

# Anatomic Variations of the Paranasal Sinuses on CT scan Images

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## Abstract:

**Statement of Problem:** Variation in paranasal sinus anatomy as shown on computed tomographic scans is of potential significance for it may pose risks during surgery or predispose to certain pathologic conditions.

**Purpose:** The aim of this study was to assess the relative frequency and concurrence of variations in paranasal sinus anatomy in a given population and to compare the results with previous investigations conducted on different populations.

**Materials and Methods:** All patients over 16 years of age referred to Valiasr hospital, Tehran, Iran, with paranasal sinus tomographic scans and a clinical diagnosis of chronic sinusitis were considered for this study. After excluding those with altered anatomy (iatrogenic or pathologic), scans of unaltered patients were meticulously analyzed for variations in sinus anatomy. Findings were recorded on the patient's data sheet. The distance between the maxillary sinus floor and the alveolar ridge at the level of the 1<sup>st</sup> molar was recorded. All findings were analyzed, and tested with Chi square, where applicable.

**Results:** Overall 143 patients were analyzed (48.3% male and 51.7% female). The frequency of major sinus variations was: Agger nasi cell in 56.7%, Haller cell in 3.5%, Onodi cell in 7%, nasal septal deviation in 63%, Concha bullosa in 35%, and dental anomalies in 4.9% of the studied cases. The distance between the upper alveolar ridge and maxillary sinus floor was 0-30mm (mean 12.16) on the right, and 0-52mm (mean 12.20) on the left.

**Conclusion:** The frequency of anatomic variations in sinus anatomy may be related to race and heredity. A lower number of cases in addition to the use of low yield imaging may explain the discrepancies observed between our results and other investigations. The findings of the present study were based on computed tomography.

**Key Words:** Anatomy; Sinus; Anatomic variation; Sinus; CT scan; Concha; Nasal

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## INTRODUCTION

Computed tomographic (CT) scanning of the face has become a standard part of oro-maxillofacial imaging. Variations in paranasal sinus anatomy as shown on CT scans is of potential significance, for it may pose risks

during surgery or predispose to certain pathologic conditions and diseases. Studying the relative frequency and concurrence of these variations in a given population, and comparing the results with that of other races may yield important hints in medical decision-

making and surgical planning for all patients [1,2]. The same diagnostic image can simultaneously be used to accurately determine the distance between the alveolar ridge and maxillary sinus floor, which in turn shall serve as a template for bone grafting and implant surgery at this location. In this study the anatomic variations of the paranasal sinus were assessed by means of CT scans in patients referred to Valiasr Hospital, Tehran, Iran.

### MATERIALS AND METHODS

All patients aged 16 years and over, successively referred to the Imaging Department of Valiasr hospital over a 6 months period (April through September 2004) with a clinical diagnosis of chronic sinusitis were considered for this study. Since the aim of our study was to evaluate normal variations, cases found to harbor nasopharyngeal tumors, polyps, gross mucosal hypertrophy, previous surgery of the face, and copious discharge or fungal masses extensive enough to distort or obscure the regional anatomy were excluded from the study. Altogether, images were collected from 143 subjects with unaltered anatomy. All CT scans were obtained on the spiral scanner beginning at the glabella and terminating at the most dorsal point of the sphenoid sinus (i.e., dorsum sella). As a standard, slice thickness and interval were set at 5 and 2 mm respectively for all sites, except for the 1<sup>st</sup> upper molar region (where 2 and 2mm were chosen in that order). Anatomical findings of each subject were meticulously scrutinized and recorded on the patient's data sheet. The identified variations included:

- Agger nasi cell, i.e. the most anterior ethmoid air cell located on the lateral nasal wall and anterosuperior to the hiatus semilunaris.
- Onodi cell: the most posterior ethmoid air cell with posterior and lateral extensions.

- Haller cells which are ethmoidal air cells extending along the medial roof of the maxillary sinus.

- Concha bullosa an anatomic variation manifesting as aeration of the middle turbinate (it may also occur in the superior and inferior turbinates, with far less frequency).

- Septal deviation i.e., asymmetric nasal septum position that can force nasal turbinates laterally [1].

The height of the alveolar ridge was also measured to 1mm precision on a coronal image. Where appropriate, the data were compared using Chi square for statistical analysis.

### RESULTS

The study group consisted of 143 subjects (48.3% male, 51.7% female), with a mean age of 35.27 years, ranging from 16 to 75 years.

