Journal of Dentomaxillofacial Radiology, Pathology and Surgery

Summer 2021, Volume 10, Number 3

Research Paper: Anatomic variations of paranasal sinuses and nasal cavities from CBCT images in the Iranian population

Maryam Derakhshan[1], Roghayeh panahi[1*], Gholamabbass Sabz[1]

[1]Oral and Maxillofacial Radiology School of Dentistry, Yasuj University of Medical Sciences, Yasuj, Iran

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Citation: Drakhshan M, Panahi R, Sabz Gh. Anatomic variations of paranasal sinuses and nasal cavities from CBCT images in the Iranian population. Journal of Dentomaxillofacial Radiology, Pathology and Surgery. 2021; 10(3):10-15. http://dx.doi.org/10.32598/3dj.7.4.145

http://3dj.gums.ac.ir

Article info:
Received: 2021/07/20
Accepted: 2021/08/03

Keywords:
Nasal Cavity
Spiral Cone-Beam
Computed Tomography
Paranasal Sinuses

ABSTRACT

Introduction: external nasal walls are an important factor in the drainage or obstruction of the ostiomeatal complex, therfor anatomical variations in the nasal cavity can elevate the risk of pathological sinus conditions. The aim of this study is to evaluate anatomical variations of paranasal sinuses and nasal cavities using cone beam computed tomography (CBCT).

Materials and Methods: This investigation assessed CBCT images from 129 patients (aged 12-65 years; 82 females and 47 males) to specify the prevalence of anatomical variations of the paranasal sinuses and nasal cavity. We analyzed the data using the Mann-Whitney test, Kruskal-Wallis test, and chi-square test.

Results: anatomical variation was observed for accessory maxillary sinus ostium (100%). Significant relationships were also found between the prevalence of middle turbinate-normal (P=0.03), nasal spine (P=0.01), and patients' age. Also, significant correlations were found between middle turbinate-normal (P=0.04), uncinate process-normal (P=0.02), uncinate process-lamina terminslis (P=0.001), and septal deviation (P=0.006) and patients' sex. Significant correlations were also found between some anatomical variations (p<0.05).

Conclusion: CBCT is a reliable method for assessing anatomical variations of the paranasal sinuses and nasal cavity. When making preoperative assessments, surgeons and radiologists should be attention to the anatomical variations of the sinonasal region in order to inhibit perioperative complications.

*** Corresponding Author:**
Roghayeh panahi.
Address: Oral and Maxillofacial Radiology School of Dentistry, Yasuj University of Medical Sciences, Yasuj, Iran.
Tel: +98 9120572510
E-mail: Roghayehpanahi2@gmail.com

Introduction

The nasal cavity at the top is terminated by the nasal, sphenoid, and ethmoid bones; in lateral portion by the medial walls of the left and right maxillary sinus; and inferiorly terminated by hard palate. The main components of the lateral walls of the nasal cavity are the inferior middle and superior conchae (turbinates). These structures act as baffles to help filter, humidify, and warm/cool inspired air. Another role of the nasal cavity is to facilitate the sense of smell (1). This anatomical area must be understood in detail. Otherwise, serious complications such as meningitis, blindness, or cerebrospinal fluid leakage can occur during surgery (2). Lateral nasal wall anatomical variations are vital because they play a significant function in the drainage or obstruction of the ostiomeatal complex (3). Furthermore, these variations can affect the safety and outcomes of surgical procedures done in this area (4). Therefore, the surgical and clinical significance of variations in paranasal sinuses should be assessed (5). The high frequency of anatomical variations of paranasal sinuses and nasal cavity is explained by the model of formation of paranasal sinuses following depression of the nasal mucosa around the facial bones (6). These anatomical variations are highly important because they can predict some types of disease in the paranasal sinuses. Such variations may complicate clinical procedures that need an accurate assessment of the nasal region such as functional endoscopic surgery (7). Most dental clinicians are acquainted with 2-dimensional radiographs such as panoramic and periapical or radiographic images of the maxillary sinuses (1). Three-dimensional (3D) CT technique can provide important information about the dental structures, nasal cavity, paranasal sinuses and craniofacial anatomic anomalies (8). Nowadays, the use of 3D radiographies such as CBCT is increasing in different fields of dentistry (9), such as maxillofacial surgery, implant dentistry, endodontics, and orthodontics in planning reconstructive surgery of the craniofacial region, and in evaluating the craniofacial growth of patients with anomalies (10). CBCT, with low doses of X-ray irradiation provides perfect quality for imaging of maxillary structures and is specifically suitable for evaluating the shape, position, and variations of the paranasal sinuses (6). Furthermore, the purpose of this research was to investigate the frequency of anatomical variations of the paranasal sinuses and nasal cavity on CBCT images to specify the statistical significance of differences in the frequency of these anatomical variations according to age and sex, and to calculate the associations between different variations in Iranian population. Therefore the present study was carried out.

