Magnetic resonance imaging study of incidental findings in the paranasal sinuses and ostiomeatal complex

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ABSTRACT

Purpose: This study aimed to assess incidental abnormal findings in the paranasal sinuses and anatomical variations of the ostiomeatal complex (OMC) on magnetic resonance imaging (MRI) scans.
Materials and Methods: MRI scans of 616 patients (mean age, 44.0 ± 19.4 years) were evaluated. Prior to obtaining the MRI scans, a checklist of patients' clinical symptoms was filled out after obtaining their consent. The Lund-Mackay classification was used to assess the paranasal sinuses and OMC. The prevalence of abnormal findings and their associations with patients' age, sex, and subjective symptoms were analyzed by the chi-square test, independent-sample t-test, and analysis of variance. The level of significance was set at 0.05.
Results: Abnormal findings in the paranasal sinuses were detected in 32.0% of patients, with a significantly higher prevalence in males ($P < 0.05$), but no significant association with age ($P > 0.05$). Epithelial thickening and retention cyst were the most common abnormal findings in the paranasal sinuses. According to the Lund-Mackay classification, 93% of the study population had normal sinuses (score < 4). Concha bullosa and paradoxical concha were detected in 15.3% and 3.4%, respectively, with no significant association with the presence of septal deviation or Lund-Mackay classification ($P > 0.05$).
Conclusion: Considering the relatively high prevalence of abnormal findings in the paranasal sinuses, it appears that clinical symptoms alone are not sufficient to diagnose sinusitis. A more accurate strategy would be to assess radiographic images of the paranasal sinuses and use a classification system. Sinusitis should be suspected in patients receiving a high score in this classification. *(Imaging Sci Dent 2022; 52: 11-8)*

KEY WORDS: Magnetic Resonance Imaging; Paranasal Sinuses; Incidental Findings; Nasal Septum

Introduction

Magnetic resonance imaging (MRI) has become an attractive complement to computed tomography (CT) due to its lack of ionizing radiation and superior soft-tissue resolution.[1,2] MRI is very efficient for identifying anatomical variations of paranasal sinuses and visualizing soft tissues. It is also highly valuable for detecting and differentiating sinus masses and inflammation.[3]

CT is often the first-choice imaging modality for assessing paranasal sinus conditions. However, considering the high diagnostic value of MRI in the differential diagnosis of cysts and soft tissue masses compared with CT, its application has been justified for patients with complex infections, invasive fungal infections, and soft tissue masses of the sinuses.[4]

MRI has particular advantages in the evaluation of certain anatomical parts of the sinonasal spaces, the evaluation of anosmia, and the characterization of sinusitis com-

plications, focal benign lesions, sinonasal malignancies, and extra-sinus pathologies extending into the sinonasal spaces.[5]

MRI allows the characterization of different tissues including normal mucosa, secretions, air, cerebrospinal fluid, and masses, whereas the ability of CT to do so is limited. Furthermore, although CT depicts the simple sinonasal causes of anosmia including rhinosinusitis, pathologies arising around the olfactory bulbs and tracts are usually well depicted or characterized on MRI.[5] Furthermore, in the diagnosis of chronic inflammatory conditions such as cystic fibrosis, MRI is comparable to CT in delineating the extent of sinonasal disease and better at differentiating the various types of secretions and masses (e.g., polyps and mucoceles).[6] However, CT has lower sensitivity in the assessment of early intra-orbital soft tissue changes, and the performance of MRI supersedes that of CT in depicting intra-cranial and orbital complications.[7-9]

Thus, MRI may be used as an adjunct to CT for the assessment of sinus conditions and anatomical variations of the ostiomeatal complex (OMC). As an imaging modality, MRI can aid radiologists in making a more accurate differential diagnosis and enhance the clinical management of patients.[10]

Considering the increasing use of MRI to detect brain lesions and assess the paranasal sinuses, the nasal cavity, and OMC, the correct interpretation of MRI images can enable the detection of incidental findings in these areas,[11,12] facilitating their early management.[12] Knowledge about the prevalence of such incidental findings in paranasal sinuses and OMC can lead to their early diagnosis and prompt management.[13] Thus, this study aimed to assess the prevalence of abnormal incidental findings in paranasal sinuses on MRI scans and analyze the correlations between imaging findings and subjective patient symptoms.

