Original Article

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 Chi-square 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 [1, 2]. 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. [2].

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 [3]. 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 [1].

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 [4]. 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 [1]. 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 µm voxel size for HR mode and 500 µm 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 µm 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.

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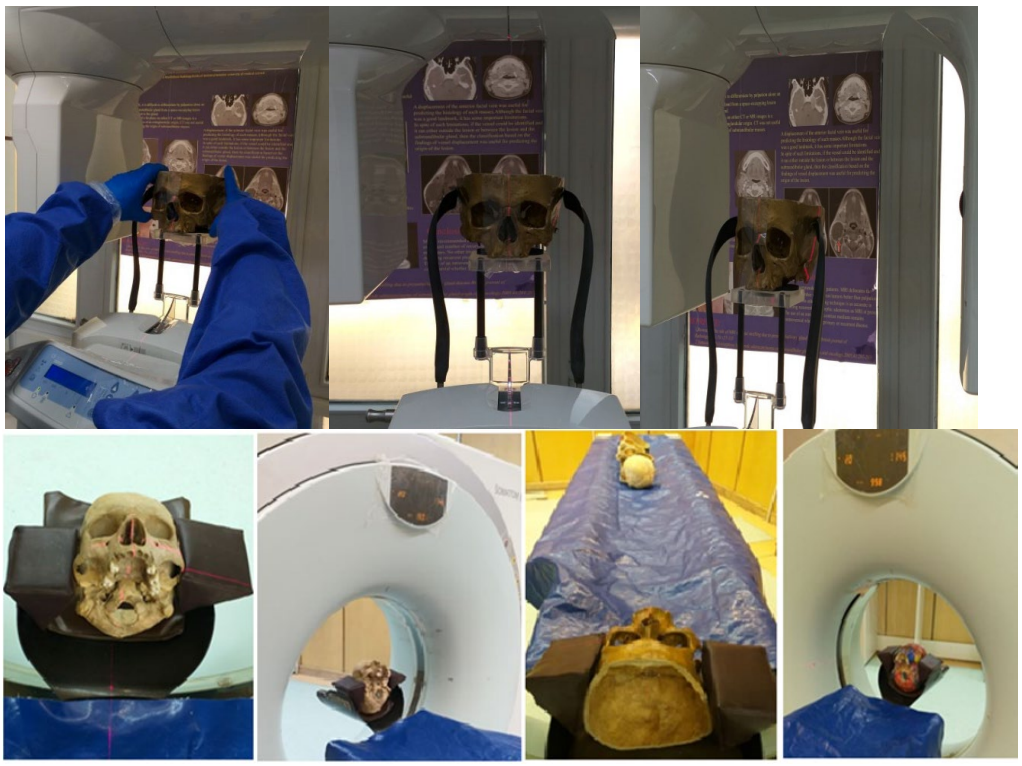


Figure 1: Positioning of the skulls; (upper row) in a CBCT scanner; (lower row) in a MDCT scanner

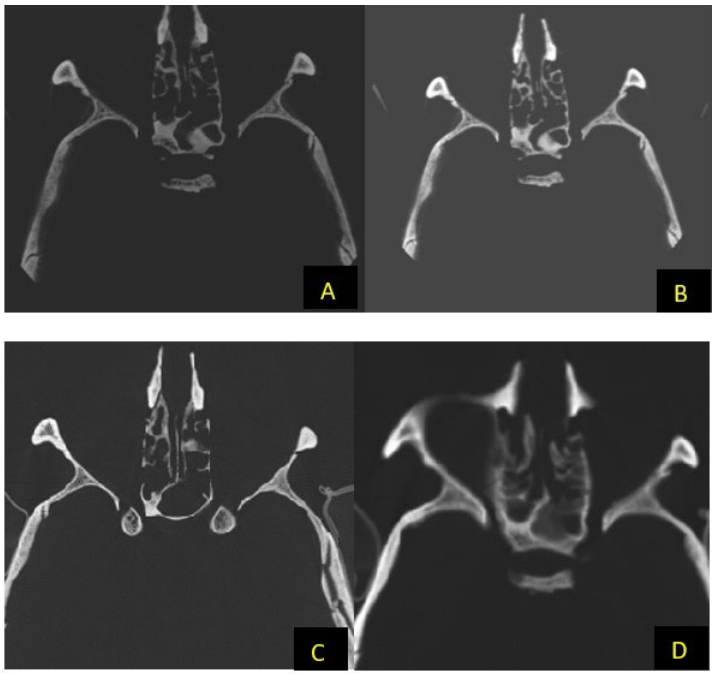


Figure 2: Axial sections; (A) high-resolution CBCT; (B) low-resolution CBCT, (C) high-resolution CT, (D) low-resolution CT

