ORIGINAL CONTRIBUTION

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Prevalence of the uncinate process, agger nasi cell and their relationship in a Taiwanese population*

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SUMMARY

Objectives: *The uncinate process (UP) and the agger nasi (AN) cell are both important anatomical landmarks in endoscopic sinus surgery. The superior attachment of the UP and the prevalence of the AN cell show great anatomical variability and affect the anatomy of the frontal recess. The aim of this study was to investigate the superior attachment types of the UP, the presence of the AN cell, and the relationship between the two.*

Method: *Two hundred sixty-four sides of 132 patients with identifiable superior attachments of the UP were selected from our 2007–'08 computed tomography (CT) scan records. Exclusion criteria were previous nasal or paranasal sinus surgery, neoplastic disease, and a history of nasal trauma. The superior attachment type of the UP and the prevalence of the AN cell were evaluated. Three case series from the English-language literature were selected for racial comparison.*

Results: *Single insertion of the UP into the lamina papyracea was the most common type (70.4%). The other types of UP superior attachment were found to have the following distribution: 10.2% into the middle turbinate; 7.6% into the lamina papyracea and the skull base; 6.1% into the skull base, 4.9% into the lamina papyracea and the middle turbinate; and 0.8% into the middle turbinate and the skull base. The distribution of the UP insertion types with respect to ethnicity was statistically significant ($p < 0.01$). The AN cell was found in 216 (81.8%) of 264 sides. The AN cell was present bilaterally in 95.3% of the cases (206 sides, 103 patients) and unilaterally in 4.7% (10 sides). The prevalence of the AN cell according to superior attachment of the UP types was not statistically significant ($\chi 2 = 8.6$, $p = 0.126$).*

Conclusions: *The nasofrontal anatomy did show some variations among different races. The single superior attachment of the UP into the lamina papyracea had the highest prevalence. The AN cell was found to be present in 81.8% of cases. The relationship between the presence of the AN cell and the superior attachment types of the UP was not statistically significant.*

Key words: uncinate process, agger nasi, computed tomography, frontal sinus, Taiwanese

INTRODUCTION

Functional endoscopic sinus surgery is a common and standard treatment for diseases of the nasal and paranasal sinuses. Endoscopic surgery of the frontal sinus remains a challenge, however, and has numerous potentially significant risks [(1)]. Surgeons must have a thorough knowledge of the relevant anatomy to perform the operation successfully and smoothly without complications. Both the agger nasi (AN) cell and the superior attachment points of the uncinate process (UP) are important anatomical structures in the frontal recess region. The UP is an important anatomical landmark in frontal surgery, but its superior attachment varies greatly. The AN cell, another important structure affecting the frontal recess anatomy, is closely related to the UP. Pneumatization of the AN cell, with or without involvement of the frontal ethmoidal cells, affects the superior attachment of UP. The presence and degree of pneumatization of the AN cell and the variations of the superior attachment of the UP affect the dimensions of the frontal sinus ostium and the size of the frontal beak. We surveyed the anatomical variations in the nasofrontal region of Taiwanese patients using CT scans. The aims of this study included determination of the prevalence of the AN cell, the anatomical variations of the superior attachment of the UP, and the frequency of these variations. We also investigated the relationship between these two structures and their side-to-side variability.

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MATERIALS AND METHODS

Study design

A retrospective anatomical study was carried out using CT scan records between January 2007 and December 2008 in the Tri-Service General Hospital, Taiwan. The images were all obtained by a multiple detector scanner (Philips Brilliance 64-slice CT scanner, Philips Medical Imaging, Best, The Netherlands) with 1-mm contiguous coronal and axial sections.

A total of 264 sides of 132 patients with identifiable superior attachment of the UP were selected. The study group comprised 98 men and 34 women (age range, 18–70 years; mean, 39.4 years). Patients with previous nasal or paranasal sinus surgery, neoplastic disease, or a history of nasal trauma were excluded. The UP was identified as a bony lamella in the coronal plane at the level of the maxilla ostium. Then, meticulously scrolling back and forth, we traced the fine superior portions of the UP to their insertion [2]. The AN is a small ridge on the lateral side of the nasal cavity. It is located midway at the anterior edge of the middle nasal turbinate, directly above the entrance of the middle meatus. It is formed by the ethmoidal crest of the maxilla covered by mucus membrane. The AN cells were defined as the ethmoid air cells that projected anterior to the attachment of the middle turbinate. They were identified as the distinct cells in the coronal plane at the level of the frontal recess, usually anterior to the middle turbinate anterior insertion. The AN cell was lateral to the middle turbinate, medial to the lacrimal bone and posterior to the frontal process of the maxilla [2]. Both the UP and the AN cell could be identified with CT scans (Figure 1). The superior attachment type of the UP and the prevalence of the AN cell were evaluated; each side of each individual was studied separately.

