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ORIGINAL PAPER

Associations between the Volume of Bilateral Inferior Turbinates with Ipsilateral and Contralateral Sinus Mucosal Lining Thicknesses in Various Ages and Sexes: a CBCT Study of 302 Individuals

Mahshid RAZAVI[a], Sanaz SHARIFISHOSHTARI[a], Farzin AFSHARI[b], Vahid RAKHSHAN[c]

[a]Assistant Professor, Department of Oral and Maxillofacial Radiology, School of Dentistry, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

[b]Postgraduate student, Department of Oral and Maxillofacial Radiology, School of Dentistry, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

[c]Dentist, Tehran, Iran

ABSTRACT

Introduction: *Rhinosinusitis is an important prevalent and bothersome problem relevant to dental specialties like maxillofacial surgery, pathology and radiology. Two main contributing factors to this problem are the inferior turbinate and sinus membrane. Except one flawed and incomplete preliminary study, no study has examined the potential link between the thickness of sinus mucosal lining and the volume of the inferior turbinate. Besides, the role of gender and aging on turbinate volume or sinus membrane thickness is not assessed, except in one or two studies. Therefore, this large study was conducted.*

Methods: *This cross-sectional study was performed on 604 right and left turbinates and sinuses in 302 patients (154 males, 184 females; mean age 30.14 ± 9.44 years). This sample size was deemed about 12 times larger than the size necessary for high powers. Archival CBCTs were screened for cases with bilateral maxillary sinuses and turbinates. The thickness of their sinus membranes was measured on six points on each side and the greatest one was recorded in millimeters (mm). Their inferior turbinates were segmented manually and their volumes were measured in cm3 using a computer program set at the threshold range of 0-300 HU. Sinus membranes 1.0 mm thick or thicker were considered mucositis. The associations among turbinate volume, the occurrence of turbinate hypertrophy, sinus mucosal membrane, sinus mucositis occurrence and patients' age and sex were examined using the multiple linear regression, partial correlation coefficient controlling for sex, Pearson correlation coefficient, chi-squared and paired and unpaired t-tests (α = 0.05).*

Address for correspondence:
Farzin Afshari, DDS, MS
Department of Oral and Maxillofacial Radiology, School of Dentistry, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
email: a.farzin1990@gmail.com

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Results: *The sample was balanced in terms of sex and age (P = 0.102). The mean (SD) for the right turbinate volume, left turbinate volume, right mucosa thickness, left mucosa thickness, average turbinate volume and average mucosa thickness were 6.223 ± 1.404 cm^3, 6.256 ± 1.811 cm^3, 1.918 ± 3.777 mm, 2.501 ± 4.793 mm, 6.239 ± 1.236 cm^3 and 2.209 ± 3.690 mm, respectively. The volume of each turbinate was correlated with the mucosal thickness of the ipsilateral and contralateral sinuses (R values ranging between 0.351 and 0.459, all P values = 0.000). The correlation between averages turbinate volume and average mucosa thickness was 62.8% (P = 0.000). Age was not correlated with any of the anatomic measurements. Multiple regression identified both left/right sinus membrane thicknesses as predictors of turbinate volume (P ≤ 0.003); sex (but not age) was the predictor for the left and average turbinates (P < 0.05). Turbinates were larger in men; mucosae were thicker in men (all P values < 0.05). The volumes of turbinates were similar on the right and left sides (P = 0.789); however, sinus membranes were significantly thicker on the left side compared to the right (P = 0.024).*

Conclusions: *The inferior turbinate volume may be associated with the thickness of both ipsilateral and contralateral sinus membranes. The male sex is associated with thicker mucosa linings and larger turbinates. Aging might not affect turbinate volume or sinus mucosa thickness.*

Keywords: inferior turbinate, maxillary sinus, mucositis, sinusitis, hypertrophy, cone-beam computed tomography (CBCT).