The frequency of variations in paranasal sinus anatomy in our patient sample was as follows:

- Agger nasi cell (56.7%), with 17.5% on the right, 7.7% left and 31.5% of all patients having Agger nasi cell as a bilateral finding.
- Haller cell occurred in 3.5% of all subjects with 1.4% on the left and 2.1% bilateral; none were observed on the right side.
- Onodi cell appeared on 7% of the scans with 2.8% on the right, 0.7% left and 3.5% located bilaterally.
- Nasal septal deviation was found in 63% of which 28.0% deviated to the right and 31.5% to the left. Bilateral deviation was observed in 3.5% of all cases.
- Concha bullosa was found in 35% of the samples. Of these, 11.9% were on the right, 11.2% left and 11.9% occurred as a bilateral anatomic variation.
- Dental anomalies were encountered in 4.9%, with 3.5% on the right and 1.4% on the left. The upper molars were responsible for maxillary sinus perforation in all cases.
- The distance between the upper alveolar ridge and maxillary sinus floor at the level of

the first molar was 12.16mm on the right and 12.20mm on the left side ( $P= 0.001$ ).

## DISCUSSION

In the current study, Agger nasi cells were found in 56.7% (right, left and bilateral put together) of the cases. Kantarci et al. reported this anatomic variation in 47% [2], Messerklinger in 10-15% [3], Davis in 65% [4] and Van Alyea in 89% [5] of their subjects. The frequency of Agger nasi cell in our study population is similar to that of Kantarci and Davis, but differs from the results obtained by Van Alyea and Messerklinger. This difference may be explained by the fact that Van Alyea et al tried to locate this anatomic variation on the ethmoid bone probably because CT scans weren't available during the 1930s. Messerklinger made most of his observations on conventional radiography, therefore also failed to verify most of these air cells. The clinical importance of Agger nasi cell has been defined by Brunner et al in 1996. They showed that the cell and its extensive pneumatization with consequent narrowing of the frontal sinus ostium is the main and clinically significant cause of persistent frontoethmoid pain and chronic frontal sinusitis. It was also stated that the dimensions of the Agger nasi cell is larger in patients who suffer from frontal sinusitis [6].

Haller cell which only seen bilaterally on the left side, occurred in only 3.5% of the scans studied in the present investigation (in none of the cases occurred on the right side). Kantarci [2] and Sarna [7] reported the frequency of Haller cell 18% and 10% respectively. Sivasli mentioned Haller cell as the 3rd most common normal anatomic variation in his sample [8]. The results of the present study are in accordance with others in that the Haller cell is an infrequent finding among the variations in paranasal sinus anatomy. The remarkably high (18%) occurrence of this cell in Kantarci's report is because of the large sample size used

in the study (overpowering effect) [2]. The clinical importance of Haller cell is its implication in sphenoid sinusitis which was described by Alho in 2003 [9]. He reported the existence of a large Haller cell can be predictive of sinusitis.

Onodi cell was found in 7% (2.8% right, 0.7% left and 3.5% bilateral) of the patients participating in the current study. Other studies reported Onodi cell in 8% [10] and 0% [2] of their samples. Sivasli also reported Onodi cell as a rare anatomic variation [8]. Our results support other investigations in defining Onodi cell as a rare anatomic variation. A numerical difference is observed between our findings and Kantarci's results. The sample size used by Kantarci was much larger than the one used in the present study; if our sample size had been increased, the difference might turn out to be significant which could probably be explained by racial, geographic and hereditary differences. Onodi cell is the most posterior ethmoid air cell that extends laterally. This extension is near the carotid canal and close to the optic nerve, which emphasizes the clinical importance of considering this anatomic variation prior to any attempt for invasive intervention. The surgeon must pay close attention to the occasional Onodi cell in preoperative evaluation to avoid potential complications of endoscopic sinus surgery. Therefore it would seem logical to assume that rhinogenic optic neuritis and Onodi cell are related findings.

Nasal septal deviation was found in 63% (28.0% right, 31.5% left and 3.5% bilateral) of the studied cases. Sarna reported septal deviation in 20% of his subjects [7]. Considering that Sarna's investigation was conducted on a larger number of cases, a possible explanation for the higher frequency of nasal septal deviation in our population might be because of difference in the Persian race. Nasal septal deviation has an important role in causing sinusitis and complications

during endoscopic sinus surgery. Asymmetric nasal septum position also can force nasal turbinates laterally and result in narrowing of the middle meatus and ultimately blocking drainage of the ipsilateral maxillary, anterior ethmoid and frontal sinuses.

Concha bullosa, was found in 35% of the studied subjects, 11.9% on the right, 11.2% left and 11.9% as a bilateral anatomic variation. Sivasli reported Concha bullosa as the most frequent anatomic variation among his patients [8]. Concha bullosa is associated with inflammation of the anterior ethmoid air cells and the maxillary sinus. Interestingly, a significant correlation was found between nasal septal deviation and the contralateral Concha bullosa ( $P=0.009$ ), in the present study; i.e. if the Concha bullosa is on the right, the nasal septum tends to deviate to the left and vice versa.