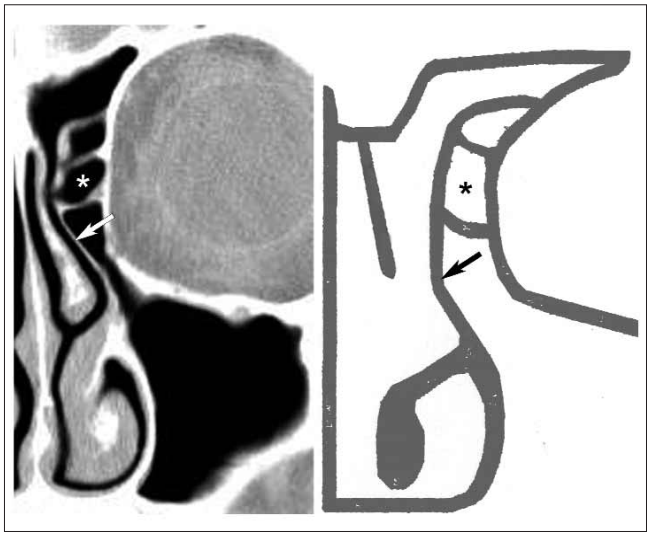

Figure 1. (Left) A coronal CT scan illustrating the agger nasi cell (*) and uncinate process (arrow). (Right) A diagram illustrating the left CT scan. The uncinate process (arrow) inserted into the lamina papyracea and bounded the agger nasi cell (*) medially.

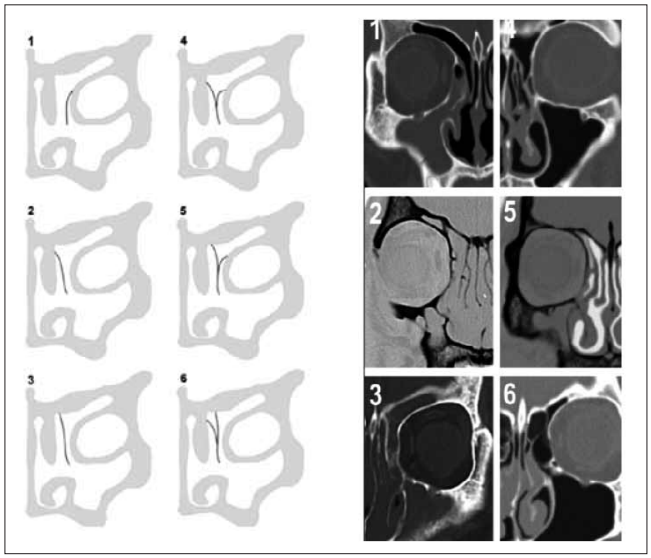

Figure 2. (Left half) Classification of uncinate process's superior attachment. 1: insertion into the lamina papyracea (type 1). 2: insertion into the middle turbinate (type 2). 3: insertion into the skull base (type 3). 4: insertion into both the lamina papyracea and the middle turbinate (type 4). 5: insertion into both the lamina papyracea and the skull base (type 5). 6: insertion into both the middle turbinate and the skull base (type 6). (Right half) Coronal CT scan could demonstrate each type of superior attachment of uncinate process.

Classification of the superior attachment of the UP was recognized according to three main structures: the lamina papyracea; the middle turbinate, including the junction with the cribriform plate; and the skull base. Six types of superior attachment of the UP were classified (Figure 2). We also reviewed the English-language literature using the PubMed (U.S. National Library of Medicine) database and selected three case series for racial or ethnic comparison [3-5].

Statistics

The chi-square test was used for statistical analysis; differences were assumed to be significant at $p < 0.01$.

RESULTS

Uncinate process

Six types of superior attachment of the UP were recognized and compared with previous case series (Table 1). The insertions might have one (types 1, 2, and 3; 229 sides or 86.7% of cases) or two (types 4, 5, and 6; 35 sides or 13.3% of cases) attachments. Single superior attachments might insert into the lamina papyracea (type 1; 186 sides, 70.4%), middle turbinate (type 2; 27 sides, 10.2%), or the skull base (type 3; 16 sides, 6.1%). Twofold superior attachments were distributed as follows: into the lamina papyracea and middle turbinate in 13 sides (type 4; 4.9%), into the lamina papyracea and skull base in 20 sides (type 5; 7.6%), and into the middle turbinate and skull base in 2 sides (type 6; 0.8%). We found no UP with three superior attachments in this study. The superior attach-

Table 1. The superior attachment type of UP and comparisons from case series of nasofrontal anatomy in English literature.

