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Ethnic variation in sinonasal anatomy on CT-scanning*

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SUMMARY

Computed tomography (CT) scanning of the paranasal sinuses provides valuable information in assessing extent of disease and fine detailed anatomy prior to endoscopic sinus surgery. Awareness of the different anatomic variants of the bony sinonasal anatomy will help the rhinologic surgeon's orientation during the procedure. We conducted a study to look at the incidence of the anatomic variation within the lateral wall of the nose and sinuses and to determine if there is any ethnic difference in these variants between a cohort of 100 Caucasian patients undergoing endoscopic sinus surgery in London and 100 Chinese patients treated in Hong Kong. We compared the two groups with chi-square test and the significant areas are those with p value of less than 0.05. The results show a higher incidence of pneumatisation of the middle turbinate (concha bullosa) and paradoxical bending of the middle turbinate in the Caucasian population. The infraorbital and suprabullar cell development was greater in the Caucasian population though the incidence of sphenoethmoidal cells was much greater in the Chinese population. When asymmetry of the anterior ethmoidal roof was considered, the left was consistently the highest in both groups, though there was no difference in the depth of the cribiform niche between right and left or between Caucasian and Chinese. The incidence of bent uncinate process and of complete absence of a sinus was higher in the Chinese population. There was no difference in the presence of pneumatisation of the agger nasi, of the uncinate process, or of the anterior clinoid process. There was no difference in the presence of septation adjoining the carotid in the lateral wall of sphenoid or in the exposure of the optic nerve within sphenoid or posterior ethmoid sinuses. Although there is no evidence that variants of the sinonasal anatomy seen on CT Scan have a causative effect in the disease process; a knowledge of their presence is paramount in minimising the potential for surgical complications.

Key words: ethnic, anatomic variation, paranasal, sinuses, CT-scanning

INTRODUCTION

The use of the endoscope as a tool in sinus surgery, along with the philosophy of aerating and restoring mucociliary clearance, has led to renewed interest in the anatomy and pathophysiology of the paranasal sinuses. In any list of aetiological factors associated with the development of chronic rhinosinusitis, anatomic variants are usually included. Stammberger [1] proposed that stenosis of the ostiomeatal complex, from either the anatomical configuration or hypertrophied mucosa, can cause obstruction and stagnation of secretions that may become infected or perpetuate infection. Computerized tomography (CT) of the paranasal sinuses offers the gold standard in terms of imaging the extent of inflammatory disease and the fine detailed anatomy and its variants. The usual list of anatomic variants includes pneumatisation of the middle turbinate (concha bullosa), paradoxical bending of the middle turbinate, bent uncinate process, pneumatisation of the uncinate process, pneumatisation of the agger nasi; the presence of infraorbital cells, spheno-ethmoidal cells, and deviation of the nasal septum. In addition, the height of the roof, concomitant depth of the cribriform niche and septations attaching to the region of carotid artery are of surgical interest. A previous study by Yeoh et al. [2] and based on anatomical dissection of a small number of specimens suggested significant differences between the frequencies of certain variations in a Chinese population as compared to Caucasians. The aim of this study is to look at the incidence of anatomic variation within the lateral wall of nose and sinuses assessed by CT Scanning to consider in more detail anatomic differences between these two ethnic groups.

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MATERIALS AND METHODS

The CT Scans of the paranasal sinuses of a total of 200 patients undergoing endoscopic sinus surgery were analysed by surgeons expert in endoscopic sinus surgery. One hundred Caucasian patients at the Royal National Throat, Nose and Ear Hospital, London had their CT Scans each reviewed independently by two of the authors. The CT Scans of one hundred Chinese patients were similarly reviewed at Queen Mary's Hospital in Hong Kong by two surgeons. Prior to the analysis all four surgeons had worked together in London to agree criteria for anatomical variation to ensure accuracy of CT assessment. The two populations were demographically comparable in sex and age. The Caucasian group had 47 men and 53 women with an age range of 16-90 (mean 42.3). The Chinese group had 61 men and 39 women with an age range of 14-82 (mean 44.4). CT Scans with gross disease were excluded and only those CT Scans that scored less than 14 on the Lund-Mackay [3] scoring system were included to allow clear definition of the anatomy. The CT plane was Direct Coronal only in 53 cases of the Caucasian population and Direct Coronal and Axial in 47 cases. The slice thickness was 5 mm (2.5 through the OMC). The CT plane was Direct Coronal only in 56 cases of the Chinese population and Direct Coronal and Axial in 44 cases. The slice thickness was 2mm. The protocol for assessing each anatomic variant was the same in both groups. Each variant was assessed for a right or a left side and those cases were the anatomic variant was bilateral were also noted. We compared the two groups with a chi-square test and the significant areas are those with p value less than 0.05.

