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COMPARISON OF CONE BEAM COMPUTED TOMOGRAPHY AND COMPUTED TOMOGRAPHY EXAMINATIONS OF PARANASAL SINUSES: PRELIMINARY STUDY

Filiz Namdar Pekiner, DDS, PhD
Associate Professor, Head,
Department of Oral Diagnosis and Radiology,
Faculty of Dentistry, Marmara University,
Istanbul, Turkey.

Asım Dumlu, DDS, PhD
Assistant Professor, Department of Oral Diagnosis and Radiology,
Faculty of Dentistry, Marmara University,
Istanbul, Turkey.

M. Oğuz Borahan, DDS, PhD
Assistant Professor, Department of Oral Diagnosis and Radiology,
Faculty of Dentistry, Marmara University,
Istanbul, Turkey.

ABSTRACT

Background and Aim: The aim of this presentation is to compare the diagnostic image quality between cone beam computed tomography (CBCT) and standard sinus-protocol in computed tomography (CT) of paranasal sinuses.

Subjects and Methods: 12 standard sinus-protocol in CT paranasal sinus examinations and 12 cone beam CT examinations were picked up from the Picture Archiving and Communication System (PACS). Several anatomic landmarks were chosen in order to be detected on the examinations. Three dentomaxillofacial radiologists evaluated the images. Before the evaluation, all observers were calibrated and reference images were available during the readings and Kendall's W was used for inter-observer agreement. The visualisation of anatomic landmarks important in sinuses was judged. The observations were graded according to a 3-point confidence scale.

Results: There was no significant difference in fovea ethmoidalis including olfactory groove, lamina papyracea, ostiomeatal unit (including proc uncinatus, maxillary ostium, infundibulum), but only visibility of nasofrontal duct/frontal recess (including frontal sinus) and sphenoethmoidal recess (including sphenoid ostium) were found to be dependent on the imaging technique ($p<0.05$). These results showed that visibility are statistically significant in CBCT imaging.

Conclusion: CT is a specialist investigation and provides unique information about the ostial anatomy, however radiation doses from CT are relatively high according to Commission on Radiological Protection (ICRP). Cone beam CT gives a substantial dose reduction compared with standart-dose protocols in CT, but detection of the most important anatomic landmarks of paranasal sinuses.

Key words: Computed Tomography, Cone Beam Computed Tomography, Standart Sinus-Protocol

Correspondence
Filiz Namdar Pekiner,DDS, PhD
Department of Oral Diagnosis and Radiology,
Faculty of Dentistry,
Marmara University,
Guzelbahce Buyukciftlik Sok. No: 6,
34365 Nisantasi-Istanbul, Turkey
Tel: +90 212 2319120
Fax: +90 212 2465247
E-mail: fpekiner@gmail.com

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INTRODUCTION

The paranasal sinuses are complex anatomical structures with a significant inter-individual variation and inflammatory diseases of the paranasal sinüs have relatively high prevalence in younger patients.[1-4] Over the past decades, radiation-based imaging of the paranasal sinuses has evolved from plain X-rays to cross-sectional imaging by computed tomography (CT).[5,6] CT has become the gold standard of diagnostic imaging providing sufficient spatial resolution while its data-set can be used for computer-assited endoscopic sinus surgery.[7,8] However, CT in general is known to be responsible for most of the collective medical radiation dose of the population in modern societies. Regarding imaging of the paranasal sinuses, it is important to emphasize radiation sensitive tissue like eye lenses and thyroid gland, because they get radiated by direct or scattered x-rays during the examination.[1,9,10] Since this patient collective is mostly of lower age and repetitive examinations might be done during follow-up examination, an increased balance in dosage of routine protocols is required.[1,11,12]

Cone-beam computed tomography (CBCT) produces three-dimensional information on the facial skeleton and teeth and is increasingly being used in many of the dental specialties. It, primarily introduced for orthodontic indications, as an alternative image modality is ought to have reasonable diagnostic value for diagnostic of rhinosinusitis.[13-15] According to literature CBCT is ought to have great advantage over multidetector CT (MDCT) concerning radiation exposure. Compared to these former single source sinus CT studies eye dosages of the proposed protocol is lower by factor 19 to 23 in mAs. Even more drastic is thyroid gland caused by scattered radiation, which are 30-130 times higher compared to CT studies.[1,16]

Therefore, the objective of this presentation is to compare the diagnostic image quality between cone beam CT (CBCT) and standard sinus-protocol in CT of paranasal sinuses.