Attachment type	Insertion area	Number (%) of sides	Landsberg and Friedman [2]	Ercan [3]	Zhang [4]
Type 1	Lamina papyracea	186 (70.4%)	122 (70.5%)	226 (62.6%)	14 (33%)
Type 2	Middle turbinate	27 (10.2%)	15 (8.7%)	72 (19.9%)	
Type 3	Skull base	16 (6.1%)	6 (3.5%)	52 (14.4%)	4 (10%)
Type 4	Both lamina papyracea and middle turbinate	13 (4.9%)	30 (17.3%)	11 (3.1%)	9 (21%)
Type 5	Both lamina papyracea and skull base	20 (7.6%)			13 (31%)
Type 6	Both middle turbinate and skull base	2 (0.8%)			1 (2%
Other	Lamina papyracea, middle turbinatee and skull bas				1 (2%)
Total		264/100%	173/100%	361/100%	42/100%
Race		Taiwanese	Israeli*	Turk*	Chinese*

*: $p < 0.01$ (comparing with Taiwanese)

ment of the UP on one side showed an identical pattern contralaterally in 61% (81 patients, 162 sides) of our cases.
Compared with previous case series, the distribution of UP insertion types with respect to race was statistically significant ($p < 0.01$) (Table 1).

Agger nasi

The AN cell was present bilaterally in 103 patients (78%), unilaterally in 10 patients (7.6%), and absent in 19 patients (14.4%). The prevalence of the AN cell was 81.8% (216 of 264 sides). When present, the AN cell was bilateral in 95.3% of patients and unilateral in 4.7%. The presence of the AN cell with respect to UP types was 144 (77.4%) in type 1, 24 (88.9%) in type 2, 15 (93.8%) in type 3, 12 (92.3%) in type 4, 19 (95%) in type 5, and 2 (100%) in type 6 (Table 2). The distribution of the AN cell with respect to UP insertion types was not statistically significant ($\chi 2 = 8.6$, $p = 0.126$) (Table 2).

DISCUSSION

Both the AN cell and the superior attachment of the UP are important structures that affect the dimensions of the frontal sinus ostium and the size of the frontal beak [6,7]. They are also important landmarks for determining the location of the frontal sinus drainage pathway [8,9].
Landsberg and Friedman [3] have used an image-guidance system to analyze the anatomical structure of the nasofrontal region. Six types of the superior attachment of the UP were defined as follows: 1) insertion into the lamina papyracea, 2) insertion into the posteromedial wall of the AN, 3) insertion into both the lamina papyracea and the junction of the middle turbinate with the cribriform plate, 4) insertion into the junction of the middle turbinate with the cribriform plate, 5) insertion into the skull base, 6) insertion into the middle turbinate. Ercan et al. [4] modified this classification by combining types 1 and 2 as type 1/2. We did not, however, adopt either classification completely. In our study, we simply classified the insertion of the UP according to three main structures: the lamina papyracea, the middle turbinate, including the junction with the cribriform plate, and the skull base (Table 1). Therefore, we counted types 1 and 2 as defined by Landsberg and Friedman [3] in the same category and interpreted them as type 1; types 4 and 6 were interpreted as type 2; type 5 was interpreted as type 3, and Landsberg and Friedman's type 3 was interpreted as type 4. The insertion might be either single or combining any two of the three structures. Although some might question the appearance of a bifurcating superior attachment, due to the presence of an ethmoid cell, a bifurcating superior attachment did occur. It was confirmed by an anatomical study of the skull and cadaver head [5]. We did not find any UP with three attachments in our study.

Table 2. Distribution of the presence of the AN cell according to superior attachment of UP types.

