# Comparison of Diagnostic Quality of Multidetector Computed Tomography and Cone-Beam Computed Tomography in High and Low Resolution Modes for Assessment of the Nasal Cavity

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# ABSTRACT

**Background:** We aimed to compare the diagnostic quality of multidetector computed tomography (MDCT) and cone-beam computed tomography (CBCT) in high (HR) and low (LR) resolution modes for assessment of the nasal cavity and paranasal sinuses.

**Methods:** This in vitro study was conducted on 5 dry human skulls by using a CBCT and a MDCT scanner in HR and LR modes to assess their diagnostic quality for 21 anatomical landmarks of the nose. The quality of images was evaluated by two oral and maxillofacial radiologists and a dentist using a four-point Likert scale of (I) poor, (II) decreased, (III) good, and (IV) excellent. Data were analyzed by STATA at 95% confidence interval. The Chisquare test was applied to compare the quality of visualization of landmarks based on the type of scanner.

**Results:** The diagnostic quality of HR CBCT and CT for the majority of landmarks was higher than that of LR CBCT and CT (P<0.05). The diagnostic quality of HR CBCT for agger nasi cells (P=0.010), olfactory cleft (P=0.032), sphenoethmoidal recess (P=0.032), and nasolacrimal duct (P=0.014) and LR CBCT for the middle turbinate (P=0.046) and middle meatus (P=0.031) was significantly higher than that of MDCT.

**Conclusion:** The diagnostic quality of HR CBCT and CT for the majority of the landmarks in the nasal cavity and paranasal sinuses was higher than that of LR CBCT and CT. For the majority of landmarks, the diagnostic quality of CBCT and CT was the same; while for some landmarks, the diagnostic quality of HR and LR CBCT was higher than HR and LR CT. In general, CBCT has high efficacy for evaluation of the paranasal sinuses and the nasal cavity, and provides diagnostic information comparable to those provided by CT, but with a much lower radiation dose.

## **KEYWORDS**

Nasal Cavity; Multidetector Computed Tomography; Cone-Beam Computed Tomography

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### INTRODUCTION

Nasal cavity is part of the craniofacial region that has a complex structure and a close anatomical correlation with the teeth and periodontal tissues <sup>1</sup>, <sup>2</sup>. The inferior, middle, and superior conchae are the main components of the lateral wall of the nasal cavity (the concha and its covering mucosa is referred to as a turbinate). Such structures that stick out from the walls into the nasal cavity serve as a bubble to warm, cool, or humidify air. The space between the conchae is referred to as meatus. The inferior meatus is below the inferior concha, and is where the nasolacrimal duct is drained. The middle meatus is where the frontal, anterior ethmoid, and maxillary sinuses drain. Also, a communication exists between the middle meatus and the maxillary sinus through an opening known as ostium. The superior meatus is connected to the posterior ethmoid and sphenoid sinuses through the sphenoethmoidal notch. The nasal cavity is divided into 2 parts by the nasal septum. The anterior part of the septum is made of cartilage while its posterior part has a bony structure. The osteomeatal complex is a functional region composed of components such as the hiatus semilunaris, uncinate process, ethmoidal bulla, ostium, etc.<sup>2</sup>.

Computed tomography (CT) is a commonly used imaging modality for evaluation of the nasal cavity, and is the standard method for diagnosis of diseases in this region <sup>3</sup>. However, CT has high radiation dose, and adverse effects on the organs and tissues that are sensitive to radiation, which is its major drawback. Thus, optimization of its radiation dose is imperative. Accordingly, it is necessary to find out whether low-dose protocols of multidetector CT (MDCT) can provide optimal-quality images for diagnostic purposes and evaluation of the nasal cavity <sup>1</sup>.

Cone-beam computed tomography (CBCT) is also one of the most advanced efficient imaging techniques for this region, which has a radiation dose lower than that of CT and imposes lower cost on patients<sup>4</sup>. However, there are doubts that whether CBCT can have a diagnostic quality as good as that of MDCT, and whether or not it can visualize all the related anatomical landmarks in this region as accurate as does the MDCT.

A wide range of variation exists in the available literature regarding the exposure parameters and the applied imaging protocols for radiographic visualization of the sinonasal area <sup>1</sup>. Thus, we aimed

to compare the diagnostic quality of MDCT and CBCT in high resolution (HR) and low resolution (LR) modes for evaluation of the nasal cavity to find the best protocol with the most reasonable dosage for clinical applications.

#### MATERIALS AND METHODS

This in vitro study was conducted on 5 dry human mandibles obtained from the Anatomy Department of the School of Dentistry, Hamadan University of Medical Sciences, Hamadan, Iran after obtaining approval from the Ethics Committee (IR.UMSHA. REC.1399.599).

The skulls were evaluated visually and then radiographically to ensure absence of fracture. The inclusion criteria were sound skulls and no fracture in the nasal cavity or paranasal sinuses. The exclusion criteria were absence of respective landmarks and sinus aplasia. The skulls underwent CBCT and MDCT in HR and LR modes, and the anatomical areas of the nasal cavity and paranasal sinuses were scanned (Fig. 1).

#### **CBCT** scanning protocol

The skulls were fixed to the CBCT scanner (Kodak 9300, Carestream, Paris, France) and the voltage of the tube was adjusted at 80 kV with an amperage of 2 mA. The size of field of view (FOV) was 13.5 x 17 cm. The entire midface was scanned with 300  $\mu$ m voxel size for HR mode and 500  $\mu$ m voxel size for LR mode. The scanning time was 11.30 seconds, and the image reconstruction time was 3-5 minutes.

Images were evaluated in axial, coronal, and sagittal sections with 0.5 mm slice interval and 0.5 mm slice thickness using OnDemand 3D app (CyberMed, Seoul, Korea).

#### **MDCT scanning protocol**

The tube voltage was adjusted at 120 kV, the FOV was 100 mm x 170 mm, collimation was 0.625 mm x 64, pitch was 0.5, and gantry rotation time was 0.5 seconds. The amperage was adjusted at 80 mA, and the scanner was set in either HR mode with 1.5 mm slice or LR mode with 5 mm slice, with 250  $\mu$ m voxel size. The overall scanning time was 15.7 seconds. The CT scanner used was a spiral CT scanner (Siemens, Berlin, Germany).

All images were analyzed by Syngo (Siemens, Berlin, Germany) software.



