COMPUTED TOMOGRAPHIC STUDY ON NEW CLASSIFICATION OF FRONTAL SINUS VARIANTS IN RELATION TO CHRONIC RHINOSINUSITIS PATIENTS

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DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF MEDICINE (OTORHINOLARYNGOLOGY-HEAD AND NECK SURGERY)

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My special appreciation to all the lecturers of Department of ORL-HNS, not to forget Dr Iskandar Hailani, Dr Zakinah Yahaya, Dr Mazlinda, Dr Nik Mohd Yunus who were my mentor at Hospital Kuala Lumpur during my freshman years in Otorhinolaryngology.

Last and foremost, I would like to dedicate very special thanks to my lovely mother Aishah Ibrahim and parents in law, Md Yusof Ismail and Salmeh ; my beloved husband, Mohd Yusairi Md Yusof and my dear children, Muhammad Adam and Noor Khadeeja, whose patience and understanding have guide me through this dissertation. Thank you for providing me with continuous encouragement and love throughout my years of study and through the process of researching and writing this thesis.

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ABSTRAK

Objektif: Terdapat variasi sel frontal dalam populasi yang berbeza, kegunaan dan penerapan klasifikasi sinus frontal baru dalam populasi kita memerlukan kajian lebih lanjut. Oleh itu, kajian kami bertujuan untuk mengkaji Klasifikasi Anatomi Sinus Frontal Antarabangsa (IFAC) pada pesakit kami dengan rhinosinusitis kronik dan menentukan kaitan sel frontal dengan perkembangan sinusitis frontal. Sebagai tambahan, hubungan varian sel frontal dengan keparahan sinusitis frontal telah dikaji.

Kaedah: Ini adalah tinjauan carta retrospektif mengenai sinus paranasal tomografi yang dikira (CTPNS). Sebanyak 200 pesakit yang mempunyai penemuan klinikal dan endoskopi yang menunjukkan CRS dan menjalani sinus paranasal CT dan ditambah 51 pesakit sebagai kawalan dikaji dan kelaziman pada varian sel frontal dianalisis berdasarkan IFAC.

Keputusan: Lima ratus dua sisi CTPNS telah dikaji dan menunjukkan sel nasi agger kebanyakannya dijumpai (95.8%) diikuti oleh sel supra bulla (59.8%), sel supra bulla frontal (54.8%), sel supra agger (48.6%), sel frontal supra agger (33.1%), sel septal frontal (8.6%) dan sel ethmoidal supraorbital (4.6%).

Kesimpulan: Pesakit dengan kehadiran sel ethmoidal supraorbital (SOEC) dan sel septal frontal (FSC) mempunyai lebih banyak peluang terkena sinusitis frontal (p value <0.05). Sel posterior dan medial lebih berperanan dalam menyebabkan sinusitis frontal. IFAC berguna dalam mengenal pasti sel-sel yang bertanggungjawab menyebabkan sinusitis frontal. Ini dapat membantu dalam membimbing pakar bedah untuk membuang sel-sel dalam mencegah penyakit berulang.

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CHAPTER 1:

INTRODUCTION

1.1 INTRODUCTION

Rhinosinusitis is a common health problem characterised by mucosal inflammation of the nose & paranasal sinuses [1]. Chronic rhinosinusitis (CRS) is an inflammatory disorder that involves the paranasal sinuses that is characterized by nasal congestion or anterior/posterior nasal discharge with either facial pain or reduced/absent sense of smell, lasting more than 12 weeks. And either endoscopic signs of polyps, mucopurulent discharge and, or edema primarily in middle meatus. And either computed tomography (CT) changes with mucosal changes within the osteomeatal complex and/or sinuses [1]. The frontal ostium is defined as the narrowest area of the transition zone from the frontal sinus to the frontal recess with its anterior edge formed by the frontal sinus beak and the posterior edge formed by the skull base [2]. Frontal recess is a space where the frontal sinus drains and it is located posterior to frontal beak, between the lamina papyracea and the vertical lamella of the middle turbinate. Based on the anatomical classification by International Frontal Sinus Anatomy Classification (IFAC) this space includes the cells or space above and anterior to the bulla ethmoidalis.

The frontal sinus is frequently described as the most difficult sinus to access surgically due to its challenging and variable anatomy, as well as its proximity to the cribriform plate, orbit, and anterior ethmoid artery [3]. An increased in understanding of the anatomy of frontal cells can improve surgeon's surgical confidence and removing specific cells that leads to frontal ostium obstruction [2]. One of the commonest causes of failure of endoscopic sinus surgery is the inability to completely removed the cells in

the frontal recess. Healing will lead to stenosis of frontal sinus outflow thus causing worsening of the symptoms.

