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Assessment of the superior turbinate pneumatization and concomitant nasal pathologies on computed tomography

Süperior türbinat pnömatizasyonu ve eşlik eden nazal patolojilerin bilgisayarlı tomografi ile değerlendirilmesi

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Abstract

Aim: Knowledge of the anatomical variations of the nasal cavity is extremely important for the safety and ease of endoscopic sinus surgery applications. The aim of the current study was to evaluate the incidence and uni/bilaterality of superior nasal turbinate pneumatization (STP). In addition, we aimed to investigate the frequency of middle turbinate pneumatization (MTP), nasal septum deviation (NSD) and paradoxical middle concha (PMC), and to relate the presence of these pathologies to the presence of STP.

Methods: We retrospectively reviewed the images of 358 consecutive patients who undertaken paranasal sinus computed tomography within five months' time in our institution. The presence and uni/bilaterality of the STP and MTP as well as the presence of NSD and PMC were noted. The relation of the STP with MTP, NSD and PMC were evaluated. Besides, the relationship between nasal variations and gender and age was evaluated.

Results: Of 358 patients, 105 (29.3%) had STP with 51 (48.6%) being bilateral and the remaining 54 (51.4%) being unilateral. The number of patients with accompanying MTP, NSD and PMC were 84 (80%), 63 (60%) and 32 (30.5%), respectively. No significant relationship between STP with NSD or PMC was recorded. However, STP significantly associated with MTP. We also noted that the patients with either STP or MTP were significantly younger than those without STP or MTP.

Conclusion: The knowledge of the variations of the structures that determine the nasal cavity anatomy and how often these variations are seen will enable the endoscopic surgical procedures to be performed easily and safely.

Keywords: Paranasal sinuses, Computed tomography, Anatomical variation, Pneumatized turbinate

Öz

Amaç: Endoskopik sinüs cerrahi uygulamalarının emniyeti ve kolaylığı yönünden nazal kavitenin varyasyonlarının bilinmesi son derece önemlidir. Bu çalışmanın amacı, üst türbinat havalanmasının (ÜTH) sıklık ve tek/çift taraflılığının değerlendirilmesidir. Yanı sıra, orta türbinat havalanması (OTH), nazal septum deviasyonu (NSD) ve paradoksal orta konka (POK) sıklıklarının saptanarak ÜTH ile ilişkilendirilmesi de amaçlanmıştır.

Yöntemler: Retrospektif olarak, ünitemizde beş ay içinde paranazal sinüs bilgisayarlı tomografisi elde olunan ardışık 358 hastanın inceleme kesitleri değerlendirildi. ÜTH ve OTH varlığı ve tek/çift taraflılığı ile NSD ve POK varlığı kaydedildi. ÜTH'nın MTH, NSD ve POK ile ilişkisi değerlendirildi. Yanı sıra, nazal varyasyonların cinsiyet ve yaşla ilişkisi değerlendirildi.

Bulgular: Çalışma grubunu oluşturan 358 hastanın, 51'i (%48,6) çift taraflı ve geri kalan 54'ü (%51,4) tek taraflı olmak üzere 105 tanesinde ÜTH mevcuttu. ÜTH'na eşlik eden OTH, NSD ve POK olgularının sayısı sırasıyla 84 (%80), 63 (%60) ve 32 (%30,5) idi. ÜTH ile NSD ve POK arasında anlamlı ilişki saptanmadı. Ancak, ÜTH ile OTH arasında anlamlı birliktelik saptandı. Ayrıca, ÜTH veya OTH mevcut olan hastaların, mevcut olmayanlara kıyasla daha genç olduğunu kaydedildi.

Sonuç: Nazal kavite varyasyonlarının ve bunların sıklıklarının bilinmesi, endoskopik cerrahi prosedürlerin kolay ve emniyetli uygulanmalarını sağlayacaktır.

Anahtar kelimeler: Paranazal sinüsler, Bilgisayarlı tomografi, Anatomik varyasyon, Türbinat havalanması

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Introduction

The rapid developments in endoscopic sinus surgery techniques and the increase in the use of this intervention method raised the importance of the nasal as well as paranasal anatomic variations. Coronal computed tomography (CT) sections are extremely informative in examining the nasal cavity prior to the endoscopic intervention because these sections demonstrate the same regions as seen during endoscopic examination [1].