Figure 1: Positioning of the skulls; (upper row) in a CBCT scanner; (lower row) in a MDCT scanner



Figure 2: Axial sections; (A) high-resolution CBCT; (B) low-resolution CBCT, (C) high-resolution CT, (D) low-resolution CT

The following anatomical landmarks were evaluated by two oral and maxillofacial radiologists and a dentist: middle turbinate, maxillary sinus ostium, middle meatus, ethmoid bulla, uncinate process, semilunar hiatus, maxillary sinus, agger nasi cells, frontal sinus, anterior ethmoidal cell, lamina papyracea, ethmoid roof, cribriform plate, olfactory cleft, sphenoid sinus, sphenoethmoidal sinus,



Figure 3: Coronal sections; (A) high-resolution CBCT; (B) low-resolution CBCT, (C) high-resolution CT, (D) low-resolution CT



Figure 4: Sagittal sections; (A) high-resolution CBCT; (B) low-resolution CBCT, (C) high-resolution CT, (D) low-resolution CT

nasolacrimal duct, foramen rotundum, supraorbital cell, and Haller cells. The images were qualitatively assessed by the observers in axial, coronal and sagittal sections (Fig 2-6), and were scored using a Likert scale as follows <sup>4</sup>:

- Poor image quality, poor anatomical details, high noise and artifact, poor diagnosis

- Decreased image quality, limited anatomical details, increased noise and artifact, impaired diagnosis

- Good image quality, clear anatomical details, slight noise and artifact, no impairment in diagnosis

- Excellent image quality, distinct anatomical details, no or minimal noise and artifact, perfect diagnosis.



Figure 5: (upper row) High-resolution CBCT in axial, coronal and sagittal sections from right to left; (lower row) low-resolution CBCT in axial, coronal and sagittal sections from right to left



Figure 6: (upper row) High-resolution CT in axial, coronal and sagittal sections from right to left; (lower row) lowresolution CT in axial, coronal and sagittal sections from right to left

To assess the inter-observer and intraobserver agreements, the images were initially evaluated by the three observers, and then 10% of the images were observed again by the same observers after a 2-week interval.

The classified variables were reported as frequency and percentage, and analyzed by STATA 14.2 software. The Chi-square test was applied to compare the quality of landmarks according to the type of imaging modality. Level of significance was set at 0.05.

## **RESULTS**

The intraobserver agreement was 92% and the interobserver agreement was over 90%, indicating excellent agreement. Since the Haller cell landmark may be absent in some skulls as a normal anatomical

-		Scanners				
Landmark	Quality	HR CBCT	LR CBCT	HR CT	LR CT	P-value
		Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	
Middle turbinate	Good	0 (0.00)	2 (13.33)	0(0.00)	7(4.67)	*0.001
Middle turbinate Maxillary sinus ostium Middle meatus Ethmoid bulla	Excellent	15(100.00)	13(86.67)	15(100.00)	8(53.33)	0.001
Maxillary sinus astium	Good	0(0.00)	0(0.00)	0(0.00)	2(13.33)	0.102
Maxillary sinus ostium	Excellent	15(100.00)	15(100.00)	15(100.00)	13(86.67)	
Middle meatus	Good	0(0.00)	1(6.67)	0(0.00)	6(40.00)	0.001*
Wildele incutus	Excellent	15(100.00)	14(93.33)	15(100.00)	9(60.00)	0.001
	Decreased	0(0.00)	2(13.33)	2(13.33)	2(13.33)	
Ethmoid bulla	Good	1(6.67)	11(73.33)	3(20.00)	10(66.67)	*<0.001
	Excellent	14(93.33)	2(13.33)	10(66.67)	3(20.00)	-
Uncinate process	Good	1(6.67)	7(46.67)	0(0.00)	7(46.67)	0.002*
Uncinate process Semilunar hiatus	Excellent	14(93.33)	8(53.33)	15(100.00)	8(53.33)	0.002
	Decreased	0(0.00)	0(0.00)	0(0.00)	1(6.67)	0.051
Semilunar hiatus	Good	2(13.33)	6(40.00)	1(6.67)	7(46.67)	
	Excellent	13(86.67)	9(60.00)	14(93.33)	7(46.67)	
NG :11 ·	Good	0(0.00)	1(6.67)	0(0.00)	0(0.00)	0.384
wiaxinary sinus	Excellent	15(100.00)	14(93.33)	15(100.00)	15(100.00)	
	Decreased	0(0.00)	0(0.00)	2(13.33)	1(6.67)	0.002*
Agger nasi cell	Good	0(0.00)	8(53.33)	5(33.33)	10(66.67)	
	Excellent	15(100.00)	7(46.67)	8(53.33)	4(26.67)	
	Decreased	0(0.00)	0(0.00)	2(13.33)	0(0.00)	
Nasofrontal duct	Good	3(20.00)	8(53.33)	2(13.33)	9(60.00)	0.016*
	Excellent	12(80.00)	7(46.67)	11(73.33)	6(40.00)	
Frontal sinus	Excellent	15(100.00)	15(100.00)	15(100.00)	15(100.00)	-
	Decreased	0(0.00)	0(0.00)	2(13.33)	2(13.33)	
Anterior ethmoidal cell	Good	1(6.67)	13(86.67)	4(26.67)	8(53.33)	*<0.001
	Excellent	14(93.33)	2(13.33)	9(60.00)	5(33.33)	
Lamina papyracea	Good	0(0.00)	0(0.00)	0(0.00)	3(20.00)	0.024*
Lamma papyracca	Excellent	15(100.00)	15(100.00)	15(100.00)	12(80.00)	0.024
Ethmoid roof	Good	0(0.00)	5(33.33)	1(6.67)	4(26.67)	0.043*
Lumou 1001	Excellent	15(100.00)	10(66.67)	14(93.33)	11(73.33)	
Cribriform plate	Decreased	0(0.00)	2(13.33)	2(13.33)	2(13.33)	0.001*
Criornorni piate	Good	0(0.00)	9(60.00)	1(6.67)	4(26.67)	
·						

Table 1: Comparison of diagnostic quality of MDCT and CBCT in HR and LR modes for assessment of the nasal cavity landmarks