Materials and Methods

This cross-sectional study was approved by the ethics committee of Hamadan University of Medical Sciences (IR. UMSHA.REC.1398.170). MRI scans of 616 patients were evaluated. All methods were carried out in accordance with relevant guidelines and regulations.

The inclusion criteria were all patients presenting to a radiology center for brain MRI due to reasons not related to this study, for whom the MRI requests were unrelated to the area of the paranasal sinuses. Patients under the age of 4 years (due to incomplete formation of the frontal sinuses), MRI scans with poor quality for evaluation of the paranasal sinuses, and patients with a history of sinus surgery were excluded. All brain MRI scans at this center were obtained using an Essenza 1.5 T MRI machine (Siemens, Munich, Germany) with the following parameters: 8-channel brain coil, 5-mm slice thickness, 2-mm inter-slice gap, T1: TR = 400, TE = 8.7, T2: TR = 3000, TE = 96, and 230-mm field of view. Prior to undergoing brain MRI, all patients signed informed consent forms, and if they were under 18, the consent form was completed by their parents and/or legal guardian. A checklist of their subjective symptoms was then filled out by the technicians at the radiology center. The MRI scans were then obtained and interpreted by a radiologist. The first part of the checklist for each patient
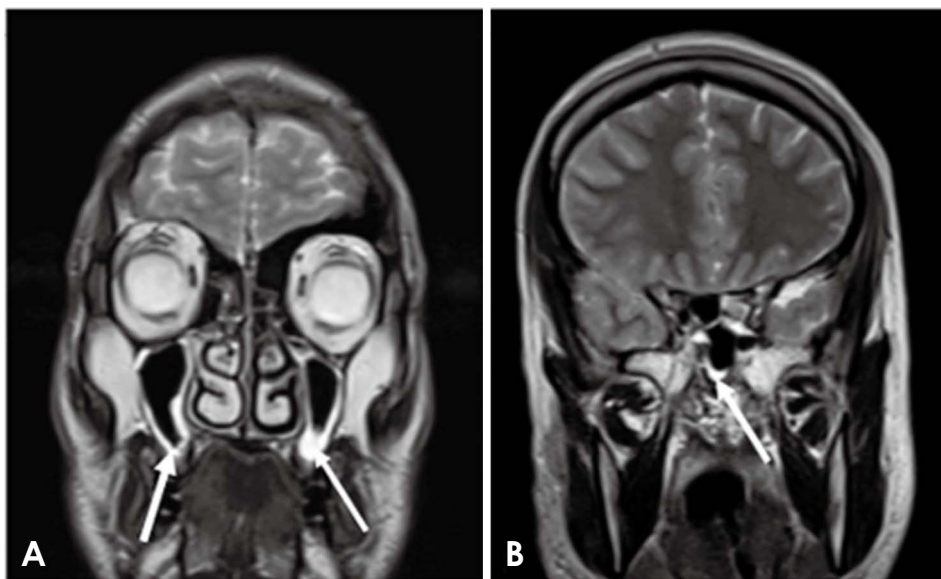