ABBREVIATIONS

CBCT: cone-beam computed tomography
kVp: peak kilovoltage
FOV: field of view
LED: light emitting diode
HU: Hounsfield unit
ICC: intraclass correlation coefficient
CI: confidence interval
SD: standard deviation

INTRODUCTION

Sinusitis and rhinitis are of importance to dental fields such as oral and maxillofacial surgery, implantology, maxillofacial pathology and radiology, among others (1-3). One of the signs that is frequently observed in the office is nasal blockage (4). Patients' quality of life is impacted by nasal blockage, which is frequently brought on by anatomical anomalies (5). The expansion of the inferior nasal turbinates' soft tissue or bone components results in inferior turbinate hypertrophy, which is frequently linked to long-term inflammatory conditions such rhinitis (6-9).

Sneezing, itching, nasal discharge and swelling of the nasal mucosa can be linked to rhinitis (6, 10). Maxillary sinusitis is brought on by the enlargement of the nasal mucosa, which reduces the outflow of the maxillary sinuses (6, 10). The thickening of the mucosal lining of the maxillary sinuses is linked to maxillary sinusitis (6, 11). Scholars have discovered parallels between the hypertrophied inferior turbinate mucosa and the inflammation-associated histological characteristics of the mucosal lining of the maxillary sinus (6, 12, 13). This data leads to the possibility that morphological alterations in the mucosal lining of the maxillary sinuses may be connected to morphological changes in the inferior turbinate hypertrophy (6).

Although this has been reported in case reports (14) and via a few histopathological assessments (12, 13), no clinical study had assessed the links between the sizes of the inferior turbinate and sinus membrane thickness until recently. Thus, Shetty *et al* (6) proposed this hypothesis and tested it in 2022 on 100 individuals; they found significant links between the thickness of sinus mucosa and total turbinate volume (6). However, their study was not complete because they did not report the exact measurements for sinus lining thickness and also did not distinctively evaluate the right and left sides, but they mixed and combined the left and right sides in terms of both turbinate sizes and sinus lining thickness measurements. Moreover, their study had erroneous statistical analyses because they used independent-samples analyses for matched data. Apart from their preliminary study, no other study has evaluated this hypothesis. Therefore, larger and more comprehensive studies are warranted in this regard. Besides scientific merit, the evaluation of this topic may have clinical implications as well: The information gathered from such research might be helpful for the post-operative radiography assessment of the sinuses, nasal cavity and inferior turbinates after surgeries performed for reducing the size of turbinate. Furthermore, the therapy of nasal septal deviation may benefit from the findings from the turbinate volume analysis (6, 15).

Besides the above scientific and clinical concerns, literature on sex dimorphism and the effect of age on sinus mucosa and inferior turbinate volume is very scarce (6). This again warrants the evaluation of the role of demographics in sinus lining thickening and inferior turbinate enlargement.

Therefore and in light the above-mentioned merits and gaps in the literature, this large study was conducted to evaluate, for the first time, the associations between each sinus mucosa thickness with its ipsilateral and contralateral turbinate volumes to test if there is any association. Also, the occurrence of mucositis and turbinate hypertrophy were determined and their associations, again on ipsilateral and contralateral sides, were examined. We also compared the left and right sides. The null hypotheses were the lack of any associations among the anatomic features as well as between age, sex and the anatomic features. ❑

MATERIALS AND METHODS

This was a retrospective cross-sectional study performed in 2023-2024 on cone-beam computed tomography (CBCT) scans of 302 individuals (604 left and right sinuses) referred to two private maxillofacial radiology clinics in Ahvaz, Iran, for the following diagnostic purposes: 1) dental problems and implants; 2) rhinoplasty operations; 3) septoplasty; 4) examination of the osteomeatal complex; 5) examining sinus and fungal diseases; 6) mid-fascial trauma; 7) examining the bones of the middle ear; 8) mastoid implants; and 9) cosmetic operation of the frontal area. All CBCTs were archival and taken retrospectively; therefore, no hazardous X-ray was emitted to any person because of this study. No personal information was collected. Because this study concerned retrospectively collected anonymized data, the need for informed consent to participate was waived by the Institutional Review Board of Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran (ethics number: IR.AJUMS.REC.1402.203). This retrospective study and its ethics were approved by the Ethics Committee of Ahvaz Jundishapur University of Medical Sciences (ethics code: IR.AJUMS.REC.1402.203). All methods were performed in accordance with the relevant guidelines and regulations (including the Declaration of Helsinki).

