Journal of the Anatomical Society of India 66 (2017) 131–134

Contents lists available at ScienceDirect

Journal of the Anatomical Society of India

journal homepage: www.elsevier.com/locate/jasi

Original article

Volumetric correlation between concha bullosa and paranasal sinuses

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ARTICLE INFO

Article history:
Received 21 December 2015
Accepted 25 May 2017
Available online 13 June 2017

Keywords:
Concha bullosa
maxillary sinus
frontal sinus
nasal septal deviation angle
computed tomography

ABSTRACT

Introduction: The aim of this study was to evaluate the volumetric analysis among the volumes of concha büllosa,maxillary and frontal sinus,nasal septal deviation angle.

Materials and Methods: We retrospectively reviewed digitally stored paranasal sinus computed tomography (CT) images of 509 adult patients. Concha bullosa, maxillary sinus and frontal sinus volume,nasal septal deviation (NSD) angle were determined on CT scans.

Results: The average volumes of concha bullosa,maxillary sinus,frontal sinus were 1,07 ± 0,88,13,26 ± 5,08 and 4,87 ± 2,64,respectively in the under the average age range patients. The average volumes of concha bullosa, maxillary sinus and frontal sinus in the above the age range were 1,13 ± 0,83,16,57 ± 7,38 and 5,07 ± 2,05,respectively.

Discussion: There was a positive correlation between concha bullosa and paranasal sinus volumes.Our results may helpful in understanding normal volumetric values of the paranasal sinuses and concha bullosa.The knowledge of presented data may be useful in clinical planning of medical or surgical interventions of the paranasal sinuses and concha bullosa.

1. Introduction

Pneumatization of the middle turbinate is called conchae bullosa.Concha bullosa was first defined by Santorinus1 in 1739 as a mutation of the anterior part of the middle turbinate into a bubble.It is a quite common condition affecting approximately 35% (range 14–53%) of the population.2

The paranasal sinuses are complex anatomical structures and it is different among individuals.The use of computed tomography (CT) instead of plain radiography in the work-up of paranasal sinus pathology was recommended in the beginning of the 1990's.3 Since then CT has become compulsory in the preoperatıve work-up of sinus surgery.In addition,CT has become an obligatory aid in navigation during the functional endoscopic sinus surgery (FESS).

The different anatomical dimensions of the paranasal sinuses can also be obtained from CT images.Kawarai's report on volume quantification of the paranasal sinuses on three-dimensional CT scans.4

In the literature,there are studies on the correlation of between conchae bullosa and nasal septal deviation.5,6 When we searched the literature, we did not observe an article about volumetric correlation between concha bullosa and paranasal sinuses volumes.

Concha bullosa is associated with deviation of the nasal septum, which itself has been associated in some studies with an increased incidence of sinus disease.1

We heve done a retrospective analysis of the CT of paranasal sinuses for the purpose of evaluate the volumetric correlation between concha büllosa and paranasal sinuses.

2. Materials and methods

We retrospectively searched our radiology database for all paranasal sinus CT finding obtained between 1 January 2012 and 28 February 2014 in the research and traınıng hospital in Kayseri. It determined the age and sex of the patients.The only inclusion criteria used was presence of conchae büllosa.Exclusion criteria were decisive as follow; (1) previous sinonasal surgery, (2) history of radiotherapy, (3) maxillofacial trauma and fracture, (4) sinonasal tumor, (5) granulomatous disease, (6) sinonasal fungal infection, (7) <18 years of age and (8) diffuse sinonasal polyposus. Concha büllosa was determined as being present when more than 50% of

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http://dx.doi.org/10.1016/j.jasi.2017.05.011

the vertical height (measured from superior to inferior coronal plane) of the middle turbinate was pneumatized.The existence of concha büllosa on the CT scan was defined as unilateral or bilaterally present.İf bilateral conchae büllosa were available the larger one was describe dominant concha.The existence of co-existent nasal septal deviation (DNS) was also noted. We described nasal septal deviation as any curvature of the nasal septal contour as evaluated on coronal CT studies.The side of convexity of the curvature determined the direction of the deviation.

