

For a more accurate prediction of LC correction in class III asymmetry patients, further studies are required to classify the samples by the pattern and amount of asymmetry, surgical method, as well as the amount/direction for the maxillary repositioning. In addition, larger sample sizes should be employed, using multicenter studies.

CONCLUSIONS

In 3-dimensional evaluation of class III asymmetry, for patients treated with 2-jaw surgery, the use of 3-dimensional FS images in conjunction with 3-dimensional CT can provide more accurate information about changes in AMXOP, PMXOP, and LC.

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Maxillary Sinus Aeration in Allergic Rhinitis

Mustafa Kaymakci, MD, Fuat Erel, MD, Erdogan Bulbul, MD, Hasmet Yazici, MD, Mustafa Acar, MD, and Bahar Yanik, MD

Objective: We aimed to investigate the relationship between allergic rhinitis, which is an important reason of nasal obstruction, and maxillary sinus aeration.

Patients and Methods: Three hundred fifteen patients who have a complaint of nasal obstruction and scheduled to undergo skin prick test (SPT) with a suspicion of allergic rhinitis (AR) were enrolled for this study. Thirty-two patients with positive SPT result and 30 patients with a negative SPT result were determined as group 1 and 2 (control group), respectively. A 3-dimensional reconstruction of computed tomography images of the 62 patients was used to assess and calculate maxillary sinus volumes (MSVs).

Results: Total maxillary sinus volumes were measured as 21.87 cm³ and 30.15 cm³ in group 1 and group 2, respectively. A statistically significant difference was observed between the MSVs of the groups ($P < 0.001$).

Conclusion: Total maxillary sinus volumes were found to be significantly smaller for patients with a positive SPT compared to patients with a negative SPT. Thus, we may conclude that AR has a negative impact on maxillary sinus aeration.

Key Words: Allergic rhinitis, maxillary sinus volumes, nasal obstruction, computed tomography

Maxillary sinus is situated in the maxillary bone and has various anatomic and physiologic functions as other paranasal sinuses. It is derived from mesodermal structures, and development begins in the third week of gestation.¹

As a dark side of rhinology, paranasal sinus development and aeration are still not fully understood. Several mechanisms such

From the Departments of Otorhinolaryngology, Allergy, and Radiology, Balikesir University Faculty of Medicine, Balikesir; and Department of Otorhinolaryngology, Eskisehir Yunus Emre Hospital, Eskisehir, Turkey.

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Address correspondence and reprint requests to Haşmet Yazici, MD, Balikesir University Faculty of Medicine ENT Clinic, Balikesir, Turkey; E-mail: hsmtzyz@yahoo.com.tr

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as nasal airflow, cranial growth, muscle mass traction, and more recently cellular mechanisms have been proposed to explain this process.² Individual differences of the degrees of paranasal sinus extension or aeration reflect the multifactorial basis of its development process. Clinical consequences of different aeration degree of maxillary sinuses have been investigated by numerous studies.^{3,4} Maxillary sinus has a biphasic growth pattern. Growth occurs initially between the ages of 3 and 7 and then between 12 years of age and early adulthood. Sinus reaches approximately 33 mm in height, 23–25 mm in width, and 34 mm in anteroposterior axis, and the mean values of the maxillary sinus volume (MSVs) have been reported to range from 11.1 ± 4.5 to $23.0 \pm 6.7 \text{ cm}^3$ in the previous studies.^{5,6} According to recently published articles, development and aeration degree of the paranasal sinuses seems to have an importance on the evolution of various clinical problems such as rhinosinusitis.⁷

Allergic rhinitis (AR) is characterized by an inflammation of the nasal and paranasal sinus mucosal linings due to a specific IgE-mediated hypersensitivity reaction.⁸ Resultant mucosal inflammation induces various symptoms and signs independently from the accused allergen. These typical clinical findings are nasal obstruction, nasal itching, sneezing, rhinorrhea, and smell disturbances.⁹ Allergic rhinitis is related with numerous upper and lower airway inflammatory diseases such as asthma, rhinosinusitis, adenotonsillary hypertrophy, etc.¹⁰ Although AR has a close relation with paranasal sinuses, the association between AR and paranasal sinus anatomy has not been investigated. In our study, we aimed to investigate the relationship between allergic rhinitis, which is an important reason of nasal obstruction, and maxillary sinus aeration.