SUBJECTS and METHODS

Patient Data

The study was based on the MDCT and CBCT images of 24 patients (11 female (45.8%), 13 male (54.2%); 11-72 years old, mean age 40.04±17.03 years). 12 standard sinus-protocol in CT paranasal sinus examinations and 12 cone beam CT examinations were picked up from the PACS. MDCT was performed on a GE DST LS 16 (GE Medical Systems, Milwaukee, United States), a multislice CT (kV 120, mA 250, slice collimation 2.5, slice thickness 2.5, pitch 0.562:1, speed (mm/rot)/ interval 5.63/2.5, sFOV/DFOV head/25mm computed tomography dose index (CTDI) volume (mGy) 101.36, dose length product (DLP) (mGycm) 1315.16, dose efficiency 78.80%). All scans were rated in the "bone windows" setting. CBCT was preformed on a 3D Accuitomo 170-XYZ Slice View Tomograph (Veraviewpocs 3D, J.Morita Mfg Corp., Kyoto; Japan).

Data Evaluation

Examinations on patients with tumors or other boned affecting diseases such as Wegener Granulomatosis, etc were excluded. In order to reduce radiographic misinterpretation, three oral maxillofacial radiologists carefully studied the each anatomic landmark. Calibration trials were performed initially to ensure an interexaminer consistency of at least 85% in recording. For calibration, 5 patients were evaluated and not included in the main study. Several anatomic landmarks were chosen in order to be detected on the MDCT and CBCT examinations and diagnostic image quality was assessed by scoring for six anatomical structures; fovea ethmoidalis including olfactory Groove (Figure 1), ostiomeatal unit (including proc. uncinatus, maxillary ostium, infundibulum) (Figure 2), lamina papyracea (Figure 3), sphenoethmoidal recess (including sphenoid ostium) (Figure 4), nasofrontal duct/frontal recess (including frontal sinus) (Figure 5).

Moreover, it was examined whether diagnostically relevant structures were obscured by artifacts which was caused by metal fillings and subjective diagnostic quality of the images was estimated with a view toward their usability. For each structure, the following score was allocated depending on how well each was visualized: 0, not demonstrated, 1, demonstrated but clearly visualized, 2, clearly visualized. The right and left sides were analyzed separately.

Statistical Analysis

The data were analysed with SPSS (Statistical Package for Social Sciences) for Windows 15.0. Descriptive statistical methods (mean, standard deviation, frequency) were used for the evaluation of the data. Statistical significance of differences among the imaging techniques were analysed by means of the Mann Whitney U test. Statistical significance of differences between the imaging techniques and all observers was determined by Friedman test and Wilcoxon sign test. Kendall's coefficient of concordance for ranks (W) calculates agreements between 3 or more