Concha bullosa is generally considered as pneumatization of the middle turbinate, but it can also be seen in superior and lower turbinates [2]. The expansion of the turbinate(s) as well as the other pathologies causing differences in the angle of the walls of the nasal cavity and/or resulting in the nasal volumetric differences are extremely important in delineating the interventional pathway during endoscopic surgery. The aim of the current study was to evaluate the incidence and uni/bilaterality of superior nasal turbinate pneumatization (STP). In addition, we aimed to investigate the frequency of the pathologies such as middle turbinate pneumatization (MTP), nasal septum deviation (NSD) and paradoxical middle concha (PMC), and to relate the presence of these pathologies to the presence of STP.

Materials and methods

Patient population and study design

The approval of the institutional review board was received before the execution of this work started. Radiological records of a total of 358 patients who underwent CT of the paranasal sinuses between January 1, 2019 and June 1, 2019 because of headache, nasal obstruction, anosmia, facial pain or facial trauma were evaluated retrospectively. There were 195 men and 163 women with a mean age of 36.8 years (range: 17 to 69). Imaging was performed using a 128-slice CT scanner (Optima CT 660, GE Healthcare System, Milwaukee, USA), (120 kV; 150 mAs; slice thickness = 0.5 mm; FOV = 18-24 cm).

The CT images of the paranasal sinuses of all patients were examined in terms of the presence and uni/bilaterality of STP. The cases with MTP, NSD and PMC were noted (Figure 1). The patients' age and gender were also recorded. Two experienced radiologists reviewed the CT images independently. In the cases of whom a discrepancy occurred in the interpretations of the images, a common re-examination was performed and the final decisions were made by consensus.

Statistical analysis

The normality of distribution of continuous variables was tested by Shapiro-Wilk test. Mann Whitney U test was used to compare 2 independent groups for non-normal data. Chi-square test was performed to investigate the relationship between categorical variables and Odds ratio and 95% confidence intervals were calculated to show effect size. Statistical analysis was performed with SPSS for Windows version 24.0 and a P value < 0.05 was accepted as statistically significant.

Results

The overall prevalence of uni/bilateral STP, uni/bilateral MTP, NSD and PMC in our study population is summarized in table 1. Of 358 patients, 105 (29.3%) had STP. Of these, 51 (48.6%) had bilateral and the remaining 54 (51.4%) had unilateral STP. The prevalence of uni/bilateral MTP, NSD and PMC in cases with STP in our study population is summarized in table 2.

Table 1: The findings of the overall study population

		n	%
Superior turbinate pneumatization	Positive	105	29.3
	Unilateral positive	54	15.1
	Bilateral positive	51	14.2
	Negative	253	70.7
Middle turbinate pneumatization	Positive	186	52.0
	Unilateral positive	97	27.1
	Bilateral positive	89	24.9
	Negative	172	48.0
Nasal septum deviation	Positive	190	53.1
	Negative	168	46.9
Paradoxical middle concha	Positive	95	26.5
	Negative	263	73.5

Table 2: The findings of 105 patients with superior turbinate pneumatization

		Superior turbinate pneumatization					*P*-value
		Positive		Negative			
		N	%	N	%	OR [95% CI]	
Middle turbinate pneumatization	Positive	84	80.0	102	40.3	5.92 [3.45-10.16]	0.001*
	Negative	21	20.0	151	59.7	1 (reference)	
Nasal septum deviation	Positive	63	60.0	127	50.2	1.49 [0.94-2.36]	0.091
	Negative	42	40.0	126	49.8	1 (reference)	
Paradoxical middle concha	Positive	32	30.5	63	24.9	1.32 [0.79-2.19]	0.277
	Negative	73	69.5	190	75.1	1 (reference)	

*Significant at 0.05 level, Chi-square test, OR: Odds ratio, CI: Confidence Interval

The number of patients with accompanying MTP, NSD and PMC were 84 (80.0%), 63 (60.0%) and 32 (30.5%), respectively. There was a significant association between the presence of STP and MTP. The likelihood of the presence of MTP in patients with STP is 5.92 times higher than those without STP. However, no significant relation of STP with NSD or PMC was recorded (Figures 2, 3).