		Scanners					
Landmark	Quality	HR CBCT	LR CBCT	HR CT	LR CT	P-value	
		Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)		
	Excellent	15(100.00)	4(26.67)	12(80.00)	9(60.00)		
Olfactory cleft	Good	0(0.00)	11(73.33)	4(26.67)	7(46.67)	*<0.001	
chuctory cleft	Excellent	15(100.00)	4(26.67)	11(73.33)	8(53.33)	(0.001	
Sphenoid sinus	Good	0(0.00)	0(0.00)	0(0.00)	3(20.00)	0.024*	
opiteliola sillas	Excellent	15(100.00)	15(100.00)	15(100.00)	12(80.00)	0.021	
Sphenoethmoidal	Decreased	0(0.00)	0(0.00)	0(0.00)	4(26.67)	0.004*	
recess	Good	0(0.00)	4(26.67)	4(26.67)	1(6.67)		
10005	Excellent	15(100.00)	11(73.33)	11(73.33)	10(66.67)		
Nasolacrimal duct	Decreased	0(0.00)	0(0.00)	0(0.00)	2(13.33)		
	Good	0(0.00)	1(6.67)	5(33.33)	3(20.00)	0.027*	
	Excellent	15(100.00)	14(93.33)	10(66.67)	10(66.67)		
Foramen rotundum	Decreased	0(0.00)	0(0.00)	0(0.00)	2(13.33)		
	Good	1(6.67)	2(13.33)	4(26.67)	6(40.00)	0.042*	
	Excellent	14(93.33)	13(86.67)	11(73.33)	7(46.67)		
Supraorbital cell	Decreased	0(0.00)	2(13.33)	0(0.00)	1(6.67)		
	Good	1(6.67)	5(33.33)	3(20.00)	6(40.00)	0.118	
	Excellent	14(93.33)	8(53.33)	12(80.00)	8(53.33)		
Haller cells	Good	0(0.00)	3(33.33)	2(22.22)	3(33.33)	0.277	
Tuner cens	Excellent	9(100.00)	6(66.67)	7(77.78)	6(66.67)	0.277	

\*Statistically significant

variation, it was present on 9 scans, and the results were analyzed based on this number.

Table 1 shows the Comparison of diagnostic quality of MDCT and CBCT in HR and LR modes for assessment of the nasal cavity landmarks.

Table 2 shows the Comparison of diagnostic quality of CBCT in HR and LR modes for assessment of the nasal cavity landmarks.

In cases with a statistically significant difference, the quality of HR CBCT was significantly higher than LR CBCT.

Table 3 shows the comparison of diagnostic quality of MDCT in HR and LR modes in assessment of the

nasal cavity landmarks.

In cases with a statistically significant difference, the quality of HR CT was significantly higher than LR CT.

Table 4 shows the comparison of diagnostic quality of HR CBCT with HR CT in assessment of the nasal cavity landmarks.

In cases with a statistically significant difference, the quality of HR CBCT was significantly higher than HR CT.

Table 5 shows the comparison of diagnostic quality of LR MDCT with LR CBCT for assessment of the nasal cavity landmarks.

		Scan		
Landmark	Quality	HR CBCT	LR CBCT	P-value
		Frequency (%)	Frequency (%)	
	Good	0 (0.00)	2 (13.33)	*0.001
Middle turbinate	Excellent	15(100.00)	13(86.67)	^0.001
5.4 HI	Good	0 (0.00)	0 (0.00)	0.100
Maxillary sinus ostium	Excellent	15(100.00)	15(100.00)	0.102
	Good	0 (0.00)	1(6.67)	*0.001
Middle meatus	Excellent	15(100.00)	14(93.33)	~0.001
	Decreased	0 (0.00)	2(13.33)	
Ethmoid bulla	Good	1(6.67)	11(73.33)	*<0.001
	Excellent	14(93.33)	2(13.33)	
Linginato pue soos	Good	1(6.67)	7(46.67)	0.002*
Uncinate process	Excellent	14(93.33)	8(33.53)	0.002*
	Decreased	0 (0.00)	0 (0.00)	
Semilunar hiatus	Good	2(13.33)	6(40.00)	0.051
	Excellent	13(86.67)	9(60.00)	_
Marrillanna airean	Good	0 (0.00)	1(6.67)	0.294
Maxillary sinus	Excellent	15(100.00)	14(93.33)	0.384
	Decreased	0 (0.00)	0 (0.00)	
Agger nasi cell	Good	0 (0.00)	8(53.33)	0.002*
	Excellent	15(100.00)	7(46.67)	
	Decreased	0 (0.00)	0 (0.00)	
Nasofrontal duct	Good	3(20.00)	8(53.33)	0.016*
	Excellent	12(80.00)	7(46.67)	_
Frontal sinus	Excellent	15(100.00)	15(100.00)	-
	Decreased	0 (0.00)	0 (0.00)	0.001<*
Anterior ethmoidal cell	Good	1(6.67)	13(86.67)	
	Excellent	14(93.33)	2(13.33)	
<b>.</b> .	Good	0 (0.00)	0 (0.00)	0.0044
Lamina papyracea	Excellent	15(100.00)	15(100.00)	0.024*
	Good	0 (0.00)	5(33.33)	0.0.401
Ethmoid root	Excellent	15(100.00)	10(66.67)	0.043*
	Decreased	0 (0.00)	2(13.33)	
Cribriform plate	Good	0 (0.00)	9(60.00)	0.001*
L.	Excellent	15(100.00)	4(26.67)	
	Good	0 (0.00)	11(73.33)	0.001.1
Olfactory cleft	Excellent	15(100.00)	4(26.67)	- 0.001<*
0.1	Good	0 (0.00)	0 (0.00)	0.02.11
Sphenoid sinus	Excellent	15(100.00)	15(100.00)	0.024*
	Decreased	0 (0.00)	0 (0.00)	
Sphenoethmoidal recess	Good	0 (0.00)	4(26.67)	0.004*
	Excellent	15(100.00)	11(73.33)	
	Decreased	0 (0.00)	0 (0.00)	0.027*
Nasolacrimal duct	Good	0 (0.00)	14(93.33)	
	Excellent	15(100.00)	14(93.33)	
	Decreased	0 (0.00)	0 (0.00)	0.042*
Foramen rotundum	Good	1(6.67)	2(13.33)	
	Excellent	14(93.33)	13(86.67)	
a 1	Decreased	0 (0.00)	2(13.33)	0.118
Supraorbital cell	Good	1(6.67)	5(33.33)	
	Excellent	14(93.33)	8(53.33)	
	Good	0 (0.00)	3(33.33)	0.1
Haller cell	Excellent	9(100.00)	6(66.67)	0.277
		. ,	. ,	

# Table 2: Comparison of diagnostic quality of CBCT in HR and LR modes for assessment of the nasal cavity landmarks

\*Statistically significant.