Fig. 1. Arrows indicate epithelial thickening in the right and left maxillary sinuses (A) and sphenoid sinus (B) in the coronal view.
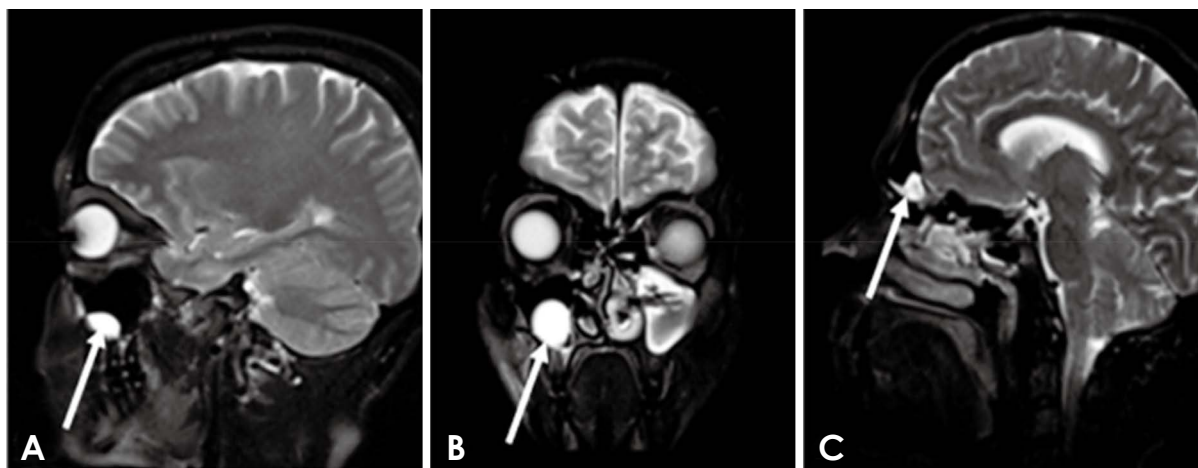
Fig. 2. Arrows indicate a mucous retention cyst in the left maxillary sinus in the sagittal view (A), the right maxillary sinus in the coronal view (B), and the left frontal sinus in the sagittal view (C).
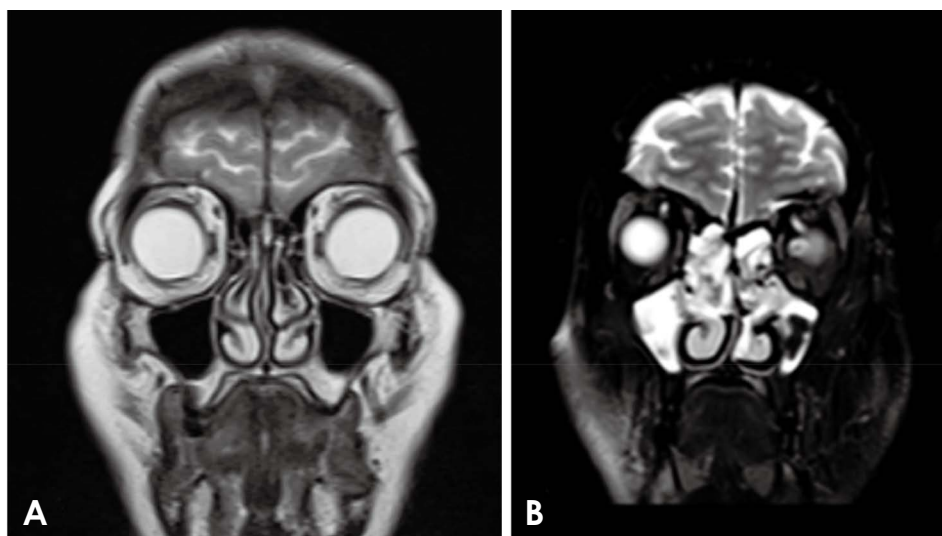

Fig. 3. A. Ostiomeatal complex patency where both the right and left sides are open. B. Both sides are obstructed.

included subjective symptoms and the second part, which was filled out by the radiologist, included imaging findings in the paranasal sinuses. For each patient, the presence of abnormal findings, including epithelial thickening (more than 3 mm) (Fig. 1), mucocele, air-fluid level, polyp, and retention cyst (Fig. 2) in the paranasal sinuses, was evaluated on different scanning planes. Furthermore, since the OMC was also visible on MRI scans, the OMC patency and the presence of nasal septal deviation, concha bullosa, and paradoxical concha were also evaluated (Fig. 3).