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,

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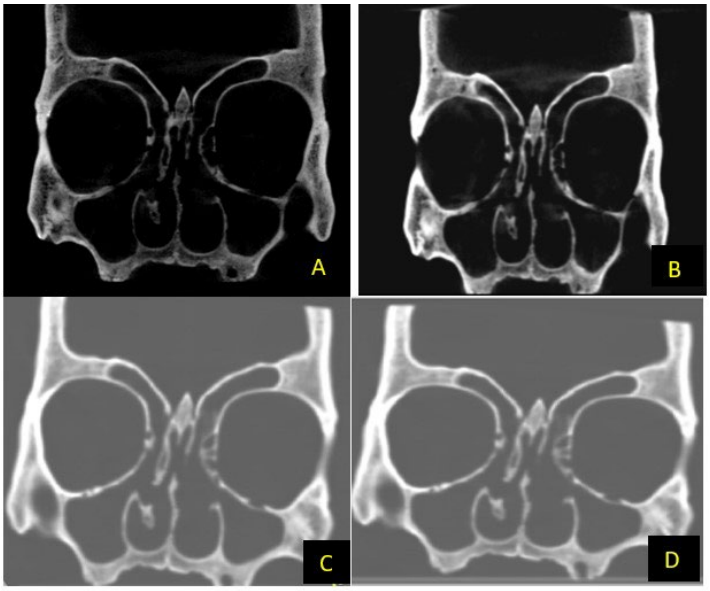


Figure 3: Coronal sections; (A) high-resolution CBCT; (B) low-resolution CBCT, (C) high-resolution CT, (D) low-resolution CT



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 [4]:

- 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.

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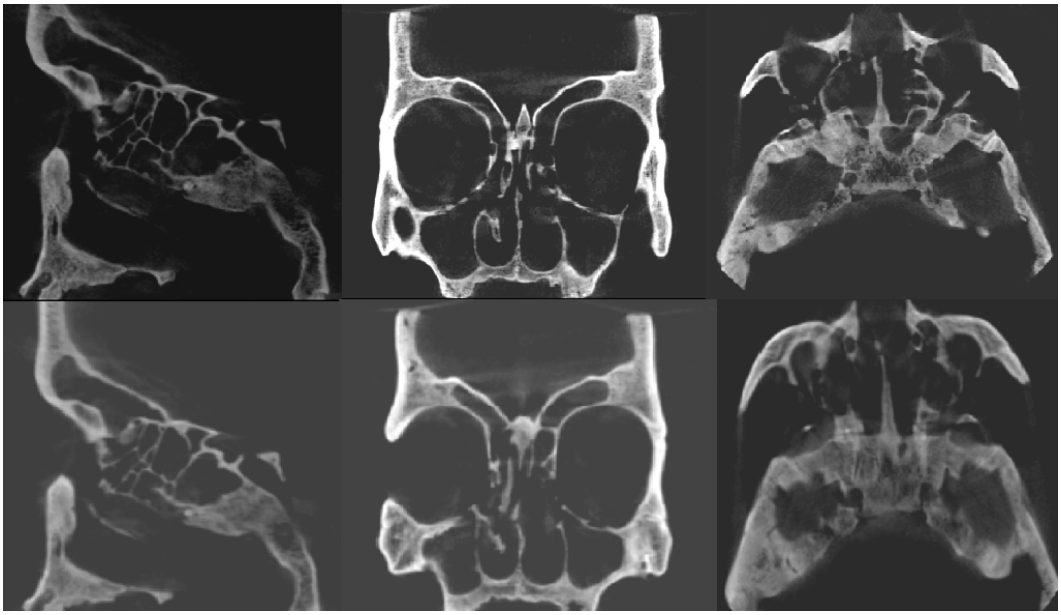


Figure 5: (upper row) High-resolution CBCT in axial, coronal and sagittal sections from right to left; (lower row) low-resolution CBCT in axial, coronal and sagittal sections from right to left