PATIENTS AND METHODS

The study was designed as prospective and was conducted at the Ear Nose Throat and Allergy Clinics. Ethics committee approval was obtained from the local ethics committee. Three hundred fifteen patients who have a complaint of nasal obstruction and scheduled to undergo skin prick test (SPT) with a suspicion of AR were enrolled for this study. Thirty-two patients with a positive SPT result and 30 patients with a negative SPT result were determined as group 1 and 2 (control group), respectively. A 3-dimensional reconstruction of computed tomography images of the 62 patients was used to assess and calculate maxillary sinus volumes. Skin prick tests involving the 25 most common regional environmental antigens (Allergopharma extracts; Allergopharma, Reinbek, Germany) were performed on all participants (Table 1). Histamine and saline solutions were used as positive and negative controls, respectively. The resulting “wheal and flare” reactions were evaluated 15 min

TABLE 1. Types of Allergens

Mixes*		
Trees I	Trees I	<i>Betula verrucosa</i> , <i>Platanus orientalis</i>
Trees II	Trees II	<i>Populus alba</i> , <i>Salix caprea</i>
	Other trees	<i>Pinus silvestris</i> , <i>Olea europaea</i>
Weeds	Weeds	<i>Artemisia vulgaris</i> , <i>Plantago</i>
Grasses-cereals	Grasses-cereals	<i>Cynodon dactylon</i> , <i>Triticum sativum</i> , <i>Phleum pratense</i>
Molds I	Molds I	<i>Alternaria tenuis</i> , <i>Cladosporium herbarum</i>
Molds II	Molds II	<i>Aspergillus fumigatus</i>
	Mites	<i>Dermatophagoides faringae</i> , <i>Dermatophagoides pteronyssinus</i>
	Epithelia	Dog epithelia, cat epithelia, cockroach

Allergopharma (Allergopharma, Reinbek, Germany) extracts were used.
* All mixes and written antigens above in table were used.

after the application. Each reaction wider than 3 mm in diameter was regarded as a positive result. The identified allergens, age of onset and the duration of the allergic symptoms, the presence of asthma (according to GINA guidelines),¹¹ and the effect of these variables on MSVs were investigated. Patients with severe septal deviation and anatomic abnormalities, such as agenesis, paradoxal nasal concha, and choanalatresia, or previous history of radiotherapy or sinonasal surgery were excluded.

Measurement of Maxillary Sinus Volumes

Non-contrast paranasal sinus computed tomography (CT) using a 64-slice CT scanner (Aquilion 64; Toshiba, Ottawara, Japan) were obtained in the supine position. Continuous non-overlapping sections of paranasal sinus CT scan were obtained with acquisition parameters of 1.0 mm slice thickness, 100–120 kV, and 100–200 mAs (according to age). The pixel spacing was 0.3 mm × 0.3 mm. The CT data sets were stored as Digital Imaging and Communication in Medicine (DICOM) files. Each maxillary sinus (right and left side) volume of all participants was measured separately. The reconstructed coronal CT data set with bony algorithm was used for segmentation processing. For segmentation, the radiologist drew demarcation lines by hand following the inner mucosal surface of maxillary sinus in all consecutive coronal slices from the anterior to the posterior sinus wall. After outlining the sinus borders, 3-dimensional (3D) images of maxillary sinuses were reconstructed using the segmented images on the workstation (Aquarius iNtuition, version 4.6; TeraRecon, San Mateo, CA). During reconstruction using a surface-rendering algorithm, the window thresholds were −1024 to +100 Hounsfield Units (HU). The volumes of maxillary sinuses were automatically calculated by workstation in the 3D reconstruction.

The results were analyzed with SPSS 15.0 software for Windows (SPSS Inc., Chicago, IL) and the statistical significance level was considered as *P* less than 0.05.

RESULTS

Thirty-two patients (13 male, 19 female) had positive results as group 1 (PER) with the mean age of 32 ± 4.23 (range, 19–51) years and 30 patients (12 male, 18 female) who had negative test results as group 2 (control group) with the mean age of 30.2 ± 3.83 (range, 17–50) years. There was no statistically difference between the groups in terms of age or gender (*P* > 0.05). Maxillary sinus volumes are shown in Table 2. There was no significant difference between the left and right side sinus volumes in two groups (*P* > 0.05). Total maxillary sinus volumes were measured as 21.87 cm^3 and 30.15 cm^3 in group 1 and group 2, respectively. A statistically significant difference was observed between the maxillary sinus volumes of the groups (*P* < 0.001).