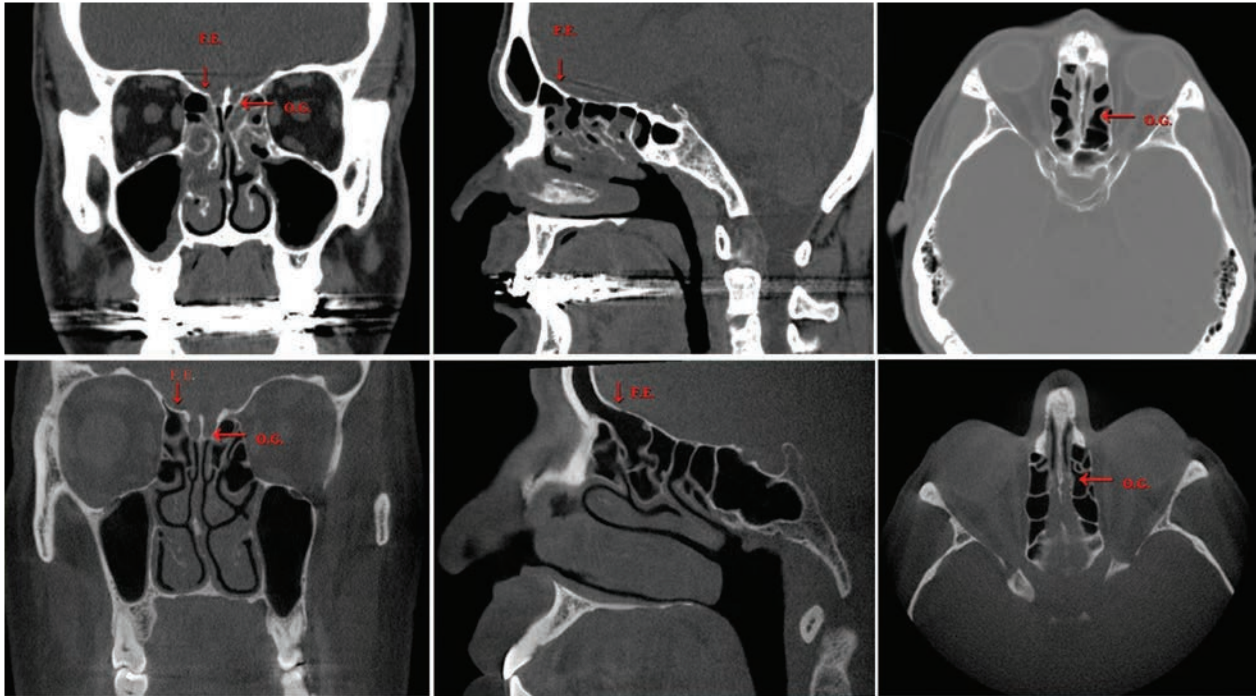

Figure 1. Coronal, sagital and axial sections of standart-CT (up) and CBCT views of fovea ethmoidalis including olfactory groove