Eligibility criteria

The inclusion criteria were appropriate image quality, the presence of necessary demographic information and appropriate coverage of the maxillary sinus and nasal cavity. The exclusion criteria were artifacts in scans, previous history of maxillary sinus surgery, maxillary sinus pathologies such as cysts and tumors, cases with closed sinus ostiums, sinus or nasal polyposis and craniofacial anomalies such as cleft palate and lip. Measurements were performed only in patients whose both right/left maxillary sinuses and both right/left inferior turbinates were clearly defined and completely covered.

Sample size

A total of 24 patients sufficed to obtain powers above 99.9% at a 0.05 level of significance, as detailed below.

The raw data provided by Shetty *et al* was used to calculate additional parameters not originally calculated and reported by them. From their raw data of all their 100 cases, we computed the Spearman correlation coefficient between their sinus mucosal lining thickness values and their turbinate sizes to be Rho = 0.863. This correlation coefficient was used within SPSS 27 (IBM, Armonk, NY, USA) to calculate the necessary sample size to obtain a power above 0.999 (or 99.9%), a false negative error rate of beta = 0.001, and a level of significance = 0.05 for a two-sided test. We used the most conservative formula for the variance estimation, i.e., the Bonett-Wright method, that would give the largest sample size possible.

We did not limit ourselves to this sample size of 24 patients that would suffice to provide extremely high powers (above 99.9%). Instead, we enrolled 302 patients as three times the size of the study by Shetty *et al* in order to ensure a high reliability and generalizability of our results.

Data curation

At first, the name, age and sex of each patient were written in the respective tables. Cone-beam computed tomography images of the maxillary sinuses were processed in three axial, coronal and sagittal sections. The CBCTs were taken by the CBCT device NewTom Giana (QR, Verona, Italy) with 11×13 FOV and 8×11 and with NNTviewer v10.1 software (QR, Verona, Italy) are stored and available in the archive. The images were prepared with 90 kVp voltage and different exposure conditions depending on the voxel size and selected FOV. The images were viewed in a semi-dark room on a 14-inch monitor (LED flat screen, ASUS) with a resolution of 1080x1920.

Sinus membrane assessments

To calculate the increase in the thickness of the maxillary sinus mucosa on both sides from the Medical mode of NNT Viewer software and was used by determining the desired range. The thickness of the maxillary sinus mucosa was measured in patients using the volume of CBCT images and also using the Medical Mode part of the NNT software.

Then, to measure the thickness of the sinus mucosa, first after opening the NNT Viewer program, we entered the New Volume section, and in this section, we could see the patient's images in three axial, coronal and sagittal views. In this section, we could see the areas covered in the images by moving the sections up and down in all three views. Measurements were on both the right and left maxillary sinuses and both the right and left inferior turbinates. First, the desired area was selected in the axial image of the patient, and then corrections were made in other views (coronal, sagittal).

Sinus mucosa was evaluated in six areas, medial and distal of the second premolar, medial and distal of the first molar, medial and distal of the second molar (6). The area with the greatest increase in mucosal thickness was set as the point for measurement in millimeter (Figure 1). This process was performed for both sinuses in each patient. Cases with thicknesses of 1 mm or greater were considered mucositis (16).

Inferior turbinate volume

Also, the Medical mode of the NNT Viewer was used to calculate the volume of the inferior turbinate on both sides: First, in the axial image of the patient, select the desired area in the cross-section of the inferior turbinate. Then, corrections were made in other views (coronal, sagittal) so that the height of the turbinate was measured from the lowest point to the highest point on the coronal view images. The turbinate width was measured on coronal view images. The anterior-posterior dimension of the turbinate was also measured from the most anterior point to the most posterior point in the sagittal view. After measuring the turbinate in all three views, this sinus turns green, which was used as a guide for correct measurement.