RESULTS

Table 1 compares the data between the two groups. Pneumatisation of the agger nasi, ie anterior to the anterior attachment of the middle turbinate is the commonest variant in both groups, 44-57% (maximum range, either unliteral or biliteral) in the Caucasian group and 47-53% in the Chinese group, and there is no statistical difference in the incidence between the two groups. Pneumatisation of the middle turbinate (concha bullosa) and paradoxical bending of the middle turbinate, is the second and third commonest variants in the Caucasian population and their incidence significantly higher than in the Chinese population. Concha bullosa occurs in 12-31% and paradoxical bending of the middle turbinate in 10-22% in the Caucasian group and in 4-13% and 5-8% respectively in the Chinese group. Spheno-ethmoidal cells (Onodi cell), ie pneumatisation of the posterior ethmoid lateral or superior to the sphenoid, are the second commonest variant in the Chinese population and the incidence is significantly higher than in the Caucasian population; 20-30% in the Chinese group compared to 5-17% in the Caucasian group. Infra-orbital cells (Haller cell), ie pneumatisation of the orbital floor inferior to the infundibulum, occur more frequently in the Caucasian than in the Chinese group; 10-15% and 1-9% respectively. The incidence of a bent uncinate process is higher in the Chinese group than in the Caucasian group; 12-24% and 3-6% respectively. The presence of suprabullar cells obstructing the frontal recess was higher in the Caucasian group (5-17%) than in the Chinese group (1-2%) whereas complete absence of a sinus was higher in the Chinese group (11-17%) then in the Caucasian group (2-6%). There was no significant difference in the incidence of pneumatisation of uncinate process (2% Caucasian, 1% Chinese), in the exposure of $>$ 50% of circumference of the carotid artery within the sphenoid or posterior ethmoid (3% Caucasian, 0% Chinese), in the presence of septation joining carotid artery in sphenoid (4-22% Caucasian, 2-20% Chinese), in the exposure of $>$50% of circumference of optic nerve within sphenoid or posterior ethmoid (2% Caucasian, 0% Chinese), in the pneumatisation of anterior clinoid process (4-6% Caucasian, 5-9% Chinese), in presence of accessory ostium in posterior fontanelle (2-3% in both groups) or in the presence of nasal septal deviation of $>$ 4 mm either side of perpendicular plate (13-20% Caucasian, 7-8% Chinese). When asymmetry of the ethmoidal roof was considered, the left was consistently the highest in both groups; though there was no difference in the depth of the cribriform niche between right and left or between Caucasian and Chinese. The depth of the cribriform niche was type I (1-3mm) or type II (4-7mm)/ III (8-16mm). Types II/III were collapsed, as it is difficult to accurately distinguish between them. Table 1 shows the percentage of type I, and type II/III corresponds to the rest.

DISCUSSION

Anatomic variation in the lateral wall of nose and ethmoid complex has been recognised for centuries, but recent advances in clinical technology, especially Computed tomography (CT) and endoscopic sinus surgery has made apparent the extent of variation. In 1995, The Royal College of Radiologists Working Party [4] said that plain radiographs have no place in the routine management of rhinosinusitis. Plain radiographs have low specificity and sensitivity when compared with clinical and surgical findings. CT provides unique information about the detailed anatomy and offers the gold standard in terms of imaging the extent of disease, both pre-requisites to the safe practice of endoscopic sinus surgery [5]. Jones [6] reviewed sixteen studies including his own and reported the incidence of the different anatomic variants in the published literature. These studies compared the prevalence of anatomical variation between a group of patients with rhinosinusitis and a control group that had CT Scanning of the area for other pathology. There appears to be no consistent difference in the prevalence of anatomical variation between the two groups. Thus the case for anatomic variation as a main causative factor in the development of rhinosinusistis is unproven. This is probably because the variants appear at an early stage in life and are part of the sinonasal development, which to a large extent accommodates their presence. Table 2 shows the incidence in percentages of the different anatomic variants seen on CT Scan in the published series. Anatomic variants seen on CT Scan are common and one or more are present in nearly two-thirds of the population that has had this imaging modality. Pneumatisation of the agger nasi is the commonest variant

	LONDON data				HONG KONG data (chi-squared tests)					
	Right	Left	Bilateral		Right	p	Left	p	Bilateral	p
Pneumatisation of the middle turbinate (concha bullosa)	31	24	12		13	≤ 0.001	6	≤ 0.025	4	≤ 0.05
Paradoxical bending of middle turbinate	17	22	10		8	≤ 0.025	5	≤ 0.001	5	≤ 0.001
Bent uncinate process	6	3	3		19	≤ 0.01	24	≤ 0.001	12	≤ 0.025
Pneumatisation of uncinate process	-	2	-		-		1	not sig	-	
Pneumatisation of the agger nasi	50	57	44		50	not sig	53	not sig	47	not sig
Infra-orbital cells (Haller cell)	15	13	10		1	≤ 0.01	9	not sig	1	£0.01
Spheno-ethmoidal cells (Onodi cells)	15	17	5		30	≤ 0.025	33	≤ 0.001	20	£0.01
Exposure of > 50% of circumference of carotid artery within sphenoid or posterior ethmoid	3	3	-		-	not sig	-	not sig	-	
Presence of septation joining carotid in sphenoid	22	18	4		20	not sig	17	not sig	2	not sig
Exposure of > 50% of circumference of optic nerve within sphenoid or posterior ethmoid	2	1	-		-	not sig	-	not sig	-	
Pneumatisation of anterior clinoid process not sig	4	6	4		8	not sig	9	not sig	5	not sig
Accesory ostium in posterior fontanelle	3	2	-		3	not sig	2	not sig	-	
Roof of ethmoid sinuses in asymmetric level (if so, Rt or Lt highest)	5	16	-		2	not sig	6	≤ 0.025	-	
Depth of cribiform niche-type I	36	27	-		29	not sig	30	not sig	-	
Presence of suprabullar cell	10	17	5		1	≤ 0.01	2	≤ 0.001	-	≤ 0.05
Septal deviation >4mm	13	20	-		8	not sig	7	not sig	-	
Complete absence of a sinus (sphenoid, frontal or maxilla)	6	2	2		15	≤ 0.05	17	0.001	11	≤ 0.01