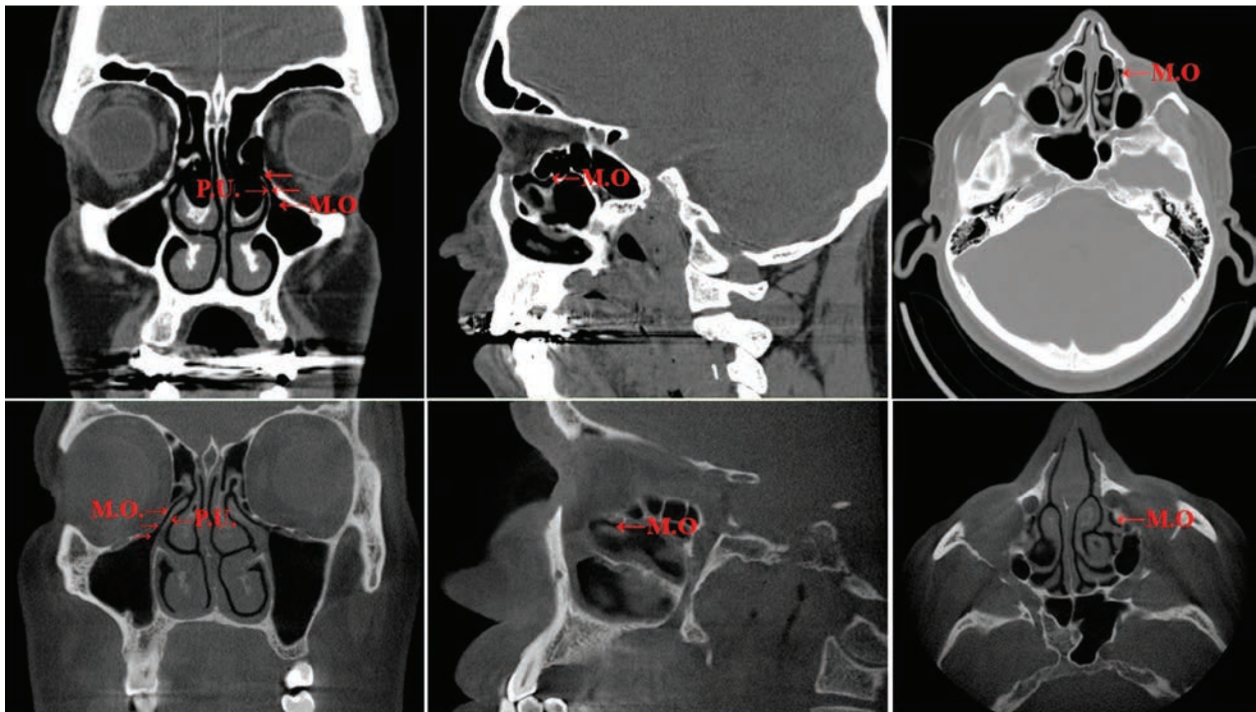

Figure 2. Coronal, sagital and axial sections of standart-CT (up) and CBCT views of including Proc Uncinatus, Maxillary Ostium, Infundibulum

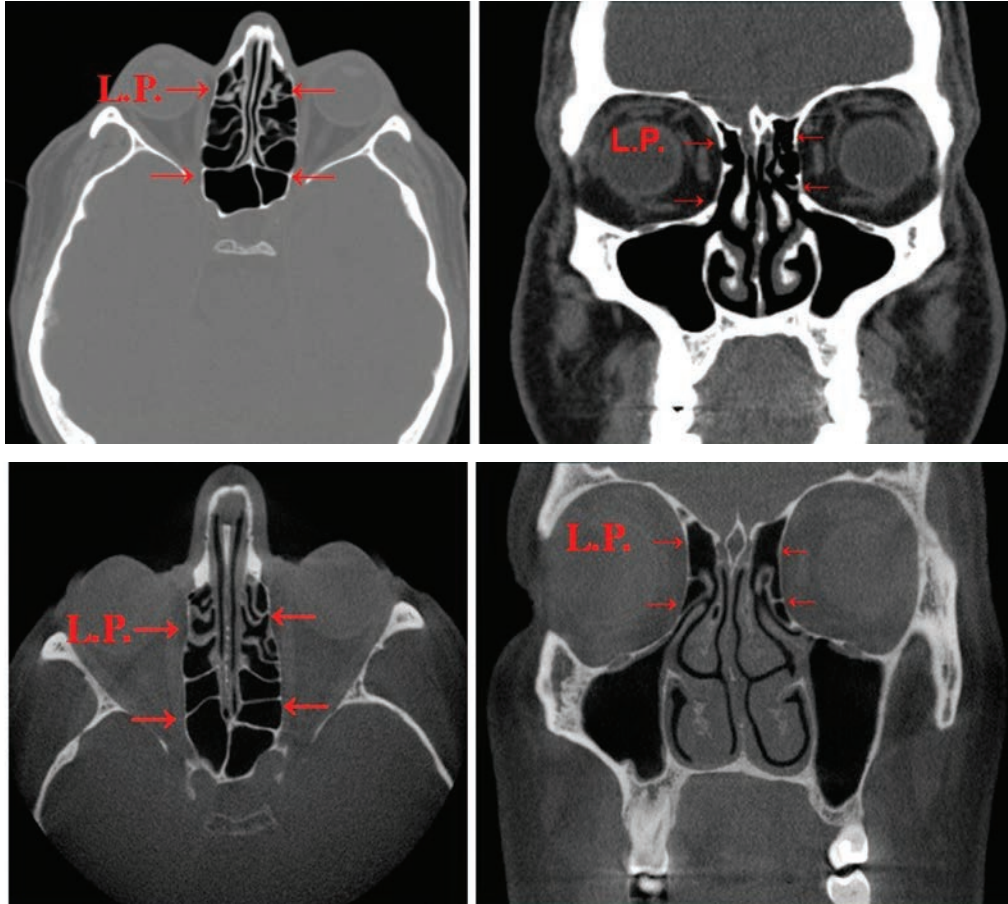

Figure 3. Axial and coronal sections of standart-CT (left) and CBCT (right) views of lamina papyracea