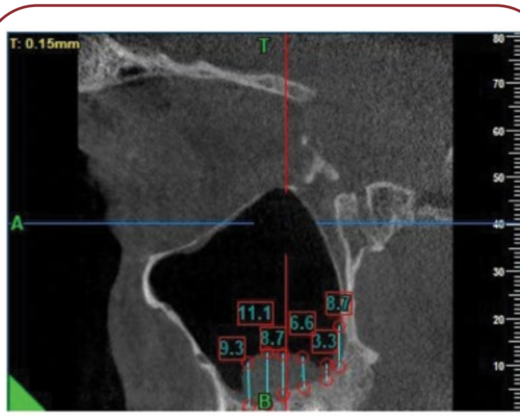

FIGURE 1. An example of the estimation of sinus membrane thickness on the sagittal plane

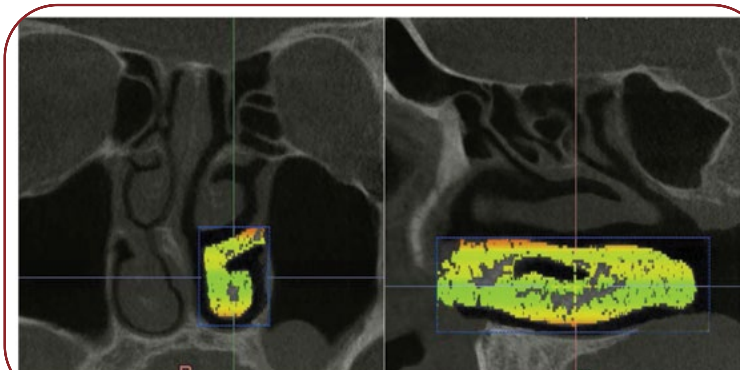

FIGURE 2. Screenshots of the cone-beam computed tomography view showing the assessment of the volume of the inferior turbinate. The color continuum reflects the volume of the identified soft tissue at each transverse plane, with green showing the largest volumes of soft tissue and orange showing the smallest volumes. The coloring is done by the measuring software, and not by the authors.

The final volume calculation was done when the maxillary sinus was completely covered in all three views. The software was set to measure the parts with densities up to 300 HU (6). In a few cases, the maximum threshold was increased slightly; in most of such cases up to 330, and in rare cases up to 400 HU, because the software gave an error in previously set maximum densities. After this, from the analyze volume statistics section, write down the total volume in the data (Figure 2). This process was performed for both the left and right turbinates in each patient.

Intraobserver agreement

The same observer randomly selected 30 cases and measured all their anatomical features again. The intraclass correlation coefficient (ICC) showed that the intraobserver agreement was perfect for sinus mucosal lining thickness on the right side (ICC = 1.0, P = 0.000), left sinus mucosal lining thickness (ICC = 1.0, P = 0.000), right turbinate size (ICC = 1.0, P = 0.000) and left turbinate size (ICC = 1.0, P = 0.000).

Statistical analysis

Descriptive statistics and 95% confidence intervals (CIs) were calculated for all variables in the left and right sides (and also both sides averaged) for males and females. Mean ages of males and females was compared using an independent-samples t-test. This test was also used to examine sex dimorphism in anatomic variables on the left and right sides, and on both sides averaged. A partial correlation coefficient, controlling for the role of sex, was used to calculate the correlations between age with anatomic features. A Pearson correlation coefficient was used to assess correlations among the anatomic features. The right and left sides were compared using a paired t-test. A multiple linear regression was used to evaluate the associations between each side's turbinate volume with its ipsilateral and contralateral sinus mucosa thickness as well as each patient's age and sex. Cases with mucositis were identified and reported. A chi-square was used to compare mucositis prevalence in men and women. The software in use was SPSS 27 (IBM, Armonk, NY, USA). The level of significance was set at 0.05. ❑

