42	28.57
Sinus evaluation	23	15.65
Orthodontics	4	2.72
Implant assessment	4	2.72
Calcification	4	2.72
None specified	16	10.88

Table 2: Age distribution of patients and number

Age of Patients	Number of Patients
0-10 years	1
10-19 years	65
20-29 years	30
30-39 years	21
40-49 years	10
50-59 years	7
60-69 years	10
70-79 years	2
80-89 years	1

TMJ, osseous, calcification, dental anomalies, nasal, and airway regions.

The most common forms of incidental pathologic findings were those of sinus origin, which occurred in 51.70% of subjects in this study. A number of subjects exhibited more than one form of sinus origin findings. Most frequently found sinus origin pathologies were mucosal thickening [Figure 1], sinusitis, and sinus polyps in maxillary, or sphenoid sinuses. There was no statistical age or gender difference found among subjects.

The second most common form of incidental finding was from the dento-alveolar region, and it was found in 50 subjects (34%). Among the subjects, the predominant findings were cortical thickening and focal sclerosis [Figure 2] in either maxilla or mandible.There was no statistical difference in subjects' age or gender.

The third most frequently found incidental finding was in the TMJ region, which occurred in 26.53% of total number of subjects. Most commonly found pathologic findings were osteoarthritic change and flattening of articular surfaces. According to logistic regression analysis, females were 2.58 times more likely to exhibit either osteoarthritic change, bifid condylar formation [Figure 3], flattening of articular surfaces or narrow joint spaces [Figure 4] compared to males (*P* value = 0.02) (95% Confidence Interval = 1.14–5.80).

Table 3: Descriptive analysis and frequency of pathologic findings in the subjects

Pathologic Category/Finding	No. of Subjects	% of Subjects
Sinus	76	51.70
Mucosal thickening	28	19.04
Sinusitis	21	14.28
Sinus polyps	14	9.52
Mucous retention cyst	7	4.76
Calcified attenuation of sinus	4	2.72
Opaque sinus/air cells	2	1.36
Dentoalveolar	50	34.01
Cortical thickening	21	14.28
Focal sclerosis (Endostosis)	18	12.24
Granular trabecular pattern	8	5.44
Rarefying osteitis	3	2.04
TMJ	39	26.53
Osteoarthritic (cortical hyperostosis)	17	11.56
Flattening of articular surfaces	11	7.48
Narrow joint spaces	4	2.72
Bifid condylar formation	4	2.72
Subchondral cyst on condyle	2	1.36
Condylar hypoplasia	1	0.68
Osseous	23	15.64
Degenerative changes (vertebral)	11	7.48
Osteophyte formation	8	5.44
Foreign object in anterior skull	2	1.36
External auditory canal obstruction	1	0.68
Fusion of C-spine	1	0.68
Calcification	19	12.92
Stylohyoid ligament calcification	9	6.12
Pineal gland calcification	7	4.76
Carotid artery calcification	3	2.04
Dental anomalies	16	10.88
Impaction	9	6.12
Supernumerary	7	4.76
Nasal	13	8.84
Deviated septum	5	3.40
Concha Bullosa	4	2.72
Enlarged concha	2	1.36
Turbinate hypertrophy	2	1.36
Airway	8	5.44
Airway obstruction	8	5.44

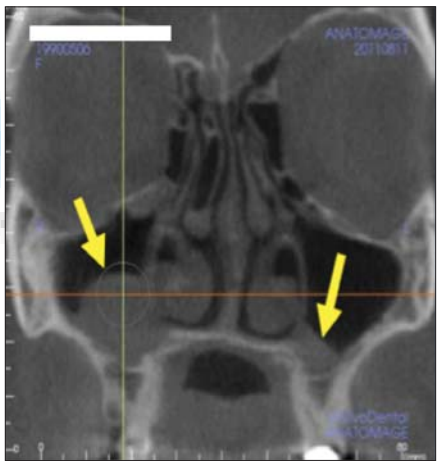

Figure 1: Sinus–mucosal thickening in maxillary sinus

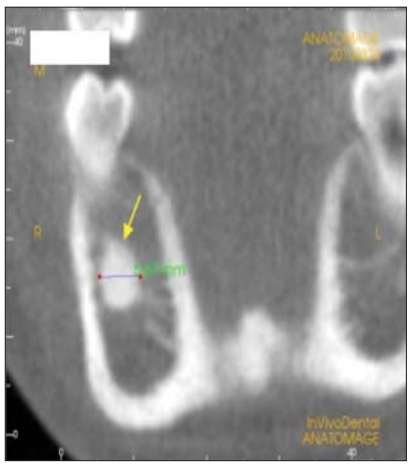

Figure 2: Dentoalveolar–focal sclerosis

The fourth most commonly found incidental finding was that of the osseous region, which occurred in 15.64% of total subjects. Commonly found pathologic findings in this category were fusion of vertebrae [Figure 5], degenerative changes [Figure 6], and osteophyte formation in vertebrae. There was no statistical age or gender difference found among subjects.