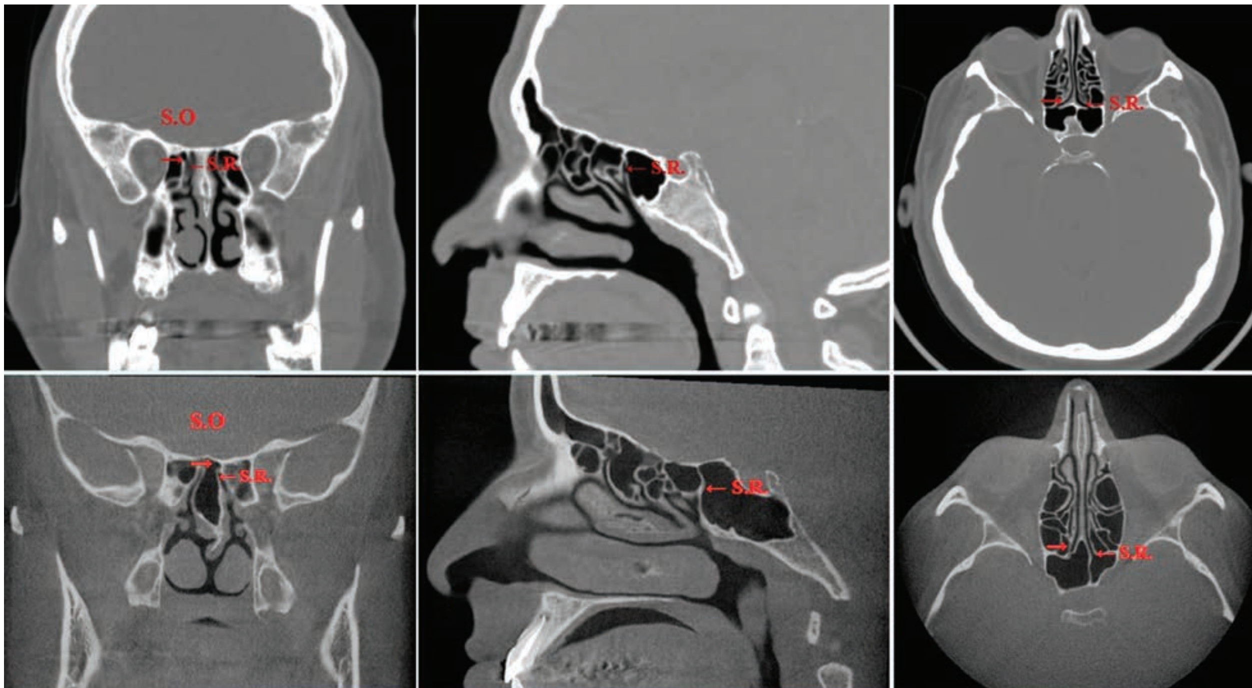

Figure 4. Coronal, sagital and axial sections of standart-CT (up) and CBCT views of sphenoethmoidal recess including sphenoid ostium.