RESULTS

There was no missing data in the 302 study cases. There were 154 males with a mean (SD) of 31.01 ± 9.87 years (95% CI 29.44 to 32.58, minimum 17, maximum 65) and 148 females with a mean age of 29.24 ± 8.91 years (95% CI 27.79 to 30.68, minimum 14, maximum 70). The difference between the mean ages of males and females was insignificant (t-test, P = 0.102). The mean age of the whole sample was 30.14 ± 9.44 years (95% CI 29.07 to 31.21, minimum 14, maximum 70).

Metric measurements

Metric measurements of the anatomic features are reported in Table 1. There was a significant sex dimorphism in both mucous thicknesses and infe-

Variable	Sex	N	Mean	SD	95% CI		Min	Max	*P*
Right turbinate volume	Male	154	6.473	1.642	6.212	6.734	2.18	15.66	0.002
	Female	148	5.963	1.048	5.793	6.134	2.91	9.75	
	Both	302	6.223	1.404	6.064	6.382	2.18	15.66	
Left turbinate volume	Male	154	6.608	2.230	6.253	6.963	2.42	26.64	0.001
	Female	148	5.889	1.128	5.706	6.073	2.70	8.88	
	Both	302	6.256	1.811	6.051	6.461	2.42	26.64	
Right mucosa thickness	Male	154	2.628	4.415	1.925	3.331	0.00	26.70	0.001
	Female	148	1.179	2.801	0.724	1.634	0.00	19.00	
	Both	302	1.918	3.777	1.490	2.345	0.00	26.70	
Left mucosa thickness	Male	154	3.265	5.386	2.407	4.122	0.00	30.20	0.005
	Female	148	1.706	3.949	1.065	2.348	0.00	32.00	
	Both	302	2.501	4.793	1.958	3.044	0.00	32.00	
Average turbinate volume	Male	154	6.540	1.409	6.316	6.765	2.67	15.91	0.00001
	Female	148	5.926	0.933	5.775	6.078	3.05	8.04	
	Both	302	6.239	1.236	6.099	6.379	2.67	15.91	
Average mucosa thickness	Male	154	2.946	4.214	2.275	3.617	0.00	21.95	0.0004
	Female	148	1.443	2.870	0.976	1.909	0.00	22.60	
	Both	302	2.209	3.690	1.791	2.627	0.00	22.60	

SD: standard deviation; CI: confidence interval; Min: minimum; Max: maximum.

TABLE 1. Descriptive statistics and 95% confidence intervals for anatomic measurements in males and females. The P values are calculated using the t-test.

		Right turbinate volume	Left turbinate volume	Right mucosa thickness	Left mucosa thickness	Average turbinate volume	Average mucosa thickness
Age	**R***	0.085	-0.018	0.088	0.071	0.035	0.091
	P	0.141	0.749	0.128	0.221	0.542	0.114
Right turbinate volume	**R**		0.170	0.441	0.351	0.692	0.454
	P		0.003	0.000	0.000	0.000	0.000
Left turbinate volume	**R**	0.170		0.404	0.459	0.829	0.505
	P	0.003		0.000	0.000	0.000	0.000
Right mucosa thickness	**R**	0.441	0.404		0.476	0.547	0.821
	P	0.000	0.000		0.000	0.000	0.000
Left mucosa thickness	**R**	0.351	0.459	0.476		0.536	0.893
	P	0.000	0.000	0.000		0.000	0.000
Average turbinate volume	**R**	0.692	0.829	0.547	0.536		0.628
	P	0.000	0.000	0.000	0.000		0.000
Average mucosa thickness	**R**	0.454	0.505	0.821	0.893	0.628	
	P	0.000	0.000	0.000	0.000	0.000	

*The correlations with age are calculated using the partial correlation coefficient. The remaining correlations are calculated using the Pearson coefficient.