CT images of patients were enrolled with 4-slices helical (Toshiba,Japan) in two projections, axial ad coronal. 1 mm slices were used for volumetric analysis. The volume size of concha bullosa and paranasal sinuses were calculated using post-processing programs through selecting the related anatomical region, utilizing the adding and dilating processes step by step and the last being demonstrated as colored areas for analysis (Fig. 1). Septum angles also were calculated with using measurement tools.

Concha bullosa volume was compared with maxillary and frontal sinus volumes.It was determined that there is a significant difference statistically. The correlation between the volume of concha bullosa and maxillary and frontal sinuses volumes were determined. The volume of concha büllosa and paranasal sinuses the difference between the sexes was determined.Concha büllosa volume was compared with nasal septal deviation angle.It was determıned that there is a significant difference statistically.The correlation between the volume of concha büllosa and nasal septal deviation angle were determıned.

2.1. Statistical Analysis

Statistical analysis was performed with SPSS 15.Whether statistically significant differences were determined by Mann-Whitney U test. P value was reduced from 0.05 considered significant. Correlation analysis was performed with Spearman Brown test.

Permission was acquired from the local ethical committee of our institution to review the patients medical charts and CT images from the picture archiving and communication system.

3. Results

509 CT images were evaluated,155 (30,4%) patients were found to have concha bullosa.There were 80 (51,6%) male patients and 75 (48,4%) female patients.Concha bullosa was found to be 155 (30,5%) patients. Unilateral CB is 95 (61,3%) patients and bilateral in 60 (38,7%) patients.

The average age of the patients was 34.The average volumes of concha bullosa, maxillary sinus and frontal sinus in the 19–33 age range (under the average age of this group) were 1,07 ± 0,88,13,26 ± 5,08 and 4,87 ± 2,64,respectively. The average volumes of concha büllosa, maxillary sinüs and frontal sinüs in the 34–70 age range (above the average age of this group) were 1,13 ± 0,83,16,57 ± 7,38 and 5,07 ± 2,05,respectively. In the 34–70 age range (above the group's average age) of patients, the average volumes of concha bullosa, maxillary sinus and frontal sinus were significantly higher compared to patients in the 19–33 age group. However, it didn't show any statistically significant difference among conchae bullosa maxillary sinus and frontal sinus volumes ($p > 0{,}05$) (Table 1).

The average volumes of the concha bullosa, maxillary sinus and frontal sinus in male patients were 1,19 ± 0,86,16,37 ± 5,98 and 6,46 ± 1,79,respectively. The average volumes of concha bullosa, maxillary sinus and frontal sinus in female patients were 0,98 ± 0,86,12,15 ± 5,39 and 3,51 ± 2,05,respectively. The average volumes of the concha bullosa,maxillary sinus and frontal sinus in the male patients were larger than in the female patients. However, the diferentiation of volume of concha bullosa was not detected according to patient's gender ($p > 0{,}05$).The differentiation of volume of maxillary sinüs was detected 0,05 level of significance according to patient's gender. The differentiation of volume of frontal sinus was detected 0,01 level of significance according to patient's gender (Table 2).

There was found a moderate positive correlation between concha büllosa and maxillary sinüs volume ($r{:}-0{,}645$, $p < 0{,}01$). There was found a low positive correlation between the volume of concha bullosa and frontal sinus ($r{:}-0{,}220$, $p > 0{,}05$) (Table 3).

Co-existent DNS was found in 120 (77,4%) patients,deviation presence opposite to the side of concha bullosa (unilateral/dominant concha). The mean age of the patients was 37. The average volume of concha büllosa in the 19–36 age range (under the average age of this group) was 0,82 ± 0,65. The average angle of nasal septal deviaiton in the 19–36 age range (under the average age of this group) was 8,55 ± 5,99.The average volume of concha bullosa in the 37–70 age range (above the average age of this group) was 0,81 ±0,61. The average angle of nasal septal deviaiton in the 19–36 age range (under the average age of this group) was 8,50 ± 6,03. In the 19–36 age range (under the group's average age) of patients, the average volume of concha bullosa and angle of NSD were significantly higher compared to patients in the 37–70 age group. However, there was not detected any statistically significant difference between conchae bullosa volume and NSD angle ($p > 0{,}05$). The correlation was evaluated between concha büllosa and NSD angle but they was not any significant correlation between each other (r:-0,08, $p > 0{,}05$) (Table 4).