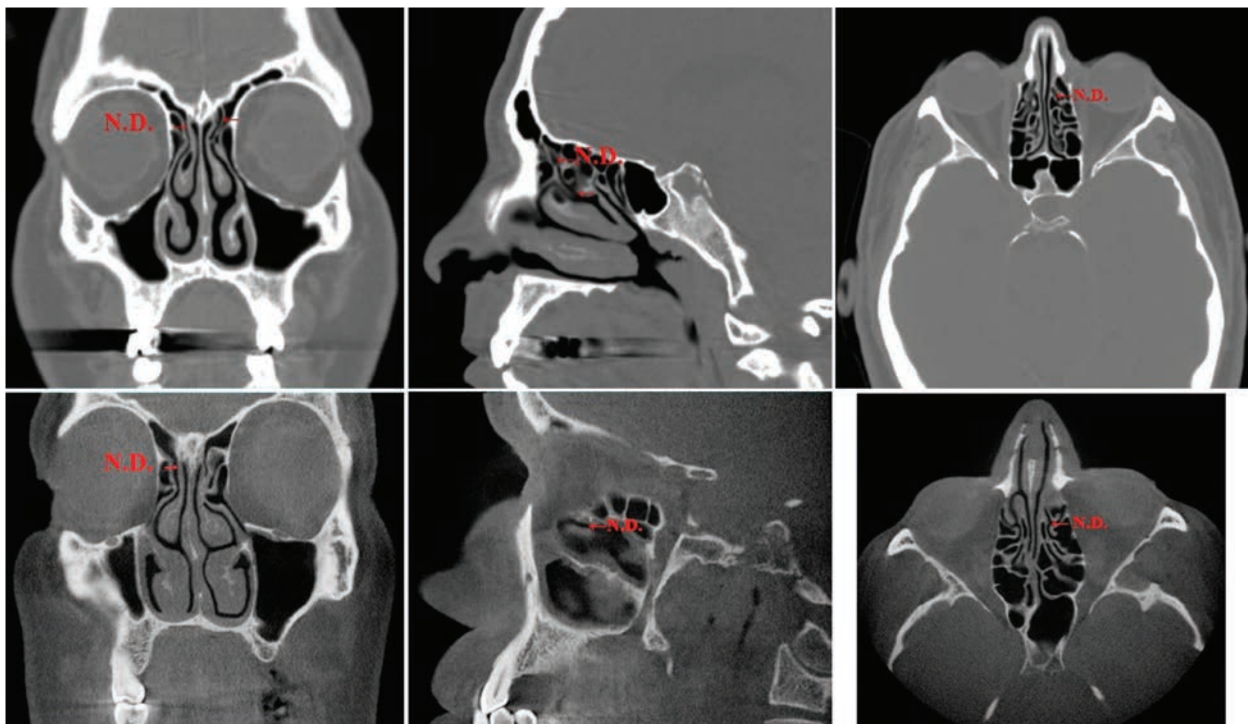

Figure 5. Coronal, sagital and axial sections of standart-CT (up) and CBCT views of Nasofrontal duct/frontal recess including frontal sinus

rankers as they rank a number of subjects according to a particular characteristics. Kendall's W was used to evaluate for inter-observer agreement, because of Cohen's Kappa and Spearman's correlation coefficient would not be more appropriate. P values of less than 0.05 were interpreted as significant, and the level in confidence intervals was 95%.

RESULTS

The inter-observer agreement between observer 1, observer 2 and observer 3 is figured out according to each anatomic landmarks using Kendall's W statistics. The inter-observer reliability of visibility of each anatomic landmarks according to imaging techniques was moderate (r= 41 [95% confidence interval, 18 to 64]; W=0.47).

There was no significant difference in fovea ethmoidalis including olfactory groove, lamina papyracea, ostiomeatal unit (including proc uncinatus, maxillary ostium, infundibulum), maxillary sinus among the 2 imaging technique, but only visibility of nasofrontal duct/frontal recess (including frontal sinus) and sphenoethmoidal recess (including sphenoid ostium) were found to be dependent on the imaging technique. For nasofrontal duct/frontal recess (including frontal sinus) and sphenoethmoidal recess (including sphenoid ostium) right and left sides, there was a significant difference in the diagnostic quality scores between CT and CBCT images ($p<0.05$) (Table 1, 2, 3, 4 and 5, respectively). These results showed that visibility are statistically significant in CBCT imaging.