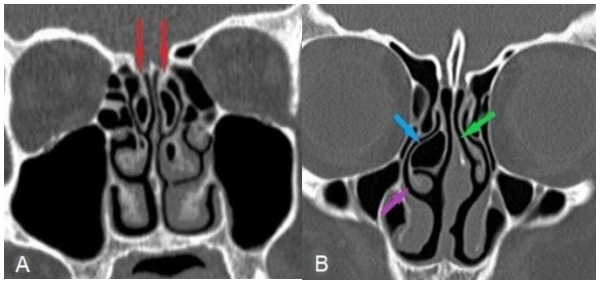

Figure 1: Coronal computed tomography sections of two different patients. (A) Bilateral superior nasal turbinate pneumatization (red arrows). (B) Unilateral middle turbinate pneumatization (blue arrow), nasal septum deviation (green arrow) and paradoxical right middle concha (purple arrow)

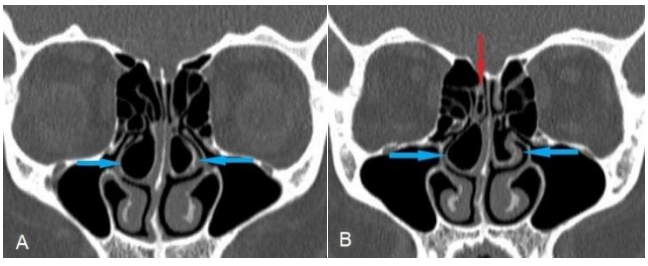

Figure 2: Consecutive coronal computed tomography sections of a 52-year-old woman demonstrating unilateral superior nasal turbinate pneumatization (red arrow) and bilateral middle turbinate pneumatization (blue arrows)

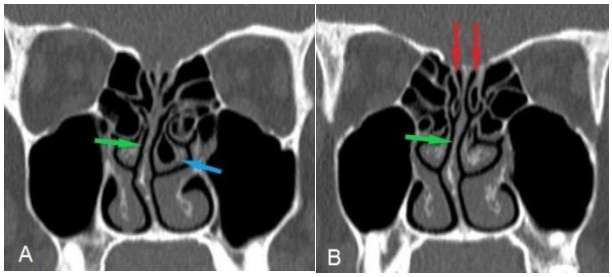

Figure 3: Consecutive coronal computed tomography sections of a 20-year-old man demonstrating bilateral superior nasal turbinate pneumatization (red arrows), unilateral middle turbinate pneumatization (blue arrow) and nasal septum deviation (green arrows)

No significant relationship between any of the nasal variations and gender was noted (Table 3). The relationship between nasal variations and age is demonstrated in table 4. It is shown that the patients with either STP or MTP were significantly younger than those without STP or MTP. For each age increase in patient age, a 2% increase in both STP and MTP frequency was recorded. There was no significant relationship between age and NSD or PMC.

Table 3: The relationship between nasal variations and gender

		Gender				*P*-value
		Female		Male		
		N	%	N	%	
Superior turbinate pneumatization	Positive	46	28.2	59	30.3	0.674
	Negative	117	71.8	136	69.7	
	OR [95% CI]	1 (reference)		0.91 [0.57-1.43]		
Middle turbinate pneumatization	Positive	90	55.2	96	49.2	0.259
	Negative	73	44.8	99	50.8	
	OR [95% CI]	1 (reference)		1.27 [0.84-1.93]		
Nasal septum deviation	Positive	89	54.6	101	51.8	0.596
	Negative	74	45.4	94	48.2	
	OR [95% CI]	1 (reference)		1.12 [0.74-1.69]		
Paradoxical middle concha	Positive	44	27.0	51	26.2	0.858
	Negative	119	73.0	144	73.8	
	OR [95% CI]	1 (reference)		1.04 [0.65-1.67]		

*Significant at 0.05 level, Chi-square test, OR: Odds ratio, CI: Confidence Interval

Table 4: The relationship between nasal variations and age

		N	Mean (SD)	Median (Min-Max)	OR [95% CI]	*P*-value
Superior turbinate pneumatization	Positive	105	33.86 (12.87)	32 (18-65)	0.98 [0.96-0.99]	0.006*
	Negative	253	38.08 (13.22)	38 (17-69)	1 (reference)	
Middle turbinate pneumatization	Positive	186	35.28 (12.93)	33 (18-67)	0.98 [0.96-0.99]	0.025*
	Negative	172	38.52 (13.39)	39 (17-69)	1 (reference)	
Nasal septum deviation	Positive	190	35.93 (13.01)	34 (17-69)	0.99 [0.97-1.01]	0.218
	Negative	168	37.86 (13.45)	38 (18-67)	1 (reference)	
Paradoxical middle concha	Positive	95	35.96 (13.46)	34 (18-69)	0.99 [0.97-1.01]	0.399
	Negative	263	37.16 (13.17)	37 (17-67)	1 (reference)	