Calcifications of carotid artery [Figure 7], stylohyoid ligament [Figure 8], or pineal gland occurred in 12.92% of subjects.There was no statistical age or gender difference found among subjects.

Incidental findings of dental anomalies were noted in 10.88% of subjects, and they were either impaction or

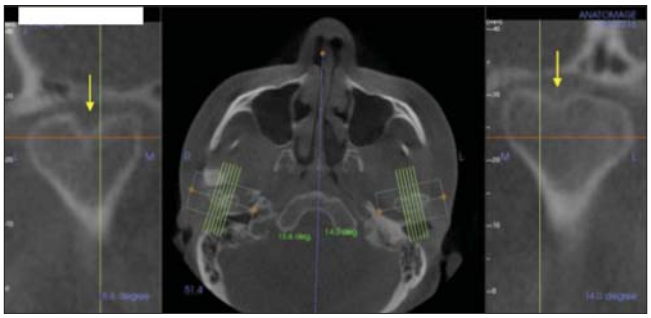

Figure 3: TMJ–bifid condyle

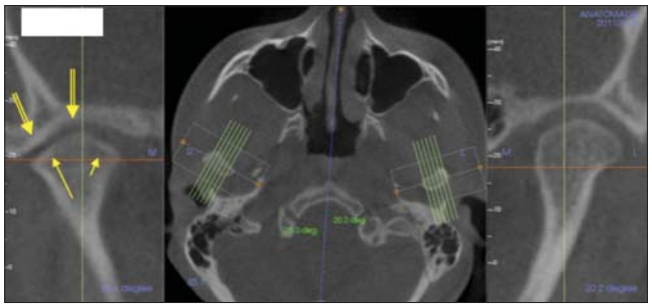

Figure 4: Flattening of the contour of the right condyle near both the lateral and medial poles (small arrows) in the oblique coronal image. Narrowing of the joint space (double arrows)

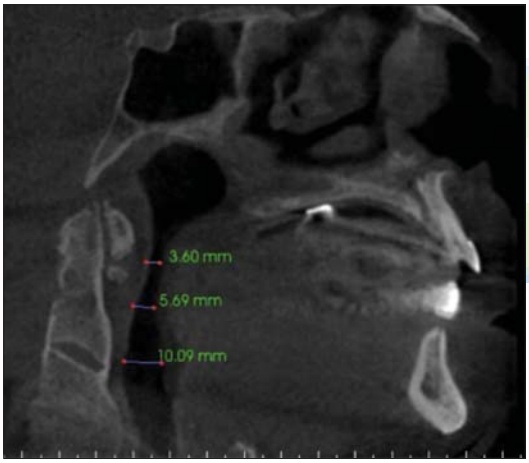

Figure 5: Fusion of the anterior and posterior borders of C2 and C3 vertebrae. The C3-C4 vertebral junction is not clearly visible since the vertebrae are on the edge of the scan field of view

Figure 6: Osseous finding. Foreign object in anterior skull with degenerative change (vertebrae)

Figure 7: Bilateral calcifications in the region of the coronary artery bifurcation

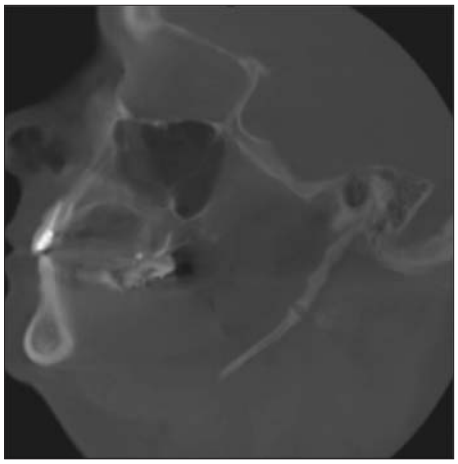

Figure 8: Calcification of stylohyoid ligament

supernumerary teeth [Figure 9]. There was no statistical age or gender difference found among subjects.