DISCUSSION

Radiology is important in the diagnostic assessment of the dental patient and guidelines for the selection of appropriate radiographic procedures for patients suspected of having dental and maxillofacial disease are available.[17,18] CBCT is well suited for imaging the craniofacial area and CBCT imaging provides clear images of highly contrasted structures. In addition, Sukovic[19] and Ziegler et al.[20] showed that CBCT was useful for evaluating bone. The use of CBCT technology in clinical practice provides many advantages for maxillofacial imaging compared with conventional CT. Especially, published reports indicate that the effective dose of radiation is significantly reduced by up to 98% compared with conventional CT.[18] As radiologists it is important that we are able to provide high quality scans; but we also have duty to minimize the radiation dose delivered to patient.[10] The theoretical risk of other radiation-induced effects

Table 1. Distribution of nasofrontal duct (right/left) and sphenoethmoidal recess (right/left) according to imaging techniques

			Sinus CT	CBCT
			n (%)	n (%)
Nasofrontal Duct Right	Observer1	0	3 (%25,0)	0 (%0,0)
		1	3 (%25,0)	1 (%8,3)
		2	6 (%50,0)	11 (%91,7)
	Observer2	0	3 (%25,0)	1 (%8,3)
		1	5 (%41,7)	1 (%8,3)
		2	4 (%33,3)	10 (%83,3)
	Observer3	0	4 (%33,3)	1 (%8,3)
		1	4 (%33,3)	2 (%16,7)
		2	4 (%33,3)	9 (%75,0)
Nasofrontal Duct Left	Observer1	0	2 (%16,7)	0 (%0,0)
		1	3 (%25,0)	0 (%0,0)
		2	7 (%58,3)	12 (%100,0)
	Observer2	0	3 (%25,0)	1 (%8,3)
		1	3 (%25,0)	0 (%0,0)
		2	6 (%50,0)	11 (%91,7)
	Observer3	0	3 (%25,0)	1 (%8,3)
		1	5 (%41,7)	3 (%25,0)
		2	4 (%33,3)	8 (%66,7)
Sphenoethmoidal Recess Right	Observer1	0	-	-
		1	5 (%41,7)	0 (%0,0)
		2	7 (%58,3)	12 (%100,0)
	Observer2	0	1 (%8,3)	0 (%0,0)
		1	1 (%8,3)	0 (%0,0)
		2	10 (%83,3)	12 (%100,0)
	Observer3	0	2 (%16,7)	0 (%0,0)
		1	4 (%33,3)	6 (%50,0)
		2	6 (%50,0)	6 (%50,0)
Sphenoethmoidal Recess Left	Observer1	0	-	-
		1	5 (%41,7)	0 (%0,0)
		2	7 (%58,3)	12 (%100,0)
	Observer2	0	1 (%8,3)	0 (%0,0)
		1	3 (%25,0)	0 (%0,0)
		2	8 (%66,7)	12 (%100,0)
	Observer3	0	2 (%16,7)	0 (%0,0)
		1	4 (%33,3)	2 (%16,7)
		2	6 (%50,0)	10 (%83,3)

0= not demonstrated, 1= demonstrated but clearly visualized, 2= clearly visualized.

Table 2. Evaluation of nasofrontal duct right according to imaging techniques

Nasofrontal Duct Right	Sinus CT	CBCT	+p
	Mean±SD (Median)	Mean±SD (Median)	
Observer1	1,25±0,86 (1)	1,92±0,29 (2)	0,023*
Observer2	1,08±0,79 (1)	1,75±0,62 (2)	0,022*
Observer3	1,00±0,85 (1)	1,67±0,65 (2)	0,041*
Observer1.-2.-3. ++p	0,717	0,607	
Observer1-2. +++p	0,480	0,414	
Obsever1-3. +++p	0,317	0,257	
Observer2-3. +++p	0,792	0,783	

+ Mann Whitney U test ++ Friedman Test +++ Wilcoxon sign test
*p<0.05

Table 3. Evaluation of left nasofrontal duct according to imaging techniques

Nasofrontal Duct Left	Sinus CT	CBCT	+p
	Mean±SD (Median)	Mean±SD (Median)	
Observer1	1,41±0,79 (1,5)	2,00±0,00 (2)	0,015*
Observer2	1,25±0,87 (1,5)	1,83±0,58 (2)	0,040*
Observer3	1,08±0,79 (1)	1,58±0,67 (2)	0,100
Observer1.-2.-3. ++p	0,401	0,074	
Observer1-2. +++p	0,577	0,317	
Observer1-3. +++p	0,157	0,059	
Observer2-3. +++p	0,527	0,408	