Table 3: Comparison of diagnostic quality of MDCT in HR and LR modes in assessment of the nasal cavity landmarks

1 0 1	, ,	Scan		
Landmark	Ouality	LR CT	HR CT	P-value
		Frequency (%)	Frequency (%)	
	Good	0 (0.00)	7(4.67)	0.001*
Middle turbinate	Excellent	15(100.00)	8(53,33)	
	Good	0 (0.00)	2(13.33)	0.102
Maxillary sinus ostium	Excellent	15(100.00)	13(86.67)	
	Good	0 (0 00)	6(40.00)	0.001*
Middle meatus	Excellent	15(100.00)	9(60.00)	0.001
	Decreased	2(13 33)	2(13.33)	
Ethmoid bulla	Good	3(20.00)	10(66.67)	0.001<*
Edimoid build	Excellent	10(66.67)	3(20.00)	0.001 <
	Good	0 (0 00)	7(46.76)	0.002*
Uncinate process	Excellent	15(100.00)	8(53.33)	0.002
	Decreased	0 (0 00)	1(6.67)	0.051
Semilupar biatus	Good	1(6.67)	7(4.67)	0.051
Seminarian matus	Excellent	1/(03.33)	7(4.67)	_
	Cood	0 (0 00)	7(4.07)	0.294
Maxillary sinus	Excellent	15(100.00)	15(100.00)	0.364
	Decreased	2(12.22)	13(100.00)	0.002*
	Cood	2(13.33)	1(0.07)	0.002
Agger hast cell	Good	D(53.55)	10(00.07)	_
	Excellent	ð(55.55)	4(20.07)	0.017
No sector and all design	Decreased	2(13.33)	0 (0.00)	0.016
Nasofrontal duct	Good	2(13.33)	9(60.00)	_
	Excellent	11(73.33)	6(40.00)	
Frontal sinus	Excellent	15(100.00)	15(100.00)	-
	Decreased	2(13.33)	2(13.33)	0.001<*
Anterior ethmoidal cell	Good	4(26.67)	8(53.33)	_
	Excellent	9(60.00)	5(53.33)	
Lamina papyracea	Good	0 (0.00)	3(20.00)	0.024*
1 17	Excellent	15(100.00)	12(80.00)	
Ethmoid roof	Good	1(6.67)	4(26.67)	0.043*
	Excellent	14(93.33)	11(73.33)	
	Decreased	2(13.33)	2(13.33)	_
Cribriform plate	Good	1(6.67)	4(26.67)	0.001*
	Excellent	12(80.00)	9(60.00)	
Olfactory cleft	Good	4(26.67)	7(46.67)	0.001<*
	Excellent	11(73.33)	8(53.33)	0.001 (
Sphenoid sinus	Good	0 (0.00)	3(20.00)	0.024*
opnenota onnas	Excellent	15(100.00)	12(80.00)	0.021
	Decreased	0 (0.00)	4(26.67)	
Sphenoethmoidal recess	Good	4(26.67)	1(6.67)	0.004*
	Excellent	11(73.33)	10(66.67)	
	Decreased	0 (0.00)	2(13.33)	0.027*
Nasolacrimal duct	Good	5(33.33)	3(20.00)	
	Excellent	10(66.67)	10(66.67)	
	Decreased	0 (0.00)	2(13.33)	0.420*
Foramen rotundum	Good	4(26.67)	6(40.00)	
	Excellent	11(73.33)	7(46.67)	
Common and its 1 - 11	Decreased	0 (0.00)	1(6.67)	
Supraorbital cell	Good	3(20.00)	6(40.00)	0.118
	Excellent	12(80.00)	8(53.33)	
TT-1111	Good	2(22.22)	3(33.33)	0.077
Haller cell	Excellent	7(77.78)	6(66.67)	0.277

\*Statistically significant.