International Frontal Sinus Anatomy Classification (IFAC) is an international consensus document published in 2016 to standardize the nomenclature of cells in the region of the frontal recess and frontal sinus. The IFAC was designed to be surgically relevant and anatomically precise and recently they have come out with a new frontal sinus variant [4].

Previously Bent and Kuhn had proposed various type of cells that surrounds the frontal recess. the classification is based on relation with agger nasi cell and orbital floor which does not precisely explain on the exact location of the cells. However, IFAC has come out with a new classification of anatomy of frontal cells which is more reliable and accurate as it specifies the location of the cells. Thus, accurate frontal cell recognition and removal can be done during surgery. The new classification of frontal cells proposed by IFAC based on location, anterior cells are agger nasi cells (ANC), supra agger cell (SAC), supra agger frontal cell (SAFC). Posterior cells are supra bulla cell (SBC), supra bulla frontal cell (SBFC) and supraorbital ethmoidal cell (SOEC). While for medial cells there is one which is frontal septal cell (FSC) [2]. All the cells mention will be evaluated in our study (Table 1).

The severity of CRS can be measure by several systems. The Lund-Mackay staging system was developed as a simple assessment tool to facilitate treatment decisions in the mid-1980s [5]. It includes symptom scores, radiologic staging, and endoscopy scores; however, it is the radiologic score that has become widely used [6]. The scoring

system for the sinus groups is based on their appearance on the CT scan. Each sinus group is then assigned a numeric grade: 0 = no abnormality, 1 = partial opacification, and 2 = total opacification.

There are variations of frontal cells in different populations, and the impact and applicability of the new frontal sinus classification in our population need further study. Hence, we aimed to validate the IFAC in our patients with chronic rhinosinusitis and determine the association of the frontal cells with the development of CRS.

This study was aimed to study the association new frontal cell variants as defined by the IFAC among CRS patient and to determine the correlation of new frontal sinus cells classification (define by IFAC) and frontal sinusitis.

CHAPTER 2:

OBJECTIVES OF THE STUDY

2.0 OBJECTIVES OF THE STUDY

2.1 General objective

To study on new frontal cell variants as defined by the IFAC (international Frontal Sinus Anatomy Classification) among chronic rhinosinusitis patient.

2.2 Specific objectives

1. To identify the prevalence of IFAC frontal sinus cells variation among CRS patients.
2. To determine the frontal sinus cell variation in between frontal sinusitis and without frontal sinusitis among CRS patient.
3. To determine the associations of IFAC frontal sinus cells classification and frontal sinusitis.

CHAPTER 3:

MANUSCRIPT

3.1 TITLE PAGE

Computed Tomographic Study on New Classification Of Frontal Sinus Variants In Relation To Chronic Rhinosinusitis Patients

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Conflict of Interest: The authors declare that they have no conflict of interest.

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3.2 ABSTRACT

Background There are variations of frontal cells in different populations, and the usefulness and applicability of the new frontal sinus classification in our population need further study. Hence, we aimed to study the International Frontal Sinus Anatomy Classification (IFAC) in our patients with chronic rhinosinusitis (CRS) and determine the association of the frontal cells with the development of frontal sinusitis. In addition, the relations of frontal cells variants with severity of frontal sinusitis was studied.

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Key words: frontal cell variants, chronic rhinosinusitis, paranasal sinuses, frontal sinus, international frontal sinus anatomy classification, frontal sinusitis.

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assigned a numeric grade: 0 = no abnormality, 1 = partial opacification, and 2 = total opacification.

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3.4 MATERIALS AND METHOD

This was a retrospective chart review on computed tomography paranasal sinus (CTPNS) performed on patient in Hospital Universiti Sains Malaysia (Hospital USM). The data was collected between January 2014 and January 2018, total of 200 patients who had clinical and endoscopic findings suggestive of CRS and undergone CT paranasal sinuses was reviewed. In addition, 51 patients from emergency department who underwent CT brain until cervical, including paranasal sinus or reconstructed paranasal sinus for other indications without past medical history of CRS were also recruited as our control group (non CRS). The inclusion criteria are all the patient with rhinosinusitis symptoms who had undergone CT PNS from year 2014 until 2018 with age more than 16 years old.

The exclusion criteria were previous sinus surgery, age less than 16 years old, history of facial trauma, and nasal or sinonasal malignancy. The CT images which were difficult to retrieve and read were also excluded. The study protocol was reviewed and approved by the local human ethics committee (USM/JEPeM/18120778) and was performed in adherence with the Declaration of Helsinki. All data were anonymous and only accessible to the research team members. Data were presented as grouped data and the responders were not identified individually.