Overall, dental anomalies were encountered in 4.9% of the study population: 3.5% on the right and 1.4% on the left. All cases were due to maxillary sinus perforation by the upper molars. It is obvious that conventional radiographic techniques, rather than CT scans, are the primary choice for investigating dental anomalies. Additionally, CT scan entails a radiation dose higher than periapical, panoramic, Waters' and other conventional images which again is naturally preferred.

The distance between the upper alveolar ridge and maxillary sinus floor at the level of the first molar was 12.16mm on the right and 12.20mm on the left side ( $P= 0.001$ ). In edentulous patients these distances were 12.73mm (max) and 7mm (min) respectively. Ulm et al in 1995, used CT scanning to measure the height of the alveolar ridge at the level of the upper molars to assess the available bone volume for endosseous implant placement, which resulted in a maximum of 13.8 mm and a minimum of 0.8mm [11]. Garg and Vicari believed that, CT scan is an appropriate technique for patients who should

be treated by many implants [12]. In addition, it is possible to reconstruct a spirally acquired CT scan in 3 dimensions and view the precise location of anatomic structures and their adjacent structures (12), an option never obtainable on a conventional radiogram. Considering the importance of the first molar in forming the occlusion, it was chosen as a reference point in the present study for obtaining the required measurements. Also, since this tooth grows insidiously without replacing a deciduous tooth; it frequently goes unnoticed by the child and the parents, and is more vulnerable to destruction; hence there is frequent need to replace its loss by implantation. In their study, Eufinger et al found only 4% of alveolar ridges to have adequate dimensions to accommodate an implant [13]. This underscores the necessity for precise measurement of the distance to the sinus floor in order to avoid complications.

The dissimilarities observed between our findings and the results of previous investigations may be attributed to racial, geographic and hereditary disparities, differing sensitivity of data acquisition and discrepant definitions for a few diagnostic variations.

## CONCLUSION

The frequency of anatomic variations in sinus anatomy may be related to race and heredity. A lower number of cases in addition to the use of low yield imaging may explain the discrepancies observed between our results and other investigations. The findings of the present study were based on computed tomography.

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# تغییرات آناتومیک سینوسهای پارانازال در تصاویر CT اسکن

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## چکیده

**بیان مسأله:** تنوع آناتومیک سینوسهای پارانازال که در سی تی اسکنها دیده می‌شوند، به طور بالقوه می‌توانند مشکلاتی در حین جراحی ایجاد کنند، همچنین قابلیت تبدیل به ضایعات پاتولوژیک را دارند.

**هدف:** هدف از مطالعه حاضر ارزیابی فراوانی انواع تغییرات آناتومیک سینوسهای پارانازال در یک گروه جمعیتی محدود و مقایسه آن با نتایج مطالعات قبلی در دیگر جمعیتها است.

**روش تحقیق:** تمامی بیماران بالای شانزده سال مراجعه کننده به بیمارستان ولی عصر که دارای اسکن از سینوسهای پارانازال و تشخیص بالینی سینوزیت مزمن بودند وارد مطالعه شدند. پس از خارج کردن بیمارانی که به دلیل پاتولوژیک یا ایاتروژنیک، آناتومی سینوس آنها تغییر یافته بود، تمامی سی تی اسکنهای بیماران مورد بررسی قرار گرفت. یافته‌ها در برگه مشخصات بیماران ثبت گردید. همچنین فاصله کف سینوس ماگزیلاری تا ریح آلوئول در ناحیه مولر اول اندازه‌گیری شد. یافته‌ها آنالیز شده و در جای مناسب با آزمون Chi-Square مورد ارزیابی قرار گرفتند.

**یافته‌ها:** از بین ۱۴۳ بیمار معادل ۴۸/۳٪ مرد و ۵۱/۷٪ زن شایعترین تغییرات آناتومیک عمده عبارت بودند از: Agger nasi cell به میزان ۵۶/۷٪، Haller cell معادل ۳/۵٪، Onodi cell برابر ۷٪، انحراف سپتوم بینی معادل ۶۳٪، Concha bullosa ۳۵٪ و آنومالی‌های دندانی برابر ۴/۹٪. فاصله کف سینوس تا ریح در سمت راست بین ۰ - ۳۰ میلی‌متر با میانگین ۱۲/۱۶ میلی‌متر و در سمت چپ بین ۰ - ۵۲ میلی‌متر با میانگین ۱۲/۲۰ میلی‌متر بدست آمد.

**نتیجه‌گیری:** فراوانی تغییرات آناتومیک سینوس ممکن است تابعی از عواملی چون نژاد و توارث باشد. تعداد کم نمونه‌ها همچنین انتخاب روشهای تصویربرداری محدودتر می‌تواند علت تفاوت یافته‌های مطالعه حاضر با دیگر مطالعات باشد. این مطالعه با استفاده از تصاویر سی تی اسکن انجام شده بود.

**واژه‌های کلیدی:** آناتومیک؛ سینوس؛ سی تی اسکن کونکا-بینی

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