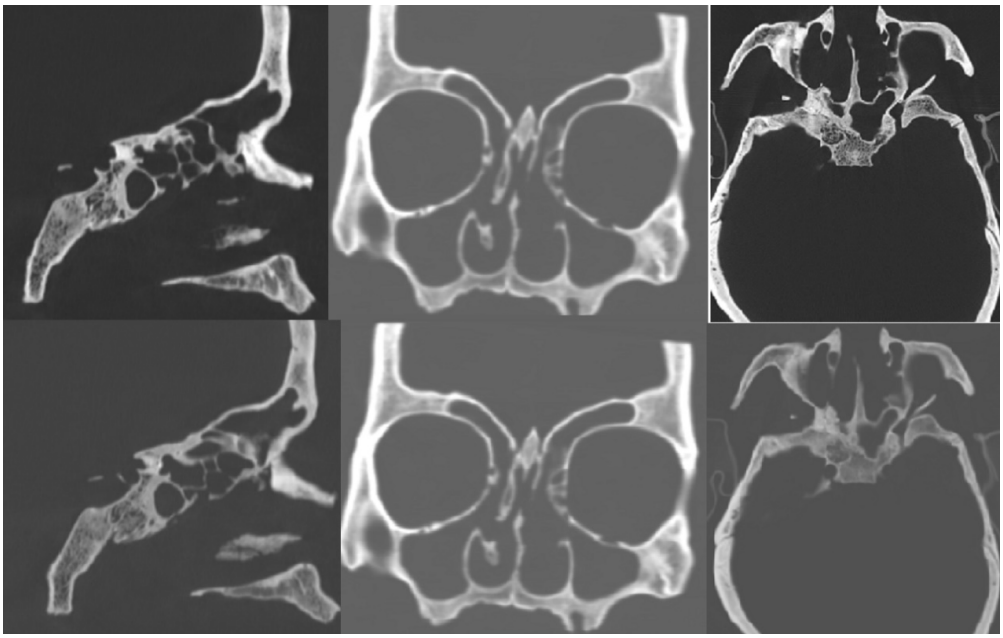


Figure 6: (upper row) High-resolution CT in axial, coronal and sagittal sections from right to left; (lower row) low-resolution CT in axial, coronal and sagittal sections from right to left

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

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

Landmark	Quality	Scanners				*P*-value
		HR CBCT Frequency (%)	LR CBCT Frequency (%)	HR CT Frequency (%)	LR CT Frequency (%)	
Middle turbinate	Good	0 (0.00)	2 (13.33)	0(0.00)	7(4.67)	*0.001
	Excellent	15(100.00)	13(86.67)	15(100.00)	8(53.33)	
Maxillary sinus ostium	Good	0(0.00)	0(0.00)	0(0.00)	2(13.33)	0.102
	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*
	Excellent	15(100.00)	14(93.33)	15(100.00)	9(60.00)	
Ethmoid bulla	Decreased	0(0.00)	2(13.33)	2(13.33)	2(13.33)	*<0.001
	Good	1(6.67)	11(73.33)	3(20.00)	10(66.67)	
	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*
	Excellent	14(93.33)	8(53.33)	15(100.00)	8(53.33)	
Semilunar hiatus	Decreased	0(0.00)	0(0.00)	0(0.00)	1(6.67)	0.051
	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)	
Maxillary sinus	Good	0(0.00)	1(6.67)	0(0.00)	0(0.00)	0.384
	Excellent	15(100.00)	14(93.33)	15(100.00)	15(100.00)	
Agger nasi cell	Decreased	0(0.00)	0(0.00)	2(13.33)	1(6.67)	0.002*
	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)	
Nasofrontal duct	Decreased	0(0.00)	0(0.00)	2(13.33)	0(0.00)	0.016*
	Good	3(20.00)	8(53.33)	2(13.33)	9(60.00)	
	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)	-
Anterior ethmoidal cell	Decreased	0(0.00)	0(0.00)	2(13.33)	2(13.33)	*<0.001
	Good	1(6.67)	13(86.67)	4(26.67)	8(53.33)	
	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*
	Excellent	15(100.00)	15(100.00)	15(100.00)	12(80.00)	
Ethmoid roof	Good	0(0.00)	5(33.33)	1(6.67)	4(26.67)	0.043*
	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*
	Good	0(0.00)	9(60.00)	1(6.67)	4(26.67)	