TABLE 2. Partial correlation matrix among anatomic measurements and age

Dependent variable	Independent variable	B	SE	Beta	t	*P*
Right turbinate volume	**(Constant)**	6.019	0.342		17.597	0.000
	Age	0.006	0.008	0.043	0.828	0.408
	Sex	-0.237	0.146	-0.085	-1.622	0.106
	Right membrane thickness	0.126	0.022	0.338	5.782	**0.000000**
	Left membrane thickness	0.051	0.017	0.173	2.967	**0.003**
Left turbinate volume	**(Constant)**	6.650	0.430		15.474	0.000
	Age	-0.012	0.010	-0.062	-1.235	0.218
	Sex	-0.381	0.184	-0.105	-2.070	**0.039**
	Right membrane thickness	0.110	0.027	0.230	4.028	**0.00007**
	Left membrane thickness	0.128	0.021	0.338	5.969	**0.000000**
Average turbinate volume	**(Constant)**	6.334	0.263		24.068	0.000
	Age	-0.003	0.006	-0.021	-0.470	0.639
	Sex	-0.309	0.113	-0.125	-2.744	**0.006**
	Right membrane thickness	0.118	0.017	0.360	7.046	**0.000000**
	Left membrane thickness	0.089	0.013	0.346	6.801	**0.000000**

B: regression coefficient; SE: standard error; Beta: standard regression coefficient.

TABLE 3. The results of the multiple linear regression analyses

rior turbinate volumes either in the left or right sides and also in the average of both sides (all P values ≤ 0.005; Table 1). Age was not associated with any of the anatomic measurements, according to the partial correlation coefficient controlling for sex (Table 2). According to the paired t-test, there was no significant difference between the volumes of the right and left turbinates (P = 0.789); however, the left mucosal membranes were significantly thicker than those on the right side (P = 0.024, Table 1). The sizes of the right and left turbinates were statistically significantly but very weakly correlated with each other (Table 2). The correlation between sinus mucosal lining thicknesses of the right and left sides was moderate (Table 2).

Main outcome: associations between sinus mucosal lining thickness and turbinate volumes

The sinus mucosal lining thickness on each side was significantly and moderately correlated with the inferior turbinate volume on the same side (Table 2). Moderate significant correlations were also found between the sinus mucosal lining thickness on one side and the turbinate volume on the contralateral side (Table 2). The correlation between the average thickness of the right and left sides was rather strong with the average volume of

TABLE 4. The net frequency and percentage of men and women with mucositis, hypertrophic turbinate, and normal sinus lining and turbinates

Anatomy	Type	Sex		Total (%)	*P*
		Male (%)	Female (%)		
Right mucus	Normal	75 (48.7)	109 (73.6)	184 (60.9)	0.00001
	Mucositis	79 (51.3)	39 (26.4)	118 (39.1)	
	Total	154 (100)	148 (100)	302 (100)	
Left mucus	Normal	78 (50.6)	103 (69.6)	181 (59.9)	0.00078
	Mucositis	76 (49.4)	45 (30.4)	121 (40.1)	
	Total	154 (100)	148 (100)	302 (100)	
Mucus (average of right and left)	Normal	66 (42.9)	93 (62.8)	159 (52.6)	0.00051
	Mucositis	88 (57.1)	55 (37.2)	143 (47.4)	
	Total	154 (100)	148 (100)	302 (100)	

the inferior turbinates on the right and left sides (Table 2).

The multiple regression analysis showed that the right turbinate volume was associated with both ipsilateral and contralateral sinus mucosa thicknesses, but not age or sex (Table 3). The left turbinate volume was associated with both ipsilateral and contralateral mucosa thicknesses as well as patients' sex (smaller turbinates in females, Table 3). The average volume of both turbinates was associated with both left and right mucosa thicknesses as well as sex (smaller turbinates in women, Table 3).