To analyze patients' self-reported subjective symptoms, the classification by the European Position Paper on Rhinosinusitis and Nasal Polyps (EP3OS) was used.[14] The EP3OS position paper mentioned that rhinosinusitis is a significant and increasing health problem that results in a large financial burden on society. This evidence-based position paper described what is known about rhinosinusitis and nasal polyps and offered recommendations on diagnosis and treatment. In this classification, the clinical diagnosis of rhinosinusitis requires the occurrence of 2 or more of the following symptoms: nasal obstruction, congestion or discharge from the anterior or posterior part of the nasal cavity, and/or facial pain or pressure, and/or hyposmia/anosmia. According to this classification, the patients were classified as symptomatic or asymptomatic.

Different classifications and scoring systems are available for the overall assessment of paranasal sinuses. The Lund-Mackay scoring system is the most commonly used classification system for the paranasal sinuses.[15] Recent studies have more commonly used this classification sys-

tem than others. In this system, a score of 0 is allocated to a completely radiolucent sinus. A score of 1 is allocated to semi-radiolucent sinuses, and a score of 2 is allocated to completely opaque sinuses. In this classification system, each paranasal sinus on each side (maxillary, anterior and posterior ethmoid, frontal and sphenoid sinus) is given a score of 0, 1, or 2 according to the criteria mentioned above. Therefore, for each patient, the minimum possible score is 0 and the highest score is 10 for 1 side and 20 for 2 sides.

The OMC of each side was also scored 0 if it was open and 2 if it was obstructed. Therefore, in patients with a completely open bilateral OMC, a score of 0 was given, and a completely obstructed bilateral OMC was allocated a score of 4.

The allocated scores to the sinuses were added to the OMC scores; therefore, each patient was allocated a score between 0 and 24 (20 points for the sinuses and 4 points for the OMC).[16]

Different scores have been used in the literature according to the Lund-Mackay classification system for identification of patients with abnormal sinuses. In the present study, we considered patients who acquired a score ≥ 4 to have abnormal sinuses according to a study conducted in 2018.[17]

The modified MLADINA classification system was used to classify septal deviation.[18] The criteria are as follows: type I: midline septum or mild deviations in the vertical or horizontal plane, which do not extend throughout the vertical length of the septum; type II: anterior vertical deviation; type III: posterior vertical deviation (ostiomeatal and middle turbinate area); type IV: 'S' septum - posterior to 1 side and anterior to the other side; type V: horizontal spur on 1 side with or without high deviation to the opposite side; type VI: type V with a deep groove on the concave side; type VII: combination of more than 1 type of types II-VI. The side of the deviation is marked left (L) or right (R). In type IV, whichever side has the anterior deviation is marked L or R. Inter- and intra-agreement was evaluated using kappa statistics.

Data were analyzed using SPSS version 21 (IBM Corp, Armonk, NY, USA) via descriptive statistics, the chi-square test, and the t-test. The level of significance was set at 0.05.

Results

This study evaluated the brain MRI scans of 616 patients, including 247 males and 369 females. The mean age of participants was 44.0 ± 19.4 years. The mean age was 46.8 ± 21.1 years in males and 42.1 ± 17.9 years in females.

Two radiologists, who were specialists in interpreting MRI images, observed the images and assessed them individually. Intra-observer agreement (kappa $= 0.9$) and inter-observer agreement (kappa $= 0.92$) confirmed the repeatability of the observations.

Of the 616 patients, 419 (68.0%) had no abnormalities in their paranasal sinuses, while 197 (32.0%) had abnormal findings. The frequency of abnormal findings was significantly higher in males than in females (chi-square test, $P < 0.05$). The mean age of patients with abnormal findings in their paranasal sinuses was 46.0 ± 18.0 years. The presence of abnormal findings in paranasal sinuses had no significant correlation with age (independent-sample t-test, $P > 0.05$).

The maxillary sinus was the most commonly involved sinus. The prevalence of abnormal findings was the highest in the maxillary sinuses (n $= 229$), followed in descending order by the anterior ethmoid (n $= 93$), posterior ethmoid (n $= 76$), sphenoid (n $= 55$), and frontal sinus (n $= 28$).