Materials and Methods

The CBCT scans of 129 patients (47 male, 82 female) were assessed in this investigation. The patients' ages ranged from 12 to 65 years. These patients referred to the Dr. Panahi Radiology Center, Yasuj, Iran. Except for the registered patients in the archive, other patients included in this research whose CBCT scanning was needed for evaluating the sinonasal region. The subjects voluntarily agreed to par¬ticipate in this experiment and completed a written informed consent form. All CBCT examinations were done in the relevant conditions (10 to 42 mA based on patients' size, effective radiation time between 2 to 6 seconds, voxel size 0.15 mm). Patients with a history of systemic disease that could have affected craniofacial growth, surgical procedures in this region, periodontal disease, history of previous orthodontic treatment, trauma to the head or face, clefts, massive polyposis, fibrous dysplasia, and benign or malignant tumors that could cause changes in the sinonasal anatomy were excluded. Patients were divided into three groups (10- 25 years, 26-40 years, and 41-55 years).

All scans were captured with a PaX-i3D Green (Vatech America, Fort Lee, NJ, USA) and assessed in the sagittal, coronal, and axial planes by two radiologists. If there was any disagreement between the two observers, the final decision was made by consulting an experienced oral and maxillofacial radiologist. Analyses of all images were repeated after two weeks, and the results were documented. The parameters that were assessed are described below.

The assessed parameters include the shape of the middle turbinate, the shape of the uncinate process, nasal septal deviation, pneumatization of the nasal septum, the presence of a nasal septal spine, the presence of an onodi cell, the presence of an anterior agger nasi cell, asymmetry of the ethmoid roof, the presence of accessory maxillary sinus ostium, the presence of a superior orbital cell, and the presence of a Haller cell.

We used Mann-Whitney, Kruskal-Wallis, and chi-square tests for multiple comparisons. The analyses were done using version 19.0 of SPSS software. The P-value of <0.05 was regarded as statistically significant.

Results

The anatomical variations found (in order of frequency) were as follows: accessory maxillary sinus ostium in 129 patients (100%), nasal septum deviation in 117 patients (90.7%), middle turbinate-concha bullosa in 101 patients (78.3%), nasal septal spine in 86 patients (66.7%), superior orbital cell in 76 patients (58.9%), agger sasi cell in 75 patients (58.1%), uncinate process-lamina terminslis in 61 patients (47.3%), onodi cell in 60 patients (46.5%), pneumatization of the nasal septum-small in 55 patients (42.6%), Haller cell in 36 patients (27.9%), uncinate process-pneumatized in 27 patients (20.9%), middle turbinate-paradoxical in 26 patients (20.2%), uncinate process-atelectatic in 26 patients (20.2%), middle turbinate-normal in 17 patients (13.2%), pneumatization of the nasal septum-medium in 17 patients (13.2%), uncinate process-normal in 13 patients (10.1%), uncinate process-curved in 11 patients (8.5%), pneumatization of the nasal septum-larg in four patients (3.1%) and asymmetry of the ethmoid roof in two patients (1.6%) .

The Kruskal-Wallis test showed a significant association between the prevalence of anatomical variations such as middle turbinate-normal (P=0.03), nasal spine (P=0.01), and patients' age. However, no significant correlation between patients' age and the prevalence of other anatomical variations was observed . The Mann-Whitney test showed a significant correlation between the prevalence of anatomical variations such as Middle turbinate-normal (P=0.04), uncinate process-normal (P=0.02), uncinate process-lamina terminslis (P=0.001), Septal devation (P=0.006), and patients' sex. However, no significant correlation between patients' sex and the prevalence of other anatomical variations was observed .