*Significant at 0.05 level, Chi-square test, OR: Odds ratio, CI: Confidence Interval

Discussion

We retrospectively reviewed the paranasal sinus CT images of 400 consecutive patients and found that, of the overall study group, 105 (29.3%) had STP. Of these, 51 (48.6%) had bilateral and the remaining 54 (51.4%) had unilateral STP. We found a significant association between the presence of STP and MTP. No significant association between any nasal variation and gender was recorded. However, it is shown that patients with either STP or MTP were significantly younger than those without STP or MTP.

Regulating the nasal air flow by heating, humidifying and filtrating the inhaled air, nasal turbinates play a critical role in maintaining the normal nasal functions [3]. They can easily be injured during endoscopic surgery resulting in postoperative hyposmia caused by the olfactory neuroepithelium damage [4]. The clinical importance of the knowledge concerning the presence of STP is not limited to its significance regarding the endoscopic interventions. They are shown to cause headaches, even in the absence of sinonasal inflammation [5]. Furthermore, they are accused of causing stenosis or obstruction of the superior meatus or sphenoid sinus ostium [1]. According to previous studies, the incidence of STP ranges between 12.2 and 50%. And the range of its being bilateral is reported to be 38.9%-44% [6-8]. In accordance with the data range determined in previous studies, we found STP in 29.3% of our study population. However, being present in 48.6% of the patients, bilaterality of STP in our population was higher than that in those of the previous studies.

MTP, which is also referred to as bullous middle turbinate was firstly described as a transformation of the anterior part of the middle turbinate into a bubble, by Santorini [9]. This type of pneumatization is considered to represent a variation of ethmoid air cell development, not the outcome of an intranasal process [9,10]. According to the previous studies, the incidence of MTP ranges from 14 to 53%, and the incidence of bilateral MTP has been reported to be between 45 and 61.5% [11-13]. In accordance with the previous literature, the prevalence of MTP was 52% and 47.8% of MTP cases were bilateral in the current study population. There was a significant association between the presence of STP and MTP. Moreover, we showed that the likelihood of the presence of MTP in patients with STP is about six times higher than those without STP. This association implies that, the development of MTP could induce the pneumatization of the superior turbinate(s) by changing the air circulation dynamics of the nasal cavity as well as the paranasal sinuses.

We recorded no significant association between any nasal variation and gender. On the other hand, according to our results, the patients with either STP or MTP were significantly younger than those without STP or MTP. We speculate that the amount of pneumatization of turbinates may vary depending on age and may be extinguished to some extent with aging.

NSD means that the nasal septum is located outside the midline and plays an important role in functional nasal breathing. It may cause symptoms such as sleep apnea, facial pain, nasal bleeding, and difficulty in breathing and impairment in smell [14]. Previous studies demonstrated that there is no significant association between STP and NSD [6,15]. We found NSD in 53.1% of our study population, and in consistence with the previous data, we found no statistically significant relation between STP and NSD. PMC is characterized by the convex curvature of the medial concha towards the lateral side and may cause nasal obstruction in cases with an extreme curve. The previously reported prevalence of PMC varies between 3 and 26.9% [16-18]. Being 26.5%, the prevalence of PMC we recorded falls within this frequency range.

The major limitation of the current study is that we did not evaluate the relation of the anatomic nasal variations with the development of sinonasal infections. The second important limitation of the study is the relatively small number of the study population. Further comprehensive studies adopting a clinico-radiological approach are needed to reach accurate and inclusive comments regarding the prevalence and clinical significance of the nasal turbinate pneumatization as well as the other anatomic nasal variations.

In conclusion, the STP, either unilateral or bilateral, are nasal anatomical variations which can be present in up to half of the population. The results of the current study revealed that, there is a significant relationship between the frequency of STP and MTP. Coronal computed tomography sections of paranasal sinuses are of particular importance for endoscopic surgeons in delineating their pathway in the nasal cavity during interventions. The knowledge of the variations of the structures that determine the nasal cavity anatomy and how often these variations are seen will ensure that endoscopic surgical procedures are performed easily and safely.

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