Attachment type	Number (%) of AN cell
Type 1	144 (77.4%)
Type 2	24 (88.9%)
Type 3	15 (93.8%)
Type 4	12 (92.3%)
Type 5	19 (95%)
Type 6	2 (100%)

($\chi 2 = 8.6$, $p = 0.126$)

While most of the AN cell is anterior to the UP, its posterior half is intimately related to the upward extension of the UP. In one anatomical variation, a large AN cell may push the upward continuation of the UP medially so that it attaches to the middle turbinate, pushing drainage of the frontal sinus posteriorly. Another anatomical variation, the upward continuation of the UP into the skull base, may be an isolated bony septum extending superiorly from the AN cell superiorly, although it is usually part of a frontal ethmoidal cell sitting on top of an AN cell [10]. These variations have a significant influence on the anatomy of the frontal recess [11]. When the UP is inserted into the lamina papyracea, the frontal sinus opens

directly into the middle meatus medial to the uncinate process and the ethmoid infundibulum ends superiorly in a blind pocket called the recessus terminalis. When the UP is inserted into the skull base or middle turbinate, the frontal recess opens into the middle meatus lateral to the uncinate process via the ethmoid infundibulum. Therefore, the superior insertion point of the UP not only defines the anterior, lateral, and medial borders of the frontal recess but also determines the drainage pattern of the frontal sinus.

We found that a single superior attachment of the UP into the lamina papyracea had the highest prevalence: 70.4%. Similar results were obtained by Landsberg and Friedman [3], Ercan et al. [4], and Zhang et al. [5] with rates of 70.5%, 62.6%, and 33%, respectively. The second most common type of attachment observed in our study was type 2, single insertion into the middle turbinate, with a frequency of 10.2%. Different results were reported by Landsberg and Friedman, Ercan et al., and Zhang et al. with type 4 (insertion into the lamina papyracea and middle turbinate, 17.5%), type 3 (insertion into the skull base, 14.4%) and type 5 (insertion into the lamina papyrace and skull base, 31%), respectively. The distribution of the insertion types of the UP with respect to race or ethnicity was statistically significant ($p < 0.01$). Taken together, 82.7% (219 sides) of the UP was attached to the lamina papyracea (types 1, 4, and 5). This result was close to the rates of 88% reported by Landsberg and Friedman [3] and 86% reported by Zhang et al. [5].

The AN cell is the most anteriosuperior ethmoid cell and is located laterosuperiorly to the anterior end of the middle turbinate. The coronal CT scans revealed that there can be one to three AN cells with some asymmetries on each side. The posterior wall of the AN forms the anterior border of the frontal recess and its roof forms the floor of the frontal recess. A large AN cell that has been pneumatized may extend superiorly into the frontal sinus and therefore affect the dimensions of the frontal sinus ostium and the drainage pattern. The prevalence of AN cells was 81.8% in this study. Similar result were obtained by Landsberg and Friedman [3], Ercan et al. [4], Zhang et al. [5], and Wormald [10] with rates of 78%, 83.3%, 90%, and 98.5% respectively.

Embryonically, both the UP and the AN cell originate from the first ethmoturbinal. While the descending portion of the first ethmoturbinal remains as the UP during fetal development, the ascending portion regresses to form the AN cell. The AN cell is bordered by the UP medially, inferiorly, and superiorly. In this study, we observed 82.7% (219 sides) of the UP with attachments to the lamina papyracea (types 1, 4, and 5). A similar prevalence (81.8%) of AN cells was also noted in this study. Wormald [6,10] stated that pneumatization of the AN cell affects the superior attachment of the UP, but the findings reported by Ercan et al. [4] revealed no statistical significance. Our results concurred with the latter. We found no relationship between the presence of the AN cell and the type of superior attachment of the UP. As for the relationship between the etiologies of frontal sinus disease (such as chronic frontal sinusitis) and anatomic variations, further studies are needed to elucidate these questions.

Badia et al., using computed tomography (CT) scanning, concluded that there is a higher incidence of pneumatization of the middle turbinate (concha bullosa) and paradoxical bending of the middle turbinate in a Caucasian population [12]. The infraorbital and suprabullar cell development was higher in the Caucasian population, though the incidence of sphenoethmoidal cells was much greater in the Chinese population. Badia et al. also stated that the incidence of a bent uncinate process and the complete absence of a sinus were higher in the Chinese population. There was, however, no difference in the presence of pneumatization of the agger nasi or of the uncinate process [12].

According to the present study, the variations in the nasofrontal region did reflect some ethnic differences between Taiwanese patients and those of other races.

CONCLUSION

The variations of the nasofrontal region among the Taiwanese patients in our study did reflect some racial differences. The relationship between the upper portion of the UP and the AN cell is important in understanding the anatomy of the frontal recess drainage pathway. We found that the frontal sinus opened into the middle meatus medial to the uncinate process in 82.7% of the patients and lateral to the uncinate process in 17.3%. A single insertion of the UP into the lamina papyracea was the most common type. The prevalence of the AN cell was 81.8%. We found no significant relationship between the presence of the AN cell and the types of superior insertion of the UP.

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