Table 1 presents abnormal findings in the paranasal sinuses of the right and left sides in males and females. In the study population, 478 patients showed abnormal findings in the paranasal sinuses, of whom 350 (73.2%) showed epithelial thickening. The mean amount of epithelial thickening was 4.4 ± 2.1 mm in the right maxillary sinus and 4.6 ± 2.2 mm in the left maxillary sinus. The greatest amount of epithelial thickening was noted in the left maxillary sinus (11.0 mm).

Retention cysts (n $= 127$) ranked second in terms of prevalence. The maxillary sinus was the most common site of retention cysts (n $= 121$). Three cases of retention cysts in the frontal sinus and 3 cases of retention cysts in the sphenoid sinus were also detected. Polyps were noted in 3 cases, and all 3 were in the maxillary sinuses.

Table 2 shows the scores of paranasal sinus findings according to the Lund-Mackay scoring system, and Table 3 shows patients' Lund-Mackay scores based on sex.

Of the study population, 573 patients (93.0%) had a score < 4 and had normal paranasal sinuses, while 43 (7.0%) received a score ≥ 4, which indicated abnormal paranasal sinuses. Males had significantly higher scores (Table 3), and a significant correlation was found between male sex and presence of abnormal paranasal sinuses (score ≥ 4).

As shown in Table 4, the mean age was 41.5 ± 17.2 years in patients with clinical symptoms and 44.3 ± 19.6 years in patients without clinical symptoms. No significant correlation was noted between the presence of clinical symptoms and sex or age in symptomatic or asymp-

Table 1. Number of paranasal sinuses showing abnormal findings in 616 patients

Sinus		Maxilla		Frontal		Anterior ethmoid		Posterior ethmoid		Sphenoid		Total
Abnormal findings		Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	
Polyp	Male	2	1	0	0	0	0	0	0	0	0	3
	Female	0	0	0	0	0	0	0	0	0	0	0
	Total	2	1	0	0	0	0	0	0	0	0	3
Epithelial thickening	Male	31	34	8	9	30	36	24	27	18	13	230
	Female	21	18	3	5	13	14	14	11	11	10	120
	Total	52	52	11	14	43	50	38	38	29	23	350
Mucocele	Male	0	0	0	0	0	0	0	0	0	0	0
	Female	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	0	0	0
Air-fluid level	Male	1	0	0	0	0	0	0	0	0	0	1
	Female	0	0	0	0	0	0	0	0	0	0	0
	Total	1	0	0	0	0	0	0	0	0	0	1
Retention cyst	Male	30	37	1	1	0	0	0	0	1	2	72
	Female	28	26	0	1	0	0	0	0	0	0	55
	Total	58	63	1	2	0	0	0	0	1	2	127
Total	Male	64	72	9	10	30	36	24	27	19	15	306
	Female	49	44	3	6	13	14	14	11	11	10	175
	Total	113	116	12	16	43	50	38	38	30	25	481

Table 2. Scores of the paranasal sinuses and ostiomeatal complex according to the Lund-Mackay classification

		Score of 0	Score of 1	Score of 2
Maxillary	Left	518 (84.0%)	94 (15.2%)	4 (0.6%)
	Right	506 (82.1%)	106 (17.2%)	4 (0.6%)
Frontal	Left	602 (97.7%)	13 (2.1%)	1 (0.1%)
	Right	597 (96.9%)	17 (2.7%)	2 (0.3%)
Anterior ethmoidal	Left	560 (90.9%)	44 (7.1%)	12 (1.9%)
	Right	558 (90.5%)	49 (9.5%)	9 (1.4%)
Posterior ethmoidal	Left	599 (96.2%)	17 (2.8%)	0 (0.0%)
	Right	595 (96.5%)	20 (3.2%)	1 (0.1%)
Sphenoidal	Left	590 (96.2%)	26 (4.2%)	0 (0.0%)
	Right	593 (96.2%)	22 (3.5%)	1 (0.1%)
Ostiomeatal complex	Left	598 (97.0%)	–	18 (2.9%)
	Right	608 (98.7%)	–	8 (1.2%)

Table 3. Lund-Mackay scores of patients according to sex

Sex	Number	Mean score	Score < 4	Score ≥ 4
Male	247	1.4 ± 2.6	218 (38.0%)	29 (67.4%)*
Female	369	0.4 ± 1.2	355 (61.9%)	14 (32.5%)
Total	616	0.8 ± 1.9	573 (100%)	43 (100%)

*: $P < 0.05$, calculated with the independent sample t-test.

tomatic patients ($P > 0.05$). No significant correlation was noted between clinical symptoms and paranasal sinus status according to the Lund-Mackay classification system ($P > 0.05$).