Table 1. Anatomic variants on CT Scans of 100 Caucasians patients compared to the anatomic variants on CT Scans of 100 Chinese patients undergoing endoscopic sinus surgery. The two groups were compared with chi-square test and the significant areas are those with p values of less than 0.05.

but the reviewed studies fail to specify whether the variant is unilateral or bilateral. Pneumatisation of the middle turbinate (concha bullosa), paradoxical bending of the middle turbinate and infra-orbital cells (Haller cells) are amongst the most common variants but their incidence varies depending on the series. Bolger et al. [7] reported that there were wide variations in the reported prevalence of anatomic variants and attributed this to the lack of consensus on clear definitions of some of these variants. An effort to circumvent these problems was exemplified by the work of Stammberger and Kennedy [8], who suggested a unified system of terminology to promote consistent international language for surgeons and to serve as a basis for discussions among anatomists and which have been employed in this study.

Anatomic variants are probably not responsible for the development of chronic rhinosinusitis, but knowledge of their presence is paramount in minimising the potential for surgical complications. Yeoh and Tan [2] performed endoscopic anatomical spheno-ethmoidectomy in 51 fresh Asian cadavers. In 65% of the specimens there was a direct relationship

	Jones (1997) [2]	Bolger (1991) [7]	Clark (1989) [13]	Calhoun (1991) [14]	Kennedy (1988) [15]	Tonai & Baba (1996) [16]	Willner (1997) [17]	Arslan (1999) [18]	Danese (1997) [19]	Lloyd (1990) (1991) [20], [21]	Basic (1999) [22]	Kayalioglu (2000) [23]	Perez--Pinas (2000) [24]
Concha bullosa	18-23%	50-53%	11-33%	16-29%		36%	11-13%	30%	31%	14-24%		27-29%	34%
Paradoxical middle turbinate	7-16%	22-27%		12-15%	15%	11-30%	7-16%			15-17%			27%
Bent uncinate	2-6%							3%	31%	16-21%		7-12%	
Pneumatized uncinate	0-3%	2-5%			0.4%		21-26%	2%					
Agger nasi cells	96%					86-89%	16-24%					5-8%	
Infra-orbital cells (Haller)	6-12%	41-46%			10%	33-39%	23-28%	6%	34%		21%	4-5%	3%
Spheno-ethmoidal cells (Onodi cells)	7-9%							12%			10%		11%
Septal deviation	24%			20-40%	21%			36%	33-42%			12-22%	55%

Table 2.Incidence in of anatomic variants of paranasal sinuses demonstrated on CT Scan in the published series. The two figures correspond to the two groups in these studies. They compare the presence of an anatomic variant in control groups versus patients with rhinosinusitis.

between the optic nerve and the posterior ethmoids usually in the form of a spheno-ethmoidal cell. Since this type of relationship is potentially the most hazardous to the optic nerve, they conclude that Asian people may be more at risk. Driben et al. [9] dissected 21 human cadaveric heads and correlated their findings with the coronal and axial plane CT. They conclude that the spheno-ethmoid cell is one of the most clinically relevant anatomic variant and CT Scan does not always reliably detect it. Our study compared CT Scans of a group of Chinese to a group of Caucasian and the incidence of spheno-ethmoid cells is significantly higher in the Chinese group. We can thus confirm Yeoh and Tan's hypothesis that the incidence of an intimate relationship between the optic nerve and the posterior ethmoid sinus is higher in Asian than in Caucasian. Another finding in our study, confirms that of Dessi et al. [10], which demonstrated that when asymmetry of the anterior skull base is present, it is usually the right anterior ethmoidal roof, which is lowest. This may be viewed in the context that most iatrogenic cerebrospinal fluid leaks occurred on the right side in a U.K study [11]. Our study also shows that pneumatisation of the agger nasi, middle turbinate pneumatisation (Concha bullosa), paradoxical bending of the middle turbinate, spheno-ethmoidal cells (Onodi cells) and septation joining carotid in sphenoid are the most common variants the surgeon will encounter during endoscopic sinus surgery in both Caucasian and Chinese groups. Further studies may be needed to consider variants in other ethnic groups, but ultimately variants must be considered on individual basis underlying the importance of adequate preoperative imaging.

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