Nasal pathologic findings were found in 8.84% of the subjects and the predominant findings were septum deviation, concha bullosa [Figure 10], and hypertrophy of turbinate [Figure 11]. There was no statistical age or gender difference found among subjects.

Airway pathologic finding was the least frequently found incidental findings, and it occurred in 5.44% of the subjects. The eight subjects who showed airway pathologic findings were noted as of airway obstruction due to hypertrophy of palatine tonsil or adenoids [Figure 12]. There was no statistical age or gender difference found among subjects.

Discussion

CBCT scans are being used increasingly during the past decade for diagnosis and treatment planning in dentistry. Many significant non-dental-related pathologic incidental findings have been observed. In this study, out of the 147 CBCT scans reviewed, 40.13% revealed a total of 244 incidental findings, unrelated to the primary indication for the CBCT scan. In other studies, the overall incidental finding rate varied from 24.6% to 92.8%.[1,2,8,9,13]

In our patient pool, the most common incidental finding was from sinus origin (51.7%). In previous studies, incidental findings in this region varied from 18% to 51.8%.[1,2,8,9,13] Consideration of these potential pathologies in the sinus region is critical when treatment planning for implant placement is indicated in posterior maxilla.[1] According to the study by Angelopoulos *et al*, patency of the osteomeatal complex is vital during sinus grafting procedures since the blockage of the osteomeatal complex may prevent aeration of the sinus cavity, and can result in accumulation of inflammatory products in the sinus cavity and therefore may increase the chance of post-operative complications.[14]

Incidental findings in the dentoalveolar region were noted

Figure 9: Dental anomaly. Supernumerary teeth

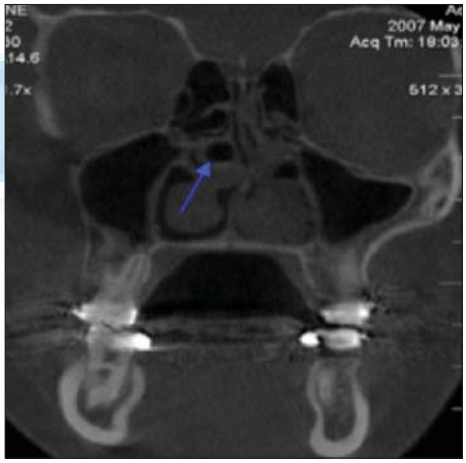

Figure 10: Nasal incidental finding (Concha bullosa)

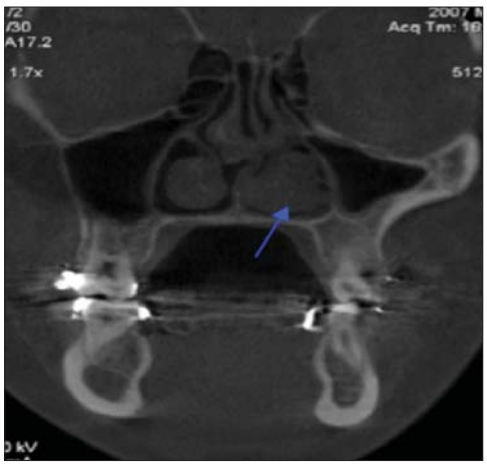

Figure 11: Nasal–hypertrophy of left inferior turbinate

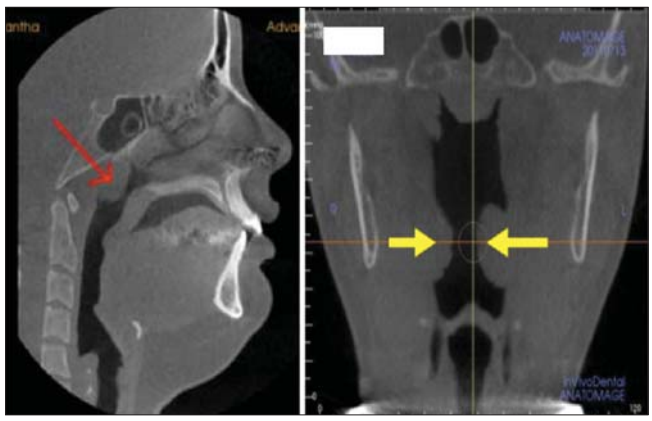

Figure 12: Airway obstruction with adenoidal hypertrophy

at a rate of 34.01% of the total subjects. Among them, 21 subjects had cortical thickening in the maxilla or mandible, 18 subjects were detected with dense boney islands (focal sclerosis or enostosis), 8 subjects had granular trabecular pattern, and 3 subjects had rarefying osteitis. Previous studies have found incidental findings in the dentoalveolar region ranged between 6.29% and 17.5%.[1,8] According to other studies, most of these are asymptomatic clinically and commonly detected incidentally during routine examinations, and therefore do not require treatment or referral except the osteoma, which requires continous monitoring of the size.[8]