Patients with a history of tobacco use had a significantly higher mean score for the paranasal sinuses (Table 5). A history of tobacco use had a significant correlation with the presence of abnormal sinuses (score ≥ 4) ($P < 0.05$).

OMC patency/obstruction showed a significant correlation with male sex ($P < 0.05$). However, age had no significant correlation with obstruction of the OMC ($P > 0.05$).

The modified MLADINA classification system was used to assess septal deviation. Table 6 presents the frequency of different types of nasal septal deviation in the study population. Only 1 male patient had type IV (S-shaped) nasal septum.

No significant relationship was noted between type of septal deviation and sex ($P > 0.05$). However, patients with

more severe septal deviation were older ($P<0.05$). As shown in Table 7, the type of septal deviation had no significant correlation with the paranasal sinus score ($P>0.05$). The presence of clinical symptoms in the study population had no significant correlation with septal deviation (chi-square test, $P>0.05$). The presence of concha bullosa or paradoxical concha had no significant correlations with patients' age or sex ($P>0.05$ for both). No significant correlation was noted between nasal septal deviation and concha bullosa (chi-square test, $P>0.05$) or between paradoxical concha and paranasal sinus status ($P>0.05$).

Table 4. Association of clinical symptoms by paranasal sinus status and epithelial thickening

	Presence of clinical symptoms*	Absence of clinical symptoms
Total	67 (10.9%)	540 (89.1%)
Male	27 (10.9%)	220 (89.0%)
Female	40 (10.8%)	329 (89.1%)
Age (years)	41.5±17.2	44.3±19.6
Normal sinus (score <4)	60	513
Abnormal sinus (score ≥4)	7	36
Presence of epithelial thickening	14	106
Absence of epithelial thickening	53	443

*: $P>0.05$

Table 5. Association of history of asthma and tobacco use by paranasal sinus status according to the Lund-Mackay classification

Sinus status	Tobacco use history		Asthma history	
	Positive*	Negative	Positive	Negative
Normal (score <4)	67 (85.8%)	506 (94.0%)	18 (100%)	555 (92.8%)
Abnormal (score ≥4)*	11 (14.1%)	32 (5.9%)	0 (0%)	43 (7.1%)

*: $P<0.05$

Table 6. Septal deviation in the study population

	None	Type I	Types II and III	Type IV	Type V
Right	–	103	108	1	17
Left	–	111	110		14
Total	152	214	218	1	31

Type I: midline septum or mild deviations in the vertical or horizontal plane, type II: anterior vertical deviation, type III: posterior vertical deviation, type IV: 'S' septum - posterior to 1 side and anterior to the other side, type V: horizontal spur on 1 side with or without high deviation to the opposite side

Discussion

Various imaging modalities are used to assess the paranasal sinuses. CT has been most commonly used for this purpose. However, MRI can reveal epithelial thickening in its early stages, and the Lund-Mackay score may be positive even in patients with mild initial clinical symptoms.[19] Thus, the superiority of MRI to CT for early diagnosis and better detection of epithelial changes in paranasal sinuses can add to the value of studies using MRI for this purpose. Considering the lack of such studies with an adequately large sample size in Iran, there was a need for a comprehensive study regarding the prevalence of abnormal findings in paranasal sinuses and anatomical variations of the nasal cavity, their correlations with patients' clinical symptoms, and the final decision regarding the most appropriate treatment approach.