Data was retrieved from medical record unit and manually from PACS online (Picture Archive Communication System). All the images were taken using Siemens SOMATOM® Definition AS+ which can produce 128-slices of images per rotation and reconstructed into multiplanar slices, 1 mm thickness in axial-coronal-sagittal cut. The images were viewed using PACS software at the computer workstation. Imaging angles, contrast, and brightness were adjusted on the computer workstation to improve bony detail, which were useful for identifying diseased frontal cells in patients with CRS. The

CT images were interpreted by one radiologist (M.E.A), one otorhinolaryngologist (B.A) and the second author (N.E.A.F). When there was conflicting opinion, further evaluation of the image was done by specialist to obtain a mutual consensus. All data obtained were entered in the study proforma.

The 502 sides of the 251 patient's images were evaluated for the presence of frontal sinusitis and also the presence of ANC, SAC, SAFC, SBC, SBFC, SOEC, and FSC. These cells were classified as three groups which were anterior cells, posterior cells, or medial cells. Lund and Mackay scoring were evaluated for all paranasal sinuses and compared in patient with and without frontal sinusitis. The sinus opacification was interpreted independently, and scoring was done based on opacification, grade: 0 = no abnormality, 1 = partial opacification, and 2 = total opacification.

Statistical analyses were performed using Statistical Package for Social Sciences (SPSS) software version 2.0. The data obtained was expressed as mean (SD=standard deviation) for numerical and n=frequency (%) for categorical variables. Multivariate logistic regression analyses were performed to identify factors associated with frontal sinusitis. The odds ratio (OR) and 95% confidence interval (CI) were calculated for each factor of ANCs, SACs, SAFCs, SBCs, SBFCs, SOECs, and FSCs were chosen as predictive variables (Figs. 1-7). Pearson chi-square test was used to examine the association between types of different cells with frontal sinus opacification based on lund mackay classification. A p value <0.05 was considered statistically significant for all measurements.

3.5 RESULTS

Demographic

A total of 502 sides of frontal sinus CT scans of 251 patients were analysed. The mean age of the participants was 44.63 years old (Table 2). Predominantly, Malay participants were included in the study with 90.4 % (n=277) followed by Chinese (7.6 %) and others (1.6 %). More than half of the patients were male 137(54.6 %).

Incidence of Anatomical Variants

Table 3 describes in how many patients a particular cell type was detected, regardless of whether a cell occurred unilaterally or bilaterally and either patients of CRS or non-CRS. The ANC was mostly found (95.8%) followed by SBC (59.8%), SBFC (54.8%), SAC (48.6%), SAFC (33.1%), FSC (8.6%) and SOEC (4.6%).

Relations of frontal cells variants with chronic rhinosinusitis

There was significant association between SAC (p=0.043), SOEC (p=0.004) and FSC (p=0.012) with status of CRS present or absent. Most of the patients with absent SAC, SOEC and FSC ended up with absent of CRS (Table 4).

Relations of frontal cells variants with development of frontal sinusitis

One hundred seventy four sides (34.7%) of the CT PNS had changes consistent with frontal sinusitis. Table 4 shows the frequency of cells in positive frontal sinusitis. In terms of association of the cells with positive frontal sinusitis, there were no significant association between the new frontal sinus variants with positive CRS-FS except for SOEC

(p=0.001) and FSC (p=0.044) status. For sample with presence of SOEC, there was 4.64 times odd to experience presence of frontal sinusitis compared to sample with absent of SOEC. For sample with presence of FSC, there were 1.91 times odd to experience presence of frontal sinusitis compared to samples with absent of FSC.

Relations of frontal cells variants with severity of frontal sinusitis

There was no significant association between listed frontal cells variants towards different severity of frontal sinus opacification in this study (Table 5). In the sample with frontal sinus opacification, the data shows present of maxillary sinus opacification more than other sinuses, followed by anterior ethmoid, posterior ethmoid and OMC. However, there was no association between the different types of frontal cells variants with frontal sinus opacification.

3.6 DISCUSSION

There are few classifications used for assessing or identifying the frontal cells variants. Previously, the most commonly used frontal cells variants classifications was described by Bent et al, where the cells were categorized into four types which is type I, II, III and IV [5]. However, recently IFAC has classified the frontal cells variants based on its relation to the frontal recess [4,6]. This classification was great in a way the descriptions of the cells in a reproducible, anatomically precise and surgically relevant style [7]. All IFAC cell types had been shown to have an excellent reliability by ICC (0.78-0.89), with the exception of the supra bulla frontal cell, which achieved good reliability (ICC, 0.71) [4,7]. Previous studies looking at normative prevalence data of frontal cells according to IFAC showed it is a dependable classification in assessing the drainage outflow tract of the frontal sinus [7,8]. With the exception of Sommer et al [9], all studies used the previous classification [5] when assessing the role of frontal cells in the development of frontal sinusitis [10-11].