Incidental findings occurring in the TMJ region was the third most common with the frequency of 26.53%. Previous studies have found that the frequency of incidental findings in this region was from 2.6% to 39.31%.[1,2,8,9,13] A logistic regression analysis showed that there was a significant difference between females and males in that females were 2.58 times more likely to exhibit any type of potential pathologic findings in the TMJ region than males (*P* value = 0.02) (95% Confidence Interval = 1.14–5.80). Pathologic findings in the TMJ region could be incidental and may not be responsible for TMJ dysfunction or symptoms.[8] While clinically asymptomatic patient may be monitored, patients with symptoms such as pain and limitation of mandibular function require a comprehensive TMJ analysis.[8] One study reported that a 60-year-old patient who had a CBCT scan for implant treatment planning showed a unilateral (left) medio-lateral bifid condyle as an incidental finding, and the implant treatment was not indicated for this patient as a result.[8]

The rate of incidences of calcification was 19 cases (12.92%) in 147 subjects. The frequency of incidental findings of calcification in previous studies was from 3.46% to 20%.[1,8] Stylohyoid ligament calcification was found in 9 subjects, and studies showed that unless the patient reports symptoms of Eagle's syndrome, such as unilateral sore throat, dysphagia, unilateral facial, and neck pain, no treatment is required.[8] On the other hand, three subjects (2.04%) were noted with carotid artery calcifications, and this radiographic evidence of atherosclerosis could be a possible indicator of potential stroke or metabolic disease.[8] Almog*et al* compared radiographic evidence of carotid artery calcifications on panoramic radiographs to the incidence of carotid artery stenosis (CAS).[15] The result showed that 3 patients out of 77 who had findings suggestive of radiographic calcifications unilaterally or bilaterally revealed stenosis greater than 80% and subsequently underwent carotid end-arterectomies as a direct result of the panoramic screening.[15] Therefore, with more accurate field of view compared to panoramic radiographs, CBCT scans can be used to detect a greater number of arterial calcification lesions, and thus the correlation between arterial calcifications and CAS should be evaluated.

16 patients or 10.88% of all subject had dental anomalies, such as impaction of canine or third molars (6.12%), or supernumerary teeth (4.76%). Previous studies have found that 0.7% of another total subjects had supernumerary teeth and the other study showed 21.7% of the total subjects had showed impaction of third molars or canines.[2,8] Although treatment of the dental anomalies depends on their type and position, early diagnosis and treatment are necessary to minimize the risk of further complications.[16] The frequency of incidental findings in the nasal region was noted with 8.84% of the total subjects, and it included deviated nasal septum (3.4%), concha bullosa (2.72%), enlarged concha (1.36%), and turbinate hypertrophy (1.36%). Previous studies have found the frequency of incidental findings in the nasal region varied from 7.4% to 17.92%.[1,8] Studies by Smith *et al* and Bolger *et al* have found 50% of patients and 83.2% of patients with deviated septum, respectively, have developed sinusitis, or any evident mucosal thickening in the maxillary sinus.[17,18] Furthermore, previous studies have suggested that abnormalities of the concha, including concha bullosa, can predispose patients to obstruction of the sinuses, leading to chronic sinusitis.[17] Therefore, patients with nasal septum or concha bullosa carefully reviewed for the presence or absence of sinusitis especially in implant patients.

CBCT scans can be useful in diagnosing airway obstruction, which is associated with obstructive sleep apnea (OSA).[1] In this study, 5.44% of the total subjects were detected with airway obstruction, and the obstruction was due to hypertrophy of palatine tonsil or adenoids. In previous study by Price *et al*, the incidental findings in the airway was detected in 7.86% of the total subjects.[8] As mentioned above, CBCT scans can serve as a screening tool for patients where sedation is indicated during dental procedures because some sedatives and narcotics may exacerbate the risk for OSA in patients with airway obstruction.[1]

Due to the absence of superimposition of anatomical structures and the elimination of geometric distortion, CBCT scans can reveal many potential pathologic findings in the maxillofacial region more clearly than the panoramic radiograph or conventional tomography.The result of this retrospective study of 147 CBCT scans and reports from radiologists showed the highest rate of incidental findings were in the sinus region (51.7%), followed by dento-alveolar region (34.01%), TMJ region (26.53%), osseous region (15.64%), calcification (12.92%), dental anomalies