Nine of the patients (28.1%) were having accompanying asthma in group 1, and no relationship was found between asthma and non-asthmatic group for MSVs (*P* > 0.05). When considering the starting age of the allergy symptoms in group 1, no statistical difference

TABLE 2. Comparison of Groups for Demographical and Sinus Volumes

			Maxillary Sinus Volumes		
			Right Max Sin Vol	Left Max Sin Vol	Total Max Sin Vol
	Age	Sex			
Group 1	32 ± 4.23	M = 13 F = 19	10,640	11,232	21,872
Group 2	30.2 ± 3.83	M = 12 F = 18	15,613	14,540	30,153
P value	>0.05	>0.05	<0.05	<0.05	<0.05

was found in volumes of sinuses whether symptoms started before or after puberty ($P > 0.05$). Additionally, no statistical difference was found in the comparison of each type of allergens whether perennial (mites, cockroach, animal dander, and mold spore) or seasonal (pollen) for MSVs ($P > 0.05$).

DISCUSSION

Human anatomy has numerous variations, which is mainly determined by genes and environmental factors. In the wide spectrum of these variations, some have a potential to influence the development of other clinical problems and some do not. As a reflection of this knowledge, our study showed that to have a positive SPT seems related with having diminished maxillary sinus aeration. In agreement with our findings, many other human and animal studies have shown that maxillary sinus or other paranasal sinus aeration and development may be affected by various clinical problems. For example, in their rabbit study, Shin et al demonstrated that unilateral obliteration of nasal cavity results in anatomical and histological changes on the ipsilateral side of the nasal cavities of rabbits.¹² Also Diner et al reported that patients who have choanal atresia reflect asymmetrical paranasal sinus development.¹³ Another study conducted by Gencer et al showed that unilateral maxillary sinus volume in patients with septal deviation decreases proportionally with the severity of the deviation.² Although we did not investigate ethmoidal cell volume in our study, Firat et al demonstrated that septal deviation affects ethmoidal cell development and aeration.¹⁴ In the light of our findings and these studies, it is possible to mention that nasal airflow seems important in the aeration of maxillary and other paranasal sinus aeration. According to our knowledge, the effect of allergy on MSVs has not been studied yet. In this study, we determined a significant decrease in MSVs in patients with AR. By the specific Ig-E-mediated edema of the inflamed nasal and paranasal mucosal linings in AR, nasal airflow decreases due to the congested inferior turbinates and other parts of the nasal cavity. Reduced nasal airflow in AR patients has been shown by numerous studies using objective measurements as rhinomanometry.^{15–17} Long-lasting nasal obstruction in AR patients seems related with decreased maxillary sinus aeration.

Tomography is the best imaging technique for demonstrating paranasal sinuses. This technique has been routinely used for patients with sinusitis as well as analysis of paranasal sinus anatomy through scanning.¹⁸ Three-dimensional reconstruction is today the most valid technique for measuring the volume of air-filled cavities in the body. Kawarai's report on volume quantification of paranasal sinuses on 3-dimensional CT scans was followed by other studies, as the technique has since been continuously developed and improved.^{4,6} To obtain a 3D image, CT images should be segmented, and a volume must be reconstructed. There are 3 options for segmentation: manual, semi-automatic, and automatic segmentation. Manual segmentation is a time-consuming process due to the per-slice user interaction required. There is as yet no automatic segmentation approach for paranasal sinuses due to the complex anatomy and high anatomical variability involved. Only semi-automatic methods are currently available for paranasal sinus segmentation. However, this method is still very time consuming and is not as accurate as manual segmentation. In our study, we used manual segmentation. Maxillary sinuses were outlined according to the inner mucosa surface.

In group 1, 11 (34%) patients' allergic symptoms initial time was before puberty, and no relation was found for the initial time of allergy and MSVs. The obstruction of the airflow may affect sinus volumes in the ventilation process, and studies reported that sinus hypoplasia may develop in association with chronic negative

pressure related to obstruction of the sinus ostium after the development of sinuses ended.^{8,9} This study clearly showed that MSV is decreased in individuals with PER. Moreover, we could not also find any statistical difference in volumes of sinuses in group 1 whether symptoms started before or after puberty, the types of allergen, and the presence of asthma.

CONCLUSION

Allergic rhinitis is a factor leading to a decrease in MSV. Therefore, we suggest that when any medical or especially surgical treatment is planned for the diseases of maxillary sinuses area in allergic individuals, allergy is an important factor that should be taken into consideration, and these have a greater risk of complications during endoscopic surgery.

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