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Landmark	Quality	Scanners				*P*-value
		HR CBCT Frequency (%)	LR CBCT Frequency (%)	HR CT Frequency (%)	LR CT 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
	Excellent	15(100.00)	4(26.67)	11(73.33)	8(53.33)	
Sphenoid sinus	Good	0(0.00)	0(0.00)	0(0.00)	3(20.00)	0.024*
	Excellent	15(100.00)	15(100.00)	15(100.00)	12(80.00)	
Sphenoethmoidal recess	Decreased	0(0.00)	0(0.00)	0(0.00)	4(26.67)	0.004*
	Good	0(0.00)	4(26.67)	4(26.67)	1(6.67)	
	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)	0.027*
	Good	0(0.00)	1(6.67)	5(33.33)	3(20.00)	
	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)	0.042*
	Good	1(6.67)	2(13.33)	4(26.67)	6(40.00)	
	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)	0.118
	Good	1(6.67)	5(33.33)	3(20.00)	6(40.00)	
	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
	Excellent	9(100.00)	6(66.67)	7(77.78)	6(66.67)	

*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.

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

Landmark	Quality	Scanners		*P*-value
		HR CBCT Frequency (%)	LR CBCT Frequency (%)	
Middle turbinate	Good	0 (0.00)	2 (13.33)	*0.001
	Excellent	15(100.00)	13(86.67)	
Maxillary sinus ostium	Good	0 (0.00)	0 (0.00)	0.102
	Excellent	15(100.00)	15(100.00)	
Middle meatus	Good	0 (0.00)	1(6.67)	*0.001
	Excellent	15(100.00)	14(93.33)	
Ethmoid bulla	Decreased	0 (0.00)	2(13.33)	*<0.001
	Good	1(6.67)	11(73.33)	
	Excellent	14(93.33)	2(13.33)	
Uncinate process	Good	1(6.67)	7(46.67)	0.002*
	Excellent	14(93.33)	8(33.53)	
Semilunar hiatus	Decreased	0 (0.00)	0 (0.00)	0.051
	Good	2(13.33)	6(40.00)	
	Excellent	13(86.67)	9(60.00)	
Maxillary sinus	Good	0 (0.00)	1(6.67)	0.384
	Excellent	15(100.00)	14(93.33)	
Agger nasi cell	Decreased	0 (0.00)	0 (0.00)	0.002*
	Good	0 (0.00)	8(53.33)	
	Excellent	15(100.00)	7(46.67)	
Nasofrontal duct	Decreased	0 (0.00)	0 (0.00)	0.016*
	Good	3(20.00)	8(53.33)	
	Excellent	12(80.00)	7(46.67)	
Frontal sinus	Excellent	15(100.00)	15(100.00)	-
Anterior ethmoidal cell	Decreased	0 (0.00)	0 (0.00)	0.001<*
	Good	1(6.67)	13(86.67)	
	Excellent	14(93.33)	2(13.33)	
Lamina papyracea	Good	0 (0.00)	0 (0.00)	0.024*
	Excellent	15(100.00)	15(100.00)	
Ethmoid roof	Good	0 (0.00)	5(33.33)	0.043*
	Excellent	15(100.00)	10(66.67)	
Cribriform plate	Decreased	0 (0.00)	2(13.33)	0.001*
	Good	0 (0.00)	9(60.00)	
	Excellent	15(100.00)	4(26.67)	
Olfactory cleft	Good	0 (0.00)	11(73.33)	0.001<*
	Excellent	15(100.00)	4(26.67)	
Sphenoid sinus	Good	0 (0.00)	0 (0.00)	0.024*
	Excellent	15(100.00)	15(100.00)	
Sphenoethmoidal recess	Decreased	0 (0.00)	0 (0.00)	0.004*
	Good	0 (0.00)	4(26.67)	
	Excellent	15(100.00)	11(73.33)	
Nasolacrimal duct	Decreased	0 (0.00)	0 (0.00)	0.027*
	Good	0 (0.00)	14(93.33)	
	Excellent	15(100.00)	14(93.33)	
Foramen rotundum	Decreased	0 (0.00)	0 (0.00)	0.042*
	Good	1(6.67)	2(13.33)	
	Excellent	14(93.33)	13(86.67)	
Supraorbital cell	Decreased	0 (0.00)	2(13.33)	0.118
	Good	1(6.67)	5(33.33)	
	Excellent	14(93.33)	8(53.33)	
Haller cell	Good	0 (0.00)	3(33.33)	0.277
	Excellent	9(100.00)	6(66.67)	

*Statistically significant.