(10.88%), nasal (8.84%), and airway (5.44%). According to logistic regression analysis, females were 2.58 times more likely to exhibit any type of potential pathologic findings in the TMJ region than males (*P* value = 0.02) (95% Confidence Interval = 1.14–5.80). Although oral radiologists or dentists are not expected to treat conditions outside of professional knowledge and expertise, they are not exempt from the moral responsibility of identifying these potential pathologies in the CBCT scan image. If any concerns are present, the patient should be referred to the relevant specialist. In conclusion, oral radiologists and dentists should be attentive to these incidental findings and comprehensively evaluate the complete image to avoid over- or underestimation of underlying diseases in order to provide comprehensive health care for their patients.

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References

1. Pette GA, Norkin FJ, Ganeles J, Hardigan P, Lask E, Zfaz S, *et al*. Incidental findings from a retrospective study of 318 cone beam computed tomography consultation reports. Int J Oral Maxillofac Implants 2012;27:595-602.
2. Caglayan F, Tozoglu U, Incidental findings in the maxillofacial region detected by cone beam CT. DiagnInterv Radiol2012;18:159-63.
3. Oberoi S, Chigurupati R, Gill P, Hoffman WY,Vargervik K. Volumetric assessment of secondary alveolar bone grafting using cone beam computed tomography. Cleft Palate Craniofac J 2009;46:503-11.
4. Oberoi S, Gill P, Chigurupati R, Hoffman WY, Hatcher D. C, Vargervik K. Three-dimensional assessment of the eruption path of the canine in individuals with bone-grafted alveolar clefts using cone beam computed tomography. Cleft Palate Craniofac J2010;47:507-12.
5. Oberoi S, Knueppel S,Three-dimensional assessment of impacted canines and root resorption using cone beam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;113:260-7
6. Hatcher DC.Cone beam computed tomography: craniofacial and airway analysis. Dent Clin North Am2012;56:343-57.
7. Cheung T, Oberoi S. Three dimensional assessment of the pharyngeal airway in indivisuals with non-syndromic cleft lip and palate. Plos One 2012;7:1-5.
8. Price JB, Thaw KL, Tyndall DA, Ludlow JB, Padilla RJ. Incidental findings from cone beam computed tomography of the maxillofacial region: A descriptive retrospective study. Clin Oral Impl Res 2011;00:1-8.
9. Pazera P, Bornstein MM, Pazera A, Sendi P, Katsaros C. Incidental maxillary sinus findings in orthodontic patients: A radiographic analysis using cone-beam computed tomography (CBCT). Orthod Craniofac Res 2011;14:17-24.
10. American Dental Association. The use of dental radiographs: Update and recommendations. J Am Dent Assoc 2006; 137:1304-12.
11. Nair MK, Pettigrew JC, Mancuso AA. Intracranial aneurysm as an incidental finding. Dentomaxillofac Radiol 2007;36:107-12.
12. Popat H, Drage N, Durning P. Mid-line clefts of the cervical vertebrae – an inci- dental finding arising from cone beam computed tomography of the dental patient. Br Dent J 2008;204:303-6.
13. Cha JY, Mah J, Sinclair P. Incidental findings in the maxillofacial area with 3-dimensional cone-beam imaging. Am J Orthodont Dentofacial Orthopedics 2007;132:7-13.
14. Angelopoulos C. Cone beam tomographic imaging anatomy of the maxillofacial region. Dent Clin North Am 2008;52:731-52.
15. Almog DM, Horev T, Illig KA, Green RM, Carter LC. Correlating carotid artery stenosis detected by panoramic radiography with clinically rel-evant carotid artery stenosis determined by duplex ultrasound. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2002;94:768-73.
16. Hurlen B, Humerfelt D. Characteristics of premaxillary hyperodontia: A radiographic study. Acta Odontologica 1985;43:75-81.
17. Smith KD, Edwards PC, Saini TS, Norton NS. The prevalence of concha bullosa and nasal septal deviation and their relation-ship to maxillary sinusitis by volumet-ric tomography. Int J Dent 2010;2010:1-5.
18. Bolger WE, Butzin CA, Parsons DS. Paranasal sinus bony anatomic variations and mucosal abnormalities: CT analysis for endoscopic sinus surgery. Laryngoscope 1991;101:56-64.

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