There were significant correlations between the presence of middle turbinate-normal and middle turbinate-paradoxical (0.02), middle turbinate-conchabullosa (0.001), and haller cell (0.03), as well as between middle turbinate-paradoxical and middle turbinate-normal (0.02), between uncinate process-normal and uncinate process-lamina terminslis (0.001), between uncinate process-atelectatic and uncinate process-lamina terminslis (0.02), between uncinate process-curved and asymmetry of the etmoid roof (0.03), between pneumatization of the nasal septum-small and pneumatization of the nasal septum-medium (0.001), between pneumatization of the nasal septum-medium and pneumatization of the nasal septum-small (0.001), between pneumatization of the nasal septum-large and onodi cell (0.02), between nasal spine and asymmetry of the etmoid roof (0.04), between onodi cell and Pneumatization of the nasal septum-large (0.02), between agger sasi cell and superior orbital cell (0.001), between asymmetry of the etmoid roof and nasal spine (0.04). Correlations were also found between the presence of the uncinate process-pneumatized and uncinate process-atelectatic (0.01), and uncinate process-lamina terminslis (0.03), as well as between the presence of a uncinate process-lamina terminslis and uncinate process-normal (0.001), uncinate process-atelectatic (0.02), uncinate process-curved (0.008), and uncinate process-pneumatized (0.03). Also, associations were revealed between the presence of the haller cell and middle turbinate-normal (0.03), and uncinate process-normal (0.02).

Discussion

In the present research, we evaluated CBCT images taken from 129 patients to determine the prevalence of anatomical variations of the paranasal sinuses and nasal cavities in southwestern Iranian subjects. To the best of the authors' knowledge, the present work is the first to evaluate the relationship between anatomical variations of the paranasal sinuses and nasal cavities in the southwest Iranian population. The prevalence of anatomical variations ranged from 1.6-100% in our study. A significant relationship was observed between the prevalence of middle turbinate-normal and nasal spine and the patients' age. Also, significant relationships were noted between middle turbinate-normal, uncinate process-normal, uncinate process-lamina terminslis, and septal deviation and the patients' sex. Furthermore, significant correlations were found between some anatomical variations.

Anatomical variations of the sinonasal area are important in surgical procedures. Anatomical variations are crucial because a direct association between this structures and ventilation and drainage of the paranasal sinuses are detected. Also, anatomical variations may have an important effect on the safety of surgical procedures (11). CBCT is a new scanning modality with a higher modulation transfer function than CT, which has a higher spatial resolution. Also, CBCT has a lower radiation dose and cost than CT. With these advantages, CBCT can provide precise information about maxillofacial anatomy (7).

Many pieces of research have reported the prevalence of anatomical variations in the sinonasal area to be 64-98%. Differences in the ethnicity and age of patients, as the type of imaging modality used, can lead to this discrepancy (12). Shokri et al. observed anatomical variations of 5.2-90.4%. Meanwhile, in our study, the prevalence of anatomical variations was 1.6-100% (13). In the present research, the prevalence of concha bullosa was 78.3%, which is in line with the findings of Dedeoğlu et al. (80.1%) (3). The prevalence of paradoxical middle turbinate was 20.2% in the present study, which is in line with the findings of Shokri et al. (16.8%) and Adeel et al. (18.2%) (13, 14).

When performing functional endoscopic sinus surgery, the surgeon must have knowledge of uncinate process variations. If the uncinate process is attached to the middle turbinate or ethmoid roof during an uncinectomy, the surgeon should be careful not to apply excessive torsional or tensile force on its superior tip. If it is unintentionally damaged, brain damage or cerebrospinal fluid rhinorrhea can occur. In some patients, the free margin of the uncinated process is attached to the inferior surface of the lamina papyracea or the orbital floor and is usually related to a hypoplastic maxillary sinus that is frequently opaque due to infundibulum obstruction. The risk of penetration into the orbit during surgery can increase when the orbital floor of the same side is low due to maxillary sinus hypoplasia. Furthermore, an abnormal position or shape can play an important role in the development of sinusitis (15, 16). In the present investigation, the prevalence of anatomical variations during the uncinate process morphology was normal (10.1%), atelectatic (20.2%), curved (8.5%), pneumatized (20.9%), and lamina terminslis (47.3%). In other studies, anatomical variations of the uncinate process morphology were 54.8% and 65% (15, 17).