IandmarkQualityHRCTHRCBCTPrequeny (%)Middle turbinatExcellent15(100.00)15(100.00)1Maxillary sinus ostiumExcellent15(100.00)15(100.00)1Maddle meatusExcellent15(100.00)15(100.00)1Middle meatusExcellent15(100.00)2(13.33)01066.07)Ethmoid bullaGood16(6.7)3(0.00)0.00Berceade14(93.33)10(66.07)0.00.000.00Muncinate processGood16(6.7)14(93.33)16(6.7)Berceade15(100.00)2(13.33)16(6.7)0.010.01Maxillary sinusExcellent15(100.00)14(93.33)0.010*Agger nasi cellFercaded00.00016(31.33)0.010*Frontal sinusExcellent15(100.00)2(13.33)0.010*Masofrontal ductGood3(20.00)2(13.33)0.010*Frontal sinusExcellent15(100.00)16(30.33)0.010*Masofrontal ductExcellent15(100.00)12(13.33)0.010*Frontal sinusExcellent15(100.00)12(13.33)0.010*Masofrontal ductExcellent15(100.00)12(13.33)0.010*Frontal sinusExcellent15(100.00)12(13.33)0.010*Masofrontal ductExcellent15(100.00)12(13.33)0.01*Frontal sinusExcellent15(100.00)12(13.33)0.01*Masofrontal ductExcellent15(100.		Quality	Scan		
Image shows the section of the sect	Landmark		HR CT	HR CBCT	P-value
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Ethmoid bullaGood1(6.67)3(20.00)0.169Incinate processGood1(6.67)0(10,00)0.309Excellent14(93.33)1(6.67)0.309Semilunar hiatusGood2(13.33)1(6.67)0.4(93.33)Maxillary sinusExcellent13(86.67)14(93.33)0.613Maxillary sinusExcellent15(100.00)15(100.00)2(13.33)Agger nasi cellGood0(0.00)5(33.33)0.01°Excellent15(100.00)8(53.33)0.01°Excellent15(100.00)2(13.33)0.216Masofrontal ductGood0(0.00)2(13.33)0.216Frontal sinusExcellent15(100.00)15(100.00)-Frontal sinusExcellent15(100.00)15(100.00)-Anterior ethmoidal cellExcellent15(100.00)16(67)0.09Anterior ethmoidal cellExcellent15(100.00)11(73.33)-Good0(0.00)1(6.67)0.016Becreased0(0.00)1(6.67)0.02*-Anterior ethmoid acoidExcellent15(100.00)11(6.37)-Becreased0(0.00)1(6.67)0.02*-Becreased0(0.00)14(6.57)Anterior ethmoid acoidExcellent15(100.00)11(73.39)-Becreased0(0.00)11(6.57)Becreased0(0.00)14(26.67)Anterior ethm		Decreased	0 (0.00)	2(13.33)	0.160
Excellent14(93.33)10(66.67)0.0.00Uncinate processGood1(6.67)0.0.000.309Semiluar hiatusGood2(13.33)15(100.00)-Semiluar hiatusExcellent13(86.67)14(93.33)0.543Maxillary sinusExcellent15(100.00)15(100.00)-Agger nasi cellGood0(00)2(13.33)0.016Excellent15(100.00)8(53.33)0.016Excellent15(100.00)2(13.33)0.016Excellent15(100.00)2(13.33)0.016Masofrontal ductGood0(0.00)2(13.33)0.087Frontal sinusExcellent15(100.00)15(100.00)-Excellent15(100.00)15(100.00)-0.087Anterior ethmoidal cellGood1(6.67)4(26.67)0.087Ethmoid roofExcellent15(100.00)11(6.67)0.087Ethmoid roofGood0(0.00)1(6.67)0.3330.309Ethmoid roofExcellent15(100.00)14(93.33)0.309Cribriform plateGood0(0.00)11(73.33)0.32*Otfactory cleftGood0(0.00)15(103.00)0.02*Sphenoid sinusExcellent15(100.00)11(73.33)0.01*Sphenoid sinusExcellent15(100.00)11(73.33)0.01*Good0(0.00)(5(33.33)0.01*0.02*Sphenoid sinusExcellent15(100.00)11(73.33)0.01*<	Ethmoid bulla	Good	1(6.67)	3(20.00)	
BoddIcon0.0000.309Excellent14(93.33)15(100.00)0.349Semilunar hiatusGood2(13.33)116(67)0.543Maxillary sinusExcellent13(8667)14(93.33)0.543Maxillary sinusExcellent15(100.00)2(13.33)0.543Agger nasi cellGood0(0.00)2(13.33)0.010*Excellent15(100.00)8(53.33)0.010*Decreased0(0.00)2(13.33)0.326Excellent15(100.00)2(13.33)0.326Excellent12(80.11)111(73.33)0.326Excellent12(80.11)111(73.33)0.326Frontal sinusExcellent15(100.00)2(13.33)Anterior ethmoidal cellGood1(667)4(26.67)Good0(0.00)2(13.33)9(87.00)0.087Ethmoid roofGood16(57)4(26.67)0.309Ethmoid roofGood0(0.00)16(67)0.309Cribriform plateGood0(0.00)2(13.33)0.324Olfactory cleftGood0(0.00)11(73.33)0.032*Sphenoid sinusExcellent15(100.00)11(73.33)0.032*Sphenoid sinusExcellent15(100.00)11(73.33)0.032*Sphenoid sinusExcellent15(100.00)11(73.33)0.032*Sphenoid sinusExcellent15(100.00)11(73.33)0.032*Sphenoid sinusExcellent15(100.00)11(73.33)0.032*		Excellent	14(93.33)	10(66.67)	
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Semilunar hiatusGood2(13.33)1(6.67)0.543Racellent13(86.67)14(93.33)0.543Maxillary sinusExcellent15(100.00)2(13.33).Agger nasi cellGood0(0.00)5(33.33)0.010°Excellent15(100.00)8(53.33)0.010°Excellent15(100.00)2(13.33)Masofrontal ductGood0(0.00)2(13.33)Masofrontal ductGood3(20.00)2(13.33)Frontal sinusExcellent12(80.11)11(70.33)Excellent12(80.11)15(100.00)15(100.00)Anterior ethmoidal cellGood1(6.67)4(26.67)Good0(0.00)11(6.67)4(26.67)	Uncinate process	Excellent	14(93.33)	15(100.00)	0.309
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Maxillary sinusExcellent15(100.00)15(100.00).Agger naic cellDecreased0 (0.00)2(13.33)	Semilunar hiatus	Excellent	13(86.67)	14(93.33)	0.543
Aggr nasi cellDecreased0 (0.00)2 (13.33)0.010*Aggr nasi cellGood0 (0.00)5 (33.33)0.010*Excellent15 (100.00)8 (53.33)0.326Masofrontal ductGood3 (20.00)2 (13.33)0.326Excellent12 (80.11)11 (73.33)0.326Excellent15 (100.00)15 (100.00)-Frontal sinusExcellent15 (100.00)2 (13.33)Anterior ethmoidal cellGood1 (6.67)4 (26.67)Mania papyraceaExcellent15 (100.00)-Ethmoid roofGood0 (0.00)1 (6.67)Ethmoid roofGood0 (0.00)1 (6.67)Mania papyraceaExcellent15 (100.00)-Ethmoid roofExcellent15 (100.00)-Olfactory cleftGood0 (0.00)1 (403.33)Sphenoid sinusExcellent15 (100.00)-Sphenoid sinusExcellent15 (100.00)-Sphenoid sinusExcellent15 (100.00)-Good0 (0.00)4 (26.67)-Sphenoid sinusExcellent15 (100.00)-Becrellent15 (100.00)11 (73.33)-Olfactory cleftGood0 (0.00)4 (26.67)Sphenoid sinusExcellent15 (100.00)-Good0 (0.00)5 (33.33)-Other paper pap	Maxillary sinus	Excellent	15(100.00)	15(100.00)	-
Agger nasi cellGood0 (0.00)5(33.3)0.010*Excellent15(100.00)8(53.33)Perceased0 (0.00)2(13.3)Perceased0 (0.00)2(13.3)Perceased0 (0.00)2(13.3)Perceased0 (0.00)2(13.3)Perceased0 (0.00)10(5.00)Perceased0 (0.00)10(5.00)Perceased0 (0.00)10(5.00)Perceased0 (0.00)10(5.00)Perceased0.087		Decreased	0 (0.00)	2(13.33)	