4. Discussion

Concha bullosa (CB), known as being the middle turbinate to pneumatized. It originates as the extension of the pneumotization from the frontal recess or agger nasi cells. Concha bullosa is a

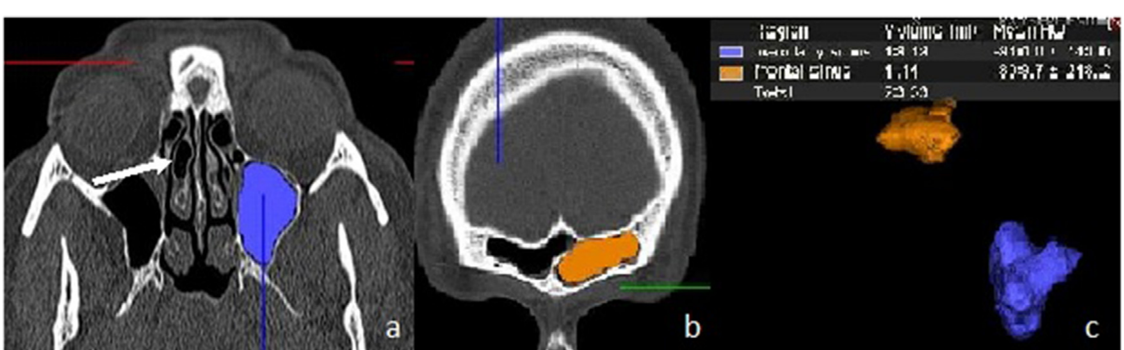

Fig. 1. This picture showed that concha bullosa (white arrow), maxillary sinus (blue area), and frontal sinus (orange area).

Table 1
The comparison of average volumes of concha büllosa,maxillary sinus and frontal sinus. The mean volume was observed to be higher in the 34–70 age group.

	ages	N	Mean volume	Std. Deviation	Mann Whitney U	p
Concha büllosa volume	19–33 age	105	1,07	0,88	102,000	0,899
	34–70 age	50	1,13	0,83		
Maxillary sinus volume	19–33 age	105	13,26	5,08	78,000	0,254
	34–70 age	50	16,57	7,38		
Frontal sinus volume	19–33 age	105	4,87	2,64	88,000	0,748
	34–70 age	50	5,07	2,05		

Table 2
The comparison of the volumes of concha büllosa,maxillary sinus and frontal sinus according to patient's gender. The volumes of maxillary sinüs, frontal sinüs and concha büllosa are larger in males.

	gender	N	Mean	Std. Deviation	Mann Whitney U	p
Concha büllosa volume	male	80	1,19	0,86	99,000	0,406
	female	75	0,98	0,86		
Maxillary sinus volume	male	80	16,37	5,98	68,000	0,040*
	female	75	12,15	5,39		
Frontal sinus volume	male	80	6,46	1,79	34,000	0,002**
	female	75	3,51	2,05		

*$p < 0.05$ **$p < 0.01$.

Table 3
The correlation of the volumes of concha büllosa,maxillary sinus and frontal sinus.There was found a moderate positive correlation between concha büllosa and maxillary sinüs volume (r:−0,645, p < 0,01).There was found a low positive correlation between the volume of concha büllosa and frontal sinüs (r:−0,220, p > 0,05) .

	Concha büllosa volume	Maxillary sinus volume	Frontal sinus volume
Concha büllosa volume	1,000		
Maxillary sinus volume	0,643(**)	1,000	
Frontal sinus volume	0,220	0,207	1,000

**$p < 0.01$.

Table 4
The comparison of the concha büllosa volume with nasal septal deviation angle. There was no statisticallay relationship between concha büllosa volume and nasal septal devitıon angle.

	Age group	N	Mean	Std. Deviation	Mann Whitney U	p
Nasal septal deviation angle	19–36 age	88	8,55	5,99	21,000	0,895
	37–70 age	32	8,50	6,03		
Concha büllosa volume	19–36 age	88	0,82	0,65	20,500	0,844
	37–70 age	32	0,81	0,61		

common anatomic variation, which can begin at any age.Most patients with concha bullosa are asymptomatic.