Based on our study, the agger nasi cell (ANC) which is the anterior most cells have shown the highest incidence with 95.8%, and this is equivalent to few studies published shows incidence range of 90% to 98% [7-9,12]. Thus, this reveal the reason for ANC to be used as reference cell for anteriorly based cells in accordance to IFAC system [8]. The prevalence of posteriorly based cells, supra bulla cell (SBC) 59.8% and suprabulla frontal cell (SBFC) 54.8% is much higher in comparison to other anteriorly based cells supra agger cell (SAC) 48.6% and supra agger frontal cell (SAFC) 33.1%. This is consistent with few other published studies SAC (16-30%) and SAFC (13-20%) [7,8]. In our study, the prevalence of supraorbital ethmoidal cell (SOEC) and frontal

septal cell (FSC) is the least which account 4.6% and 8.6% respectively, as oppose to study by choby and trans shows higher percentage of SOEC (28.5% and 17.3%) and for FSC (30% and 10.6%) [7,8].

Our results showed there was no significant association between all frontal cells except for SOEC and FSC with the development of frontal sinusitis. Although, both SOEC and FSC have the least prevalence, both cells have a significant association with frontal sinus sinusitis. Hence, this imply that in the presence of either or both of this cell patient has high chance to get frontal sinusitis. In contrary to study done by Sommer et al and Johari et al demonstrated there was no significant association for all the cells with present of frontal sinusitis [9]. Whereas study from DelGaudio consistent with our findings [13]. Due to the existence of multiples and different types of cells in the frontoethmoidal region making the frontal recess a very complex anatomical structure. Thus, understanding and locating the exact cells that involve in the developing frontal sinusitis is very imperative.

CONCLUSION

Patients with the presence of SOEC and FSC have more chance of developing frontal sinusitis. Posterior and medial cells play more role in causing frontal sinusitis. IFAC is useful in identifying the cells responsible for causing frontal sinusitis. It may help in guiding the surgeon to remove the cells in preventing recurrent disease.

Compliance with ethical standards

Conflict of interest

The authors have no funding, financial relationships, or conflicts of interest to disclose.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the Human Research Ethical Review Board (JEPeM Code: USM/JEPeM/18120778) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Written informed consent was not obtained from all patients. Permission to review the CT images obtained from director Hospital USM.

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3.8 TABLES AND FIGURES

Table 1. International Frontal Anatomy Classification (IFAC)

Cell type	Cell name	Abbreviation
Anterior cells	Agger nasi cell	ANC
	Supra agger cell	SAC
	Supra agger frontal cell	SAFC
Posterior cells	Supra bulla cell	SBC
	Supra bulla frontal cell	SBFC
	Supraorbital ethmoidal cell	SOEC
Medial cells	Frontal septal cell	FSC

Table 2 : Patients' demographic data (n=502)

Variable	CRS n (%)	Non-CRS n (%)	Total n (%)
Age (mean ± SD)	42.59 (15.41)	52.60 (18.50)	44.63(16.57)
Side			
Left	200 (50)	51 (50)	251 (50)
Right	200 (50)	51 (50)	251 (50)
Gender			
Male	114(57)	23 (45.1)	137 (54.6)
Female	86 (43)	28 (54.9)	114 (45.5)
Ethnicity			
Malay	180 (90)	47 (92.2)	227 (90.4)
Chinese	15 (7.5)	4 (7.8)	19 (7.6)
Indian	1 (0.5)	0 (0)	1 (0.4)
Others	4 (2)	0 (0)	4 (1.6)

Table 3. Prevalence of anatomical variants

Frontal cell variants	Position	CRS	Control	Total n (%)
Agger nasi cell	Anterior	382 (95.5)	99 (97.1)	481 (95.8)
Supra agger cell	Anterior	200 (50.0)	44 (43.2)	244 (48.6)
Supra agger frontal cell	Anterior	144 (36.0)	22 (21.6)	166 (33.1)
Supra bulla cell	Posterior	243 (60.8)	57 (55.9)	300 (59.8)
Supra bulla frontal cell	Posterior	212 (53.0)	63 (61.8)	275 (54.8)
Supraorbital ethmoidal cell	Posterior	22 (5.5)	1 (1.0)	23 (4.6)
Frontal septal cell	Medial	33 (8.3)	10 (9.8)	43 (8.6)