Mucositis

Of the 302 right sinus mucosal linings, 184 were normal (118 had mucositis). Of the 302 left mucosal linings, 181 were normal (with 121 mucositis). After averaging the left and right sides, of the 302 bilateral mucosal linings, 159 were normal. According to the chi-square test, the occurrence of mucositis turbinate was more prevalent in men than women (Table 4). ❑

DISCUSSION

The findings of this study suggested for the first time that turbinate volume may be associated with both the ipsilateral and contralateral sinus mucosa thickness. The male sex is associated with thicker mucosa linings and larger turbinates. Also, both mucositis and turbinate hypertrophy may be more prevalent in men. Aging does not affect turbinate volume or sinus mucosa thickness.

Similar to our study, Shetty *et al* (6) identified a significant link between the average of sinus mucosa lining on both sides and turbinate volume on both sides. Such a connection can be attributable to the fact that factors that can contribute to thickening of sinus lining might as well contribute to the enlargement of the inferior turbinate: The most common causes of inferior turbinate hypertrophy include allergies, prolonged sinus infections, deviated septum, smoking, vasomotor rhinitis, and exposure to irritants (4, 6, 9, 17). This link might be understood in light of the general process of inflammation of the sinonasal cavity: The inflammatory response known as maxillary sinus mucosal thickening is typified by the mucosal lining becoming hyperplasic. Thickness of the mucosa in the sinuses of the upper jaw is frequently linked to chronic sinusitis, infections, or allergies (6, 18). Hence the inferior turbinate enlargement and nasal membrane swelling might be associated with chronic rhinosinusitis (6, 19). Besides, recurrent sinusitis and nasal obstruction might be caused by an increase in turbinate size (6, 20). The histological inflammatory alterations that develop in the sinus epithelial lining and the turbinate may also be contributing factors. Similarities between thicker mucosal membrane of the maxillary sinus and the inflammatory aspect of turbinate enlargement have been identified by clinicohistopathological investigations (6, 13, 21). Two case reports have drawn attention to the thicker mucosal lining of the maxillary sinus when there is either hypertrophy or pneumatization of the inferior turbinates (14, 22). There is no other study in this regard. But according to a study that examined nasal turbinate thickness against sinus volumes, increasing turbinate thickness accompanied a considerable decrease in sinus volumes (23).

In the present study, age did not affect turbinate volume or sinus mucosa thickness. Our result regarding age was in line with that of Shetty *et al* (6) who did not observe an association between turbinate size with age; they did not, however, examine the correlation between age and sinus lining thickness. When it comes to the role of sex, Shetty *et al* did not report a significant link between sex and turbinate volume. In the multiple regression analyses, we as well did not observe a significant link for the right turbinate; nevertheless, in the case of the left turbinate or the average of both turbinates, it was found that men tend to have larger turbinates than do women. Besides, univariable comparisons showed that sexual dimorphism exists in both the left and right turbinates, in both men having larger turbinates. In this regard, the literature is scarce: No significant age-related linear dimensional changes in the turbinate were seen in a recent CT-based analysis (24). Moreover, in a report concerning the polymorphism of the inferior turbinates, no variation in turbinate size associated to sex was found (25).

Various modalities can be used for imaging of the nose and paranasal sinuses (26, 27). These include CT scan which is one of the most common modalities in use and can provide properly detailed 3D volumes and sections of hard tissues and soft tissues (26, 27). CBCT is a form of CT which needs lower X-ray doses compared to CT, and is usually used in oral and maxillofacial surgeries (28). Of course, plain X-ray is the oldest method of imaging the nasal and paranasal structures and can provide 2D images (26, 27). Magnetic resonance imaging (MRI) is a non-invasive 3D imaging technique which is more utilized in imaging of soft tissues such as tumors, soft tissue masses, or inflammations as well as image-guided surgeries (26, 27, 29, 30). Positron Emission Tomography (PET) scan is used to detect malignancies in the head and neck areas, including the nose and paranasal sinuses (31). Endoscopy is yet another modality that allows direct visualization of the internal cavities of the nasal and paranasal areas. Finally, ultrasonography as a non-invasive economic and fast method can be utilized to diagnose pediatric nasal fractures or guide fine-needle aspiration biopsies of masses or to evaluate the nasal passages in children (32-34). According to a recent study by Neagos *et al* (34), it has a high specificity and sensitivity in ruling out patients without rhinosinusitis in outpatient settings.