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

Landmark	Quality	Scanners		*P*-value
		LR CT Frequency (%)	HR CT Frequency (%)	
Middle turbinate	Good	0 (0.00)	7(4.67)	0.001*
	Excellent	15(100.00)	8(53.33)	
Maxillary sinus ostium	Good	0 (0.00)	2(13.33)	0.102
	Excellent	15(100.00)	13(86.67)	
Middle meatus	Good	0 (0.00)	6(40.00)	0.001*
	Excellent	15(100.00)	9(60.00)	
Ethmoid bulla	Decreased	2(13.33)	2(13.33)	0.001<*
	Good	3(20.00)	10(66.67)	
	Excellent	10(66.67)	3(20.00)	
Uncinate process	Good	0 (0.00)	7(46.76)	0.002*
	Excellent	15(100.00)	8(53.33)	
Semilunar hiatus	Decreased	0 (0.00)	1(6.67)	0.051
	Good	1(6.67)	7(4.67)	
	Excellent	14(93.33)	7(4.67)	
Maxillary sinus	Good	0 (0.00)	0 (0.00)	0.384
	Excellent	15(100.00)	15(100.00)	
Agger nasi cell	Decreased	2(13.33)	1(6.67)	0.002*
	Good	5(33.33)	10(66.67)	
	Excellent	8(53.33)	4(26.67)	
Nasofrontal duct	Decreased	2(13.33)	0 (0.00)	0.016*
	Good	2(13.33)	9(60.00)	
	Excellent	11(73.33)	6(40.00)	
Frontal sinus	Excellent	15(100.00)	15(100.00)	-
Anterior ethmoidal cell	Decreased	2(13.33)	2(13.33)	0.001<*
	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*
	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)	
Cribriform plate	Decreased	2(13.33)	2(13.33)	0.001*
	Good	1(6.67)	4(26.67)	
	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)	
Sphenoid sinus	Good	0 (0.00)	3(20.00)	0.024*
	Excellent	15(100.00)	12(80.00)	
Sphenoethmoidal recess	Decreased	0 (0.00)	4(26.67)	0.004*
	Good	4(26.67)	1(6.67)	
	Excellent	11(73.33)	10(66.67)	
Nasolacrimal duct	Decreased	0 (0.00)	2(13.33)	0.027*
	Good	5(33.33)	3(20.00)	
	Excellent	10(66.67)	10(66.67)	
Foramen rotundum	Decreased	0 (0.00)	2(13.33)	0.420*
	Good	4(26.67)	6(40.00)	
	Excellent	11(73.33)	7(46.67)	
Supraorbital cell	Decreased	0 (0.00)	1(6.67)	0.118
	Good	3(20.00)	6(40.00)	
	Excellent	12(80.00)	8(53.33)	
Haller cell	Good	2(22.22)	3(33.33)	0.277
	Excellent	7(77.78)	6(66.67)	

*Statistically significant.

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

Landmark	Quality	Scanners		*P*-value
		HR CT Frequency (%)	HR CBCT Frequency (%)	
Middle turbinate	Excellent	15(100.00)	15(100.00)	-
Maxillary sinus ostium	Excellent	15(100.00)	15(100.00)	-
Middle meatus	Excellent	15(100.00)	15(100.00)	-
Ethmoid bulla	Decreased	0 (0.00)	2(13.33)	0.160
	Good	1(6.67)	3(20.00)	
	Excellent	14(93.33)	10(66.67)	
Uncinate process	Good	1(6.67)	0 (0.00)	0.309
	Excellent	14(93.33)	15(100.00)	
Semilunar hiatus	Good	2(13.33)	1(6.67)	0.543
	Excellent	13(86.67)	14(93.33)	
Maxillary sinus	Excellent	15(100.00)	15(100.00)	-
Agger nasi cell	Decreased	0 (0.00)	2(13.33)	0.010*
	Good	0 (0.00)	5(33.33)	
	Excellent	15(100.00)	8(53.33)	
Nasofrontal duct	Decreased	0 (0.00)	2(13.33)	0.326
	Good	3(20.00)	2(13.33)	
	Excellent	12(80.11)	11(73.33)	
Frontal sinus	Excellent	15(100.00)	15(100.00)	-
Anterior ethmoidal cell	Decreased	0 (0.00)	2(13.33)	0.087
	Good	1(6.67)	4(26.67)	
	Excellent	14(93.33)	9(87.00)	
Lamina papyracea	Excellent	15(100.00)	15(100.00)	-
Ethmoid roof	Good	0 (0.00)	1(6.67)	0.309
	Excellent	15(100.00)	14(93.33)	
Cribriform plate	Decreased	0 (0.00)	2(13.33)	0.189
	Good	0 (0.00)	1(6.67)	
	Excellent	15(100.00)	12(80.00)	
Olfactory cleft	Good	0 (0.00)	4(26.67)	0.032*
	Excellent	15(100.00)	11(73.33)	
Sphenoid sinus	Excellent	15(100.00)	15(100.00)	-
Sphenoethmoidal recess	Good	0 (0.00)	4(26.67)	0.032*
	Excellent	15(100.00)	11(73.33)	
Nasolacrimal duct	Good	0 (0.00)	5(33.33)	0.014*
	Excellent	15(100.00)	10(66.67)	
Foramen rotundum	Good	1(6.67)	4(26.67)	0.142
	Excellent	14(93.33)	11(73.33)	
Supraorbital cell	Good	1(6.67)	3(20.00)	0.283
	Excellent	14(93.33)	12(80.00)	
Haller cell	Good	0 (0.00)	2(22.22)	0.134
	Excellent	9(100.00)	7(77.78)	