Nasal septal deviation might cause infections in all paranasal sinuses due to weak mucociliary clearance, mucus drainage, and the narrowing of the airway (14). In this study, the prevalence of nasal septal deviation was 90.7%, which is in line with the findings of Shokri et al. (90.4%) (13). In the present research, the prevalence of the nasal spine was 66.7%, contrasting the findings of Dasar and Gokce (42.3%). About 50% of cases with nasal spine were found to have sinonasal diseases (12). In this study, the P-value of correlation between the presence of a nasal septal spine and deviated septum was 0.05. In another research, a relationship was reported between nasal septum deviation and nasal septal spine (13, 16).

Many researchers believe that Haller cells play an important role in the recurrence of maxillary sinusitis, but their exact effect on the prevalence of sinusitis is still a matter of debate (11, 16). In previous research, the reported prevalence of Haller cells was 2-70%. Meanwhile, in the present investigation, the prevalence of Haller cells was 27.9%. The wide range reported can be due to controversies in the imaging protocols used and differences in the mean age and ethnicity of cases, as well as the definition of Haller cells (18-20). In the current study, an association was detected between Haller cells, middle turbinate-normal, and uncinate process-normal.

Onodi cells usually extend close to the optic nerve and carotid canal. In the preoperative evaluation, surgeons must pay attention to Onodi cells to prevent any problems during surgery (21). The presence of an Onodi cell may cause injury in the olfactory nerve during surgery. Furthermore, infections of Onodi cells can traumatize the optic nerve and lead to periorbital swelling (12). In previous studies, the prevalence of Onodi cells ranges from 3.4% to 51%, and the prevalence reported in the current investigation was 46.5%, which is in agreement with the findings of Dedeoğlu et al. (32.7%) (3, 16). In this study, a significant association between Onodi cell and pneumatization of the nasal septum-large was found.

It is demonstrated, in previous studies, that a larger size of agger nasi cells may impair the drainage of the frontal sinus (12, 17). The prevalence agger nasi cell, shown in the present study, was 58.1%. Also, associations were revealed between the presence of agger sasi cell and superior orbital cell.

One of the most common anatomical variations of the sinonasal area is the presence of an asymmetrical ethmoid sinus roof. It has a significant association with chronic sinusitis and is found in over eighty percent of sinusitis patients (16). This variation had a prevalence of 1.6% in the current research. In this study, a correlation was found between uncinate process-curved and asymmetry of the etmoid roof, between asymmetry of the etmoid roof and nasal spine. Anterior ethmoid cells can pneumatize the orbital floor as supraorbital ethmoid cells. Neglecting the diseased condition of the cells can cause failure in frontal sinus surgical procedures (22). In our study, the prevalence of supraorbital cells was 58.9%, which is in agreement with the findings of Dedeoğlu et al. (47%) (3). In the previous studies, the prevalence of accessory maxillary sinus ostium was 15%-40% (23). The prevalence of accessory maxillary sinus ostium was 100% in our study, which is different from the findings of Dasar and Gokce (21.8%) and Shokri et al. (26%) (12, 13).

In the present study, we evaluated CBCT images of individuals to specify the prevalence of anatomical variations of the paranasal sinuses and nasal cavity. CBCT is an advanced technique for obtaining precise data and may be used as a noninvasive preoperative evaluation (8). The limitations of the present study included the different ethnic groups living in the southwest of Iran and the low sample size; therefore, we did not use a control group which might have affected the results. Cases were selected from people having a CBCT evaluation in Dr. Panahi Radiology Center, Yasuj. Also, the clarity of CBCT scans is affected by and poor soft tissue contrast, noise, artifacts.

Conclusion

The high prevalence of anatomical variations in the sinonasal region and their relationships indicate that these factors are crucial when establishing a diagnosis or treatment plan. Radiologists should focus on anatomical variations when making preoperative assessments, and it is very important for surgeons to be aware of these variations.

Conflict of interest

Nonedeclared.

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