+ Mann Whitney U test ++ Friedman Test +++ Wilcoxon sign test
*p<0.05

Table 4. Evaluation of right sphenoethmoidal recess according to imaging techniques

Sphenoethmoidal Recess Right	Sinus CT	CBCT	+p
	Mean±SD (Median)	Mean±SD (Median)	
Observer1	1,58±0,51 (2)	2,00±0,00 (2)	0,014*
Observer2	1,75±0,62 (2)	2,00±0,00 (2)	0,149
Observer3	1,33±0,78 (1,5)	1,50±0,52 (1,5)	0,699
Observer1.-2.-3. ++p	0,577	0,317	
Observer1-2. +++p	0,414	1,000	
Observer1-3. +++p	0,059	0,317	
2-3. gözlemci +++p	0,102	0,607	

+ Mann Whitney U test ++ Friedman Test +++ Wilcoxon sign test
*p<0.05

Table 5. Evaluation of left sphenoethmoidal recess according to imaging techniques

Sphenoethmoidal Recess Left	Sinus CT	CBCT	^{+}p
	Mean±SD (Median)	Mean±SD (Median)	
Observer1	1,58±0,51 (2)	2,00±0,00 (2)	0,014*
Observer2	1,58±0,67 (2)	2,00±0,00 (2)	0,033*
Observer3	1,33±0,78 (1,5)	1,83±0,39 (2)	0,070
Observer1.-2.-3. ^{++}p	0,641	0,135	
Observer1-2. ^{+++}p	1,000	1,000	
Observer1-3. ^{+++}p	0,257	0,157	
Observer2-3. ^{+++}p	0,366	0,157	

+ Mann Whitney U test ++ Friedman Test +++ Wilcoxon sign test
*$p<0.05$

are not dependent on a minimum threshold of exposure, such as carcinogenesis. Therefore, as with all radiological investigations, radiation dose should be kept as low as reasonably practicable.[20]

In this study, image quality was assessed upon analysis of the images based on anatomy. A European study group has produced a working document relating to quality criteria for CT in response to a European Commission directive. Our assessment of image quality of the paranasal sinuses is similar to these European guidelines, that is assessing images for visually sharp reproduction (i.e. clearly defined) or just reproduction (i.e.details visible but not clearly defined) of anatomic details.[21]

The growth of tumors within the maxilla is not concentric, therefore the site of origin is not necessarily the epicenter of lesion. The maxillary sinus, or antra, constituted the path of least resistance for the growth of such maxillary lesions as cysts and benign neoplasms. Antral malignancies produce clinical signs and symptoms relatively late, when the prognosis is often quite poor. Experimental studies have shown that CT provides evaluation of osteolitic lesions in the latero-superior or middle of the posterior sinus wall.[22]

The radiation exposure to a patient from a conventional CT is approximately 1,031-1,420 microsieverts for the maxilla and 1,320-3,324 microsieverts for the mandible.[16,23] The radiation exposure (for both mandible and maxilla) from CBCT 34-102 microsieverts depending on the time and resolution of the scan.[4] Our results indicate that the CBCT has sufficient diagnostic validity while causing only minimal radiation exposure to the patient. Regarding detection of rhinosinusitis the sensitivity of even discrete findings was 100%, implying a safe use for daily clinical practice.

In conclusion, compared to the literature our results an impressing advantage in dose reduction by CBCT techniques. CT is a specialist investigation and provides unique information about the ostial anatomy, however radiation doses from CT are relatively high according to ICRP. Cone beam CT gives a substantial dose reduction compared with standart-dose protocols in CT, but detection of the most important anatomic landmarks of paranasal sinuses.

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