*Statistically significant.

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

Landmark	Quality	Scanners		*P*-value
		LR CT Frequency (%)	HR CT Frequency (%)	
Middle turbinate	Good	2(13.33)	7(46.67)	0.046
	Excellent	13(86.67)	8(53.33)	
Maxillary sinus ostium	Good	0 (0.00)	2(13.33)	0.143
	Excellent	15(100.00)	13(86.67)	
Middle meatus	Good	1(6.67)	6(40.00)	0.031*
	Excellent	14(93.33)	9(60.00)	
Ethmoid bulla	Decreased	2(13.33)	2(13.33)	0.884
	Good	11(73.33)	10(66.67)	
	Excellent	2(13.33)	3(20.00)	
Uncinate process	Good	7(46.67)	7(46.67)	1.000
	Excellent	8(53.33)	8(53.33)	
Semilunar hiatus	Decreased	0 (0.00)	1(6.67)	0.515
	Good	6(40.00)	7(46.67)	
	Excellent	9(60.00)	7(46.67)	
Maxillary sinus	Good	1(6.67)	0 (0.00)	0.309
	Excellent	14(93.33)	15(100.00)	
Agger nasi cell	Decreased	0 (0.00)	1(6.67)	0.361
	Good	8(53.33)	10(66.67)	
	Excellent	7(46.67)	4(26.67)	
Nasofrontal duct	Good	8(53.33)	9(60.00)	0.713
	Excellent	7(46.67)	6(40.00)	
Frontal sinus	Excellent	15(100.00)	15(100.00)	-
Anterior ethmoidal cell	Decreased	0 (0.00)	2(13.33)	0.107
	Good	13(86.67)	8(53.33)	
	Excellent	2(13.33)	5(33.33)	
Lamina papyracea	Good	0 (0.00)	3(20.00)	0.068
	Excellent	15(100.00)	12(80.00)	
Ethmoid roof	Good	5(33.33)	4(26.67)	0.690
	Excellent	10(66.67)	11(73.33)	
Cribriform plate	Decreased	2(13.33)	2(13.33)	0.146
	Good	9(60.00)	4(26.67)	
	Excellent	4(26.67)	9(60.00)	
Olfactory cleft	Good	11(73.33)	7(46.67)	0.136
	Excellent	4(26.67)	8(53.33)	
Sphenoid sinus	Good	0 (0.00)	3(20.00)	0.068
	Excellent	15(100.00)	12(80.00)	
Sphenoethmoidal recess	Decreased	0 (0.00)	4(26.67)	0.054
	Good	4(26.67)	1(6.67)	
	Excellent	11(73.33)	10(66.67)	
Nasolacrimal duct	Decreased	0 (0.00)	2(13.33)	0.160
	Good	1(6.67)	3(20.00)	
	Excellent	14(93.33)	10(66.67)	
Foramen rotundum	Decreased	0 (0.00)	2(13.33)	0.055
	Good	2(13.33)	6(40.00)	
	Excellent	13(86.67)	7(46.67)	
Supraorbital cell	Decreased	2(13.33)	1(6.67)	0.809
	Good	5(33.33)	6(40.00)	
	Excellent	8(53.33)	8(53.33)	
Haller cell	Good	3(33.33)	3(33.33)	1.000
	Excellent	6(66.67)	6(66.67)	

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

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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 semi-automatic 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 [7]. 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 [1]. However, the present study revealed that although the diagnostic quality of CBCT and CT was not significantly different for assessment of the 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 [5]. 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. [5] 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.

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,

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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 [9].

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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