Pneumotization of the middle turbinate in accordance with anatomical definition occurs in the bony structures of the ethmoid complex.Because the middle turbinate is part of the ethmoid complex. CB is seen a highly pneumotize ethmoid sinus.7 The process of pneumotization of the ethmoid cells and secondary sinuses is contemplated an active achievement of the nasal mucosa (to be procise,of the ectodermal Schneiderian membrane).8

The prevalence of concha bullosa ranges from 14 to 53%6,11 as assessed on the basis of CT findings.In our study,concha bullosa was found 155 (30,5%) of the patients in the comparison with the study conducted by Stallman et al. (35%).6,9 However,the population studied was referred for CT scan due to the presence of a specific symptom presumably related to the potential disease in the sinonasal region.For this reason the statistical inference of our resultsapplies only a asymptomatic population.No conclusion about the general population is made from the result of this study.

The functional importance of paranasal sinuses,despite difference theories on the matter,has not as yet been clarified.10 In spite of the clinical importance to otolaryngology of paranasal sinus as a site of chronic infection,the real function of the paranasal sinus cavity is still uncertain.Providing normative values of paranasal sinus size and their changes with age colud be helpful in evaluating the presence of abnormality. The normative size rather than the comparison with the opposite side can be used for treatment planning and evaluation of the outcome.Measurement of the sinus volume in the clinic is not always possible,if feasible,it involves much effort. A suitable index,which is well correlated with the volume is, for this reason, necessary.11

The Cavalieri principle of modern stereological approaches provides reliable and efficient estimation of structures and organs of interest.In this method,two dimensional images obtained by CT and magnetic resonance (MR) were used to obtain a three dimensional parameter, the volume.12 The volume can also be obtained using the software combined with the tool. Post processing software program were used in this study for paranasal sinus volumes and NSD angle.

There are some studies evaluating the volume of paranasal sinuses.11,13 Maxillary sinus volume fluctuating between 8,6 and

24,9 cm^3. In our study,the average volume of maxillary sinus was found 13,26 cm^3 in the 19–33 age range group,16,57 cm^3 in the 34–70 age range group. The average CB volume was found 1,07 cm^3 in the 19–33 age range group,1,13 cm^3 in the 34–70 age range group. The only important parameter was age;the maxillary sinus volume tends to decrease after the age of 20 years.14 It was determined that all paranasal sinuses and concha büllosa have the larger volume in the above the average age range group from the another group in this study.There was found a moderate positive correlation between concha büllosa and maxillary sinüs volume ($r{:}-0{,}645$, $p < 0{,}01$). That is,if concha büllosa volume is rise maxillary sinüs volume is rise.There was found a low positive correlation between the volumes of concha büllosa and frontal sinüs ($r{:}-0{,}220$, $p > 0{,}05$).

Some of studies statement that the volumes of paranasal sinuses show gender differences,the sinuses in males being larger than in females.14,15 However, Sanchez Fernandez at al.16 reported that there were no statistically significant differences regarding asymetry and gender. Kawarai at al.4 also statement that males tend to have larger sinuses but there were no statistically significant differences between genders except fort he size of frontal sinuses,which was significantly smaller in females. Our results also showed that the volumes of maxillary sinus,frontal sinus and concha büllosa are larger in males. But concha bullosa volume did not show a significant difference between the sexes. Maxillary sinus volume showed a moderately significant relationship. Frontal sinüs volume showed low levels significant relationship.

With regard to the nasal septal deviation,there are very few studies,which report the relationship between concha büllosa and nasal septal deviation.Volumetric analysis of concha bullosa with paranasal sinuses and nasal septal deviation studies done in the literature is rare or nonexistent.We think that this is one of the first study about in this section. In our study,we found that 77,4% patients with concha büllosa had co-existent NSD to the contralateral side, which is statistically significant.In our study, concha büllosa volume didn't show any significant relationship with nasal septal deviation angle.

5. Conclusions

There was a moderate correlation between the volume of cocha büllosa and maxillary sinüs. It was not any association between concha büllosa volume and NSD angle.n The volumes of maxillary sinüs,frontal sinüs and concha büllosa are larger in males.Our results may helpful in understanding normal volumetric values of the paranasal sinuses and concha büllosa. The knowledge of presented data may be useful in clinical planning of medical or surgical interventions of the paranasal sinuses and concha büllosa.

Conflict of Interest

There is no conflict of interest among authors.

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