Previous studies have reported the prevalence of incidental findings in the paranasal sinuses on MRI scans to be 25% to 85%. This wide range of variation in the reported prevalence rates can be attributed to heterogeneity in the study design, methodology, study population, and definitions of abnormal findings.[17,20,21] In our study population, 197 (32.0%) patients had abnormal findings in the paranasal sinuses. Mucosal thickening was the most common abnormal finding, followed by retention cysts. Polyps,

Table 7. Association of type of nasal septal deviation with sex, age, and sinus score according to the Lund-Mackay classification (1 case of type IV or S-shaped septum is not presented in this table)

	Male	Female	Total	Age*	Score of sinus status
Normal	63 (25.6%)	89 (24.1%)	152 (24.7%)	38.7±21.3	0.7±1.5
Type I	85 (34.5%)	129 (34.9%)	214 (34.7%)	44.6±17.6	0.9±2.2
Types II and III	84 (34.1%)	134 (36.3%)	218 (35.4%)	46.0±18.9	0.8±2.1
Type IV	14 (5.6%)	17 (4.6%)	31 (5.0%)	51.8±19.0	0.7±1.2

*: $P<0.05$

mucocele, and air-fluid level had very low prevalence in our study population. These findings align with those of previous studies in different communities regarding incidental findings in the paranasal sinuses, which reported that mucosal thickening was the most commonly detected finding,[12,20,22] and that retention cysts ranked second.[12,22] Studies evaluating the prevalence of air-fluid level either did not detect it at all[23] or detected it in a very small number of patients.[12]

It should be noted that the majority of previous studies on incidental findings in the paranasal sinuses used scoring systems for the paranasal sinuses for easy evaluation, and did not separately assess lesions or variations. Contrastingly, in the present study, in addition to using a scoring system, each paranasal sinus was individually evaluated for the presence/absence of each lesion/variation. The EP3OS classification was used in this study to assess the correlations of patients' clinical symptoms with MRI findings.[7] Clinically symptomatic patients had higher frequency of incidental findings; however, this correlation was not statistically significant. Nazri et al.,[19] in their study conducted in Malaysia, used the same checklist and reported a higher prevalence of abnormal findings in paranasal sinuses of clinically symptomatic patients. A previous study using the SNQ-11 questionnaire reported a significant correlation between the Lund-Mackay score and clinical symptoms.[19] However, another study used 3 different questionnaires to assess clinical symptoms and found no significant correlation between clinical symptoms and imaging findings.[13] In our study, no significant correlation was noted between the Lund-Mackay score and clinical symptoms.

In the present study, the OMC was open in most patients, and its obstruction was noted in only 21 (3.1%) patients; 16 patients had unilateral and 5 had bilateral obstruction. According to the Lund-Mackay classification, 16 patients received a score of 2 and 5 patients had a score of 4.

Nazri et al.[19] used both CT and MRI. They evaluated CT scans of 54 patients and MRI scans of 61 patients, and found no incidental findings related to the OMC on CT scans; however, 8 patients (18.0%) had OMC obstruction on MRI scans.

The high prevalence of septal deviation in the present study (75.2%) was predictable. The prevalence of septal deviation was significantly higher in males, and its severity increased with age. A previous study evaluated the status of the paranasal sinuses and reported the prevalence of septal deviation to be 40.0%; however, the researchers did not assess the frequency of different types of septal deviation.[13] Another study evaluated 214 patients in Poland and reported that 79.9% of participants had septal deviation.[24]

Imaging of the brain, head, and face provides various information about the paranasal sinuses, nasal septum, and OMC. However, most studies only analyzed 1 specific area. The present study performed a comprehensive investigation of all these areas, which was a strength of this study. However, a limitation of this study is the lack of a precise physical examination by a specialist, for which reason it is suggested that future studies particularly focus on the relationship between clinical examination observations and imaging findings of the paranasal sinuses.

Abnormal incidental findings were found in the paranasal sinuses of 32.0% of the study population on MRI scans, with a significantly higher prevalence in males. it can be concluded that clinical symptoms alone are not sufficient for a diagnosis of sinusitis. A more accurate strategy would be to assess radiographic images of the paranasal sinuses and use a scoring system. Patients with a high score should be suspected of having sinusitis and referred to an otorhinolaryngology specialist.

Acknowledgments

Conflicts of Interest: None

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