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Nasofrontal ductDecreased0 (0.00)2 (13.33)AnteriorFrontal sinusExcellent12 (80.11)11 (73.33)0.326Frontal sinusExcellent15 (100.00)15 (100.00)-Anterior ethmoidal cellGood1 (6.67)4 (26.67)0.087Excellent14 (93.33)9 (87.00)Excellent15 (100.00)15 (100.00)Ethmoid roofExcellent15 (100.00)16 (6.67)-Becreased0 (0.00)11 (6.67)Becreased0 (0.00)11 (6.67)Becreased0 (0.00)11 (83.33)Becreased0 (0.00)11 (83.33)Becreased0 (0.00)11 (73.33)Becreased0 (0.00)11 (73.33)Becreased0 (0.00)11 (73.33)Becreased0 (0.00)11 (73.33)Bernotifictory cleftGood0 (0.00)4 (26.67)-Bernotifindi sinusExcellent15 (100.00)11 (73.33)-Sphenotifindi recessGood0 (0.00)4 (26.67)-Bernotifindi sinusExcellent15 (100.00)11 (73.33)-Bernotifindi sinusExcellent15 (100.00)11 (73.33)-Bernotifindi sinusExcellent15 (100.00)11 (73.33)-Bernotifindi sinusExcellent15 (100.00)11 (73.33)-		Excellent	15(100.00)	8(53.33)	
Nasofrontal ductGood3(20.00)2(13.33)0.326Excellent12(80.11)11(73.33)Frontal sinusExcellent15(100.00).Anterior ethmoidal cellGood1(6.67)4(26.67).Becreased0(0.00)2(13.33)ManapayraceaExcellent14(93.33)9(87.00).Camina papyraceaExcellent15(100.00)15(100.00).Bethmoid roofGood0(0.00)16(6.67).Becreased0(0.00)11(493.33)		Decreased	0 (0.00)	2(13.33)	
Excellent12(80.11)11(73.33)Frontal sinusExcellent15(100.00)15(100.00)Anterior ethmoidal cellGood1(6.67)4(26.67)Good1(6.67)4(26.67).0.087Excellent14(93.33)9(87.00).Excellent15(100.00)15(100.00).Ethmoid roofGood0(0.00)1(6.67)	Nasofrontal duct	Good	3(20.00)	2(13.33)	0.326
Frontal sinusExcellent15(100.00)15(100.00)-Decreased0 (0.00)2(13.33)000000000000000Anterior ethmoidal cellGood1(6.67)4(26.67)0.087Excellent14(93.33)9(87.00)-0.087Lamina papyraceaExcellent15(100.00)15(100.00)-Ethmoid roofGood0 (0.00)1(6.67)0.0309Ethmoid roofExcellent15(100.00)14(93.33)0.0309Cribriform plateGood0 (0.00)2(13.33)0.189Cribriform plateGood0 (0.00)1(6.67)0.189Olfactory cleftGood0 (0.00)4(26.67)0.032*Sphenoid sinusExcellent15(100.00)11(73.33)0.032*Sphenoid sinusExcellent15(100.00)11(73.33)0.014*Good0 (0.00)3(3.33)0.014*11(73.33)0.014*Sphenoethmoidal recessGood1(6.67)4(26.67)0.014*Foramen rotundumGood1(6.67)4(26.67)0.014*Supraorbital cell5(0000)11(73.33)0.14*Good1(6.67)4(26.67)0.142Excellent15(100.00)11(73.33)0.14*Foramen rotundumGood1(6.67)3(20.00)0.283Supraorbital cellGood1(6.67)3(20.00)0.283Haller cellGood0(0.00)2(22.21)0.13*Haller cellGood0(0.00)2(22.22)		Excellent	12(80.11)	11(73.33)	
Decreased0 (0.00)2(13.33)PropriateAnterior ethmoidal cellGood1(6.67)4(26.67)0.087Excellent14(93.33)9(87.00)-Lamina papyraceaExcellent15(100.00)15(100.00)-Ethmoid roofGood0 (0.00)11(6.67) $-$ 0.309Ethmoid roofExcellent15(100.00)14(93.33)0.039Cribriform plateGood0 (0.00)2(13.33)-Decreased0 (0.00)11(6.67)0.189Excellent15(100.00)11(6.67)-Olfactory cleftGood0 (0.00)4(26.67)-Excellent15(100.00)11(73.33)0.032*Sphenoid sinusExcellent15(100.00)11(73.33)-Sphenoid sinusExcellent15(100.00)11(73.33)-Sphenoid sinusExcellent15(100.00)11(73.33)-Sphenoid sinusExcellent15(100.00)11(73.33)-Sphenoid sinusExcellent15(100.00)11(73.33)-Baolacrimal ductGood0 (0.00)5(33.33)Baolacrimal ductGood1(6.67)4(26.67)Bauparobital cellGood1(6.67)4(26.67)Bauparobital cellGood1(6.67)3(20.00)Bauparobital cellGood1(6.67)3(20.00)Bauparobital cellGood1(6.67)3(20.00)- <td>Frontal sinus</td> <td>Excellent</td> <td>15(100.00)</td> <td>15(100.00)</td> <td>-</td>	Frontal sinus	Excellent	15(100.00)	15(100.00)	-
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Cribriform plateGood0 (0.00)1 (6.67)0.189Excellent15(100.00)12(80.00)000Olfactory cleftGood0 (0.00)4(26.67)0.032*Sphenoid sinusExcellent15(100.00)11(73.33)0.032*Sphenoid sinusExcellent15(100.00)4(26.67)0.032*Sphenoethmoidal recessGood0 (0.00)4(26.67)0.032*Masolacrimal ductGood0 (0.00)5(33.33)0.032*Foramen rotundumGood11(6.67)4(26.67)0.032*Supraorbital cellGood1 (6.67)4(26.67)0.014*Supraorbital cellGood1 (6.67)4(26.67)0.142Haller cellGood1 (6.67)3(20.00)0.283Haller cellGood0 (0.00)2(22.22)0.134		Decreased	0 (0.00)	2(13.33)	
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$\begin{array}{ c c c c c } \hline & Good & 0 & 0 & 0 & 4 & (26.67) & & & & & & & & & & & & & & & & & & &$		Excellent	15(100.00)	12(80.00)	
$\begin{tabular}{ c c c c c } \hline Excellent & 15(100.00) & 11(73.33) & 0.032^{4} \\ \hline Excellent & 15(100.00) & 15(100.00) & - \\ \hline & & & & & & & & & & & & & & & & & &$		Good	0 (0.00)	4(26.67)	0.022*
$ \begin{array}{ c c c c c c c } & & & & & & & & & & & & & & & & & & &$	Offactory cleft	Excellent	15(100.00)	11(73.33)	0.032*
$\begin{array}{c c} \mbox{Sphenoethmoidal recess} & Good & 0 & 0 & 0 & 4 & (26.67) & 0.032^{*} \\ \hline Excellent & 15 & 100.00 & 11 & (73.33) & 0.032^{*} \\ \hline Masolacrimal duct & Good & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & $	Sphenoid sinus	Excellent	15(100.00)	15(100.00)	-
$\frac{1}{1} + \frac{1}{1} + \frac{1}$	Cabon o other sidel as ease	Good	0 (0.00)	4(26.67)	0.032*
$\begin{tabular}{ c c c c } \hline & Good & 0 & (0.00) & 5(33.33) & & & & & & & & & & & & & & & & & & $	sphenoeumoidal recess	Excellent	15(100.00)	11(73.33)	
$\frac{1}{1} \frac{1}{1} \frac{1}$	Nacala mine al du at	Good	0 (0.00)	5(33.33)	0.014*
$\begin{tabular}{ c c c c c } \hline \mbox{Foramen rotundum} & \hline & Good & 1(6.67) & 4(26.67) & $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$	Nasolacrimal duct	Excellent	15(100.00)	10(66.67)	
Foramen rotundum         Excellent         14(93.33)         11(73.33)         0.142           Supraorbital cell         Good         1(6.67)         3(20.00)         0.283           Excellent         14(93.33)         12(80.00)         0.283           Haller cell         Good         0(0.00)         2(22.22)         0.134	Foreman and the last	Good	1(6.67)	4(26.67)	0.142
Good         1(6.67)         3(20.00)         0.283           Excellent         14(93.33)         12(80.00)         0.283           Haller cell         Good         0 (0.00)         2(22.22)         0.134	Foramen rotundum	Excellent	14(93.33)	11(73.33)	
Supraorbital cell         Excellent         14(93.33)         12(80.00)         0.283           Haller cell         Good         0 (0.00)         2(22.22)         0.134           Excellent         9(100.00)         7(77.78)         0.134	Common and Starl 11	Good	1(6.67)	3(20.00)	0.283
Haller cell         Good         0 (0.00)         2(22.22)         0.134           Excellent         9(100.00)         7(77.78)         0.134	Supraordital cell	Excellent	14(93.33)	12(80.00)	
Excellent 9(100.00) 7(77.78)	TT-1111	Good	0 (0.00)	2(22.22)	0.134
	Haller Cell	Excellent	9(100.00)	7(77.78)	