This study had some advantages and limitations. As an important limitation, we did not take into account possible allergic status of the patients. The advantages were its very large sample and the evaluation of potential links between each turbinate with its both ipsilateral and contralateral sinus mucosal thicknesses (instead of limiting the results to the averages of both sides). The method of assessment might be considered another advantage. In our study, we did not rely on AI to segment the turbinate; instead, we segmented it ourselves before letting the software calculate the volume. Moreover, the sinus membrane was as well measured by the operator. This along with the perfect intraobserver values obtained after remeasuring the values indicate a high accuracy in metric measurements. The use of the software itself was valid, since recent versions of such software programs have been shown to allow very high accuracies (6, 35). The limitations included the continuity of the nasal and paranasal cavities, allowing some pathologies to propagate from one to the other. Another limitation was not separating the bony part of the turbinate from the soft-tissue part during the evaluation due to technical limitations shared with Shetty *et al*; it should be noted that it is mostly the soft-tissue part that is affected by the etiologies that can cause rhinosinusitis (6, 8). The generalizability of this research is limited to the ethnic group of the sample. Still, we tried to broaden our sample characteristics in terms of patients' range of age and sex. The generalizability could be also affected by the patients' chief complaints. Although a great part of our cases were maxillofacial surgery patients, we also had referrals from medical specialists as well. The imaging of choice for sinus areas is CT scan. However, CBCT is becoming increasingly common in fields other than dentistry (like ENT) due to its much lower X-ray doses and good resolutions (36). Besides, it should be noted that none of the included patients had any sinus changes due to dental issues. In other words, we carefully checked the cases for their teeth, and any cases that had teeth with the possibility of any lesions (e.g., endodontically treated teeth, teeth with root canal infections, any other forms of dentoalveolar lesions) were excluded. ❑

CONCLUSIONS

The inferior turbinate volume may be associated with the thickness of both ipsilateral and contralateral sinus mucosal linings. The male sex is associated with thicker mucosa linings and larger turbinates. Also, mucositis may be more prevalent in men. Aging might not affect turbinate volume or sinus mucosa thickness. ❑

Ethics approval and consent to participate: All CBCTs were archival and taken retrospectively; therefore, no hazardous X-ray was emitted to any person because of this study. No personal information was collected. Because this study was on retrospectively collected anonymized data, the need for informed consent to participate was waived by the Institutional Review Board of Ahvaz Jundishapur University of Medical Sciences, Ahvaz, *Iran (ethics number: IR.AJUMS.REC.1402.203). This retrospective study and its ethics were approved by the Ethics Committee of Ahvaz Jundishapur University of Medical Sciences (ethics code: IR.AJUMS.REC.1402.203). All methods were performed in accordance with the relevant guidelines and regulations (including the Declaration of Helsinki).*

Availability of data and material: The data are available from the corresponding author upon request.

Conflicts of interest: none declared.

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Authors' contributions: Mahshid Razavi conceived the idea of the thesis and the main hypothesis (the link between turbinate and ipsilateral sinus mucosa thickness), searched the literature, designed the study, provided the CBCTs, interpreted the findings, wrote the thesis and critically reviewed the article. Sanaz Sharifi searched the literature, supervised the thesis, interpreted the findings and critically reviewed the thesis and article. Farzin Afshari searched the literature, collected the data, interpreted the findings, wrote the thesis and critically reviewed the article. Vahid Rakhshan searched the literature, hypothesizes the link between turbinate and its contralateral sinus membrane and other hypotheses tested in the study, designed the study, validated and analyzed the data, interpreted and discussed the findings and drafted the article.

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