Table 4: Comparison of diagnostic quality of HR CBCT with HR CT in assessment of the nasal cavity landmarks

\* Statistically significant.

		Scan		
Landmark	Quality	LR CT	HR CT	P-value
		Frequency (%)	Frequency (%)	
Mille tooking to	Good	2(13.33)	7(46.67)	0.046
wilddie furbiliate	Excellent	13(86.67)	8(53.33)	0.046
	Good	0 (0.00)	2(13.33)	0.142
Maxinary sinus ostium	Excellent	15(100.00)	13(86.67)	0.143
	Good	1(6.67)	6(40.00)	0.021*
Middle meatus	Excellent	14(93.33)	9(60.00)	0.031^
	Decreased	2(13.33)	2(13.33)	-
Ethmoid bulla	Good	11(73.33)	10(66.67)	0.884
	Excellent	2(13.33)	3(20.00)	
TT : /	Good	7(46.67)	7(46.67)	1 000
Uncinate process	Excellent	8(53.33)	8(53.33)	1.000
	Decreased	0 (0.00)	1(6.67)	
Semilunar hiatus	Good	6(40.00)	7(46.67)	0.515
	Excellent	9(60.00)	7(46.67)	-
	Good	1(6.67)	0 (0.00)	0.000
Maxillary sinus	Excellent	14(93.33)	15(100.00)	0.309
	Decreased	0 (0.00)	1(6.67)	
Agger nasi cell	Good	8(53.33)	10(66.67)	0.361
00	Excellent	7(46.67)	4(26.67)	-
Nasofrontal duct	Good	8(53.33)	9(60.00)	
	Excellent	7(46.67)	6(40.00)	0.713
Frontal sinus	Excellent	15(100.00)	15(100.00)	-
	Decreased	0 (0.00)	2(13.33)	0.107
Anterior ethmoidal cell	Good	13(86.67)	8(53.33)	
	Excellent	2(13.33)	5(33.33)	
	Good	0 (0.00)	3(20.00)	
Lamina papyracea	Excellent	15(100.00)	12(80.00)	0.068
	Good	5(33.33)	4(26.67)	
Ethmoid roof	Excellent	10(66.67)	11(73.33)	0.690
	Decreased	2(13.33)	2(13.33)	
Cribriform plate	Good	9(60.00)	4(26.67)	0.146
I	Excellent	4(26.67)	9(60.00)	
	Good	11(73.33)	7(46.67)	
Olfactory cleft	Excellent	4(26.67)	8(53.33)	0.136
	Good	0 (0.00)	3(20.00)	
Sphenoid sinus	Excellent	15(100.00)	12(80.00)	0.068
	Decreased	0 (0.00)	4(26.67)	
Sphenoethmoidal recess	Good	4(26.67)	1(6.67)	0.054
opnenoeumiotaal recess	Excellent	11(73 33)	10(66.67)	0.001
	Decreased	0 (0 00)	2(13 33)	
Nasolacrimal duct	Good	1(6.67)	3(20,00)	0.160
i tussiuci initi duct	Excellent	14(93 33)	10(66.67)	
	Decreased	0 (0.00)	2(13 33)	
Foramen rotundum	Good	2(13 33)	6(40.00)	0.055
i oranich fotultulli	Excellent	13(86 67)	7(46.67)	
	Decreased	2(13 33)	1(6.67)	
Supraorbital cell	Good	5(33.33)	6(40.00)	0.809
	Excellent	8(53.33)	8(53 33)	0.007
	Good	3(33.33)	3(33.33)	
Haller cell	Excellent	6(66.67)	6(66.67)	1.000
	DACCHEIII	0(00.07)	0(00.07)	

# Table 5: Comparison of diagnostic quality of LR MDCT with LR CBCT for assessment of the nasal cavity landmarks

\*Statistically significant. In cases with a statistically significant difference, the quality of LR CBCT was significantly higher than

## DISCUSSION

This study compared the diagnostic quality of MDCT and CBCT in LR and HR modes for evaluation of the nasal cavity to find the best protocol with the most logical dosage for clinical applications. The results showed that the diagnostic quality of CBCT in HR mode for four landmarks of agger nasi cells, olfactory cleft, sphenoethmoidal recess, and nasolacrimal duct, and in LR mode for three landmarks of middle turbinate, middle meatus, and lamina papyracea was significantly higher than CT. However, no significant difference existed in diagnostic quality of CT and CBCT in HR and LR modes for sphenoid sinus and maxillary sinus landmarks. In line with the present results, Szabo et al, evaluated manual and semiautomatic methods for maxillofacial reconstruction by using CT and CBCT. They found that CBCT provides more reliable volumetric data about the maxillary sinus and sphenoid sinus volume and the nasal cavity compared with CT, and can be used for maxillofacial reconstruction 6.

In the present study, the quality of HR and LR CT was not significantly different for evaluation of the maxillary sinus ostium, frontal sinus, and maxillary sinus, which may be due to the fact that air cells of most sinuses have a significant difference in contrast with the adjacent bony structures, and such a high contrast facilitates the interpretation of images; thus, high resolution is not necessarily required for such observations. Also, assessment of the anatomy of sinuses is easy for most users, and excellent-quality images are not required. However, in the present study, a significant difference was noted in diagnostic quality of HR and LR CT for assessment of sphenoid sinus landmark, which may be due to more posterior position and small size of this landmark located adjacent to complex structures such as the carotid artery and optic nerve. Pirimoglu et al, in their study conducted in Turkey for evaluation of paranasal sinuses with low-dose CT concluded that low-dose CT can provide high-quality images <sup>7</sup>. Almashraqi et al, evaluated 14 landmarks in an Alderson Rando phantom with a FOV including the paranasal sinuses and found no significant difference between low-dose protocols of MDCT and CBCT for assessment of landmarks. They concluded that both scanners can be used with low-dose protocol for examination of the maxillary sinus<sup>1</sup>. However, the present study revealed that although the diagnostic quality of CBCT and CT

sinuses, a significant difference existed in diagnostic quality of LR CT and LR CBCT in assessment of the middle meatus and middle turbinate landmarks. Accordingly, the present study assessed more diverse anatomical landmarks in the same FOV and found more accurate results. Veldhoen et al, compared the efficacy of CBCT and MDCT for evaluation of the midface and concluded that low-dose CBCT had higher or equal quality in resolution compared with the standard dose. In images with similar quality, the resolution of higher dose CBCT was better <sup>5</sup>. The present sample size was smaller than that of Veldhoen et al; however, 21 landmarks were evaluated on images taken with more advanced scanners by two radiologists and one dentist in the present study. The results showed a significant correlation between HR and LR CBCT and CT at 15 points, indicating that CBCT and CT with LR mode can be used for primary diagnostic purposes. In case of requiring high-quality images for better observation of fine details at the aforementioned 15 points, HR CBCT and CT can be requested. Also, Veldhoen et al. <sup>5</sup> used 3D Accuitomo CBCT scanner (Morita, Japan) that required the patients to stand still for 31 seconds. They reported this as a drawback of this scanner compared with LR MDCT. However, a more advanced scanner, namely Kodak 9300 (Carestream, Paris, France) was used in the present study which was produced in 2019 and has a shorter exposure time of 11 seconds.

was not significantly different for assessment of the

Fakhran et al, compared CBCT simulated by the conventional spiral CT for imaging of rhinosinusitis cases. They concluded that in the majority of patients under simulated CBCT assessment for sinusitis, acute soft tissue findings were scarce. By proper patient selection, CBCT can provide a considerably lower radiation dose, and may serve as a suitable alternative to standard MDCT sinus imaging protocols 8. In the present study, the quality of CBCT images for nasofrontal duct and agger nasi cells was significantly higher than MDCT. However, for structures related to sinusitis, i.e. ethmoid bulla, uncinate process, semilunar hiatus, maxillary sinus, frontal sinus, and sphenoid sinus, no significant difference existed between the diagnostic quality of CBCT and MDCT. Considering the lower radiation dose of CBCT than MDCT, CBCT with lower radiation dose can serve as a suitable alternative to MDCT. However, in case of requiring soft tissue assessment of the region,

MDCT may be used due to inability of CBCT to show the soft tissue contrast. Since no significant difference was found in diagnostic quality of LR and HR CT for evaluation of the frontal sinus, maxillary sinus, and semilunar hiatus landmarks, LR CT may be requested for such assessments to decrease the patient radiation dose. However, since a significant difference was found in diagnostic quality of HR and LR CT for ethmoid bulla, uncinate process, agger nasi cells, nasofrontal duct, and sphenoid sinus, HR CT may be preferred for such assessments.

Tschauner S concluded that dedicated trauma extremity CBCT may require lower radiation doses than MDCT at increased semi-objective image quality parameters. However, beam hardening artifacts might degrade the subjective image impression in many cases <sup>9</sup>.

Comprehensive assessment of multiple landmarks by HR and LR CBCT and MDCT, and precise evaluation of scans by two independent radiologists and a dentist were among the main strengths of the present study. However, conduction of study on dry skulls and absence of soft tissue can be considered as possible limitations of this study.

#### **CONCLUSION**

The diagnostic quality of HR CBCT and CT for the majority of landmarks in the nasal cavity and paranasal sinuses was higher than the diagnostic quality of LR CBCT and CT. In most landmarks, the diagnostic quality of CT and CBCT was the same while in some landmarks, the diagnostic quality of HR and LR CBCT was higher than HR and LR CT. In general, CBCT has high efficacy for assessment of the paranasal sinuses and the nasal cavity and provides diagnostic information comparable to those provided by CT with much lower patient radiation dose.

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## **CONFLICT OF INTEREST**

The authors declare that there is no conflict of interests.

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