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Original Research Article

Variants in the superior attachment of uncinated process and their corresponding frontal sinus drainage pattern: a computed tomography-based retrospective clinical study

Visali M. G. A.[1], Praveen Ravichandran[1], Naveen Kumar Balasubramani[1], Saranya Ayyadurai[2]*

[1]Department of Otorhinolaryngology, A. C. S. Medical College and Hospital, Chennai, Tamil Nadu, India
[2]Department of Radiology, A. C. S. Medical College and Hospital, Chennai, Tamil Nadu, India

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***Correspondence:**
Dr. Saranya Ayyadurai,
E-mail: saranya_thiru@yahoo.com

ABSTRACT

Background: Understanding the morphology and spatial relationships of the uncinate process and its associated spaces is crucial for diagnosing and treating conditions affecting sinus drainage and ventilation. This consistent anatomical structure is an important surgical landmark for endoscopic sinus surgery.
Methods: Computed tomography (CT) records of 100 patients over two years were extracted via the hospital's PACS system. The type of superior insertion of uncinate process (UP) was observed in coronal cuts of CT scan images, and classification was done based on the Friedmann and Landsberg classification system and tabulated. The corresponding variations in the frontal sinus outflow tract were noticed, and their effect on frontal sinusitis was recorded. Sinusitis of the frontal sinus was in guidance with EPOS 2020 (mucosal changes within the ostiomeatal complex or sinus).
Results: Type 2 was the most common of uncinate attachments (39.5%). The least common variant was type 5 (4%). Medial-type frontal sinus drainage pathway was observed in 78.5% of patients. Sinusitis was present in 23.5% of our study population. Type 2 had a 25% contribution to the occurrence of sinusitis. The medial frontal sinus drainage pathway contributes 24% to sinusitis with a significant p value of 0.010.
Conclusions: Uncinate process, with its varying superior attachment, influences the frontal sinus outflow tract and may contribute to the development of frontal sinusitis. Awareness of the possible variations in the attachment of the uncinate process is vital in the preoperative planning process, which will serve as a road map to surgeons and aid in preparedness for intraoperative complications.

Keywords: Uncinate process, Frontal sinusitis, Frontal sinus outflow

INTRODUCTION

The osteomeatal complex (OMC) is a crucial anatomical region situated in the lateral wall of the nose within the middle meatus.[1] It is a drainage pathway for the anterior ethmoid, maxillary, and frontal sinuses. Any variation in the components of the osteomeatal complex can lead to variations in drainage pathways of these sinuses, which in turn can result in sinusitis.[1] One of the critical structures within the osteomeatal complex is the uncinate process (UP). The UP is a distinctive structure of the ethmoid bone, resembling a thin, sickle-shaped projection situated on the lateral wall of the nose.[2] UP extends superiorly from the frontal recess and inferiorly to the ethmoid process of the inferior turbinate. The space between the free edge of the UP and the anterior surface of the bulla ethmoidalis (BE) is referred to as the hiatus semilunaris inferioris.[2] This space, which has a crescent shape in two dimensions, transitions laterally into a three-dimensional cavity called

the infundibulum.[3] The natural opening of the maxillary sinus, or the ostium, connects to the infundibulum.

The frontal recess is a three-dimensional space connecting the frontal sinus superiorly with the middle meatus inferiorly.[2] A thick bone forms the anterior wall of the frontal recess, the frontal process of the maxilla (frontal beak), and agger nasi. The anterosuperior wall of bulla ethmoidalis forms the posterior wall. The lateral wall is formed by lamina papyracea, and the olfactory fossa forms the medial wall. Medial and lateral wall components vary based on superior attachment of uncinate process (SAUP).[4] Based on SAUP, the frontal sinus outflow tract is of two types – medial to UP and lateral to UP. The superior attachment of the uncinate process has varying attachments. Understanding the morphology and spatial relationships of the uncinate process and its associated spaces is crucial for diagnosing and treating conditions affecting sinus drainage and ventilation.

The uncinate process is not a simple vestigial structure but plays an essential role in the ventilatory process of the sinus surfaces. The position of superior attachment of the uncinate process was initially suggested by Stammberger et al. This consistent anatomical structure is an important surgical landmark for endoscopic sinus surgery. Computed tomography (CT) has served as the gold standard for evaluating preoperative anatomy of paranasal sinuses, identifying anatomical variations, and serving as a road map to surgery and helping avoid intraoperative complications.[5]

The objective of this study is to estimate the prevalence of varying patterns of SAUP in terms of percentage and to determine the association between SAUP and its effect on frontal sinusitis. From a surgical perspective, removing the uncinate process is necessary to access the ethmoid infundibulum and the maxillary sinus ostium.[6] Once the uncinate process has been excised, the opening of the maxillary sinus becomes visible and can be enlarged through a procedure known as maxillary antrostomy. These crucial steps, namely uncinectomy and maxillary antrostomy, are fundamental components of functional endoscopic sinus surgery (FESS). They are indispensable for achieving the best possible surgical outcome. Creating a clear pathway to the affected sinuses facilitates adequate drainage and ventilation, ultimately alleviating symptoms, promoting healing, and providing access for better penetration of topical medications.

METHODS

This is a retrospective hospital-based analytical clinical study, wherein CT records of 100 patients (200 sides) over two years will be extracted via the hospital's PACS system. This study aims to retrospectively investigate the prevalence of anatomical variations in the superior attachment of uncinate and its relationship with the frontal sinus outflow tract using CT images. After obtaining permission from institutional ethical committee CT images of both sexes and those aged 18 years and above have been included in the study. The CT images of patients diagnosed with chronic rhino sinusitis with nasal polyposis, paranasal sinus tumours, history of skull base surgeries, history of previous endoscopic sinus surgery, and a history of nasal trauma were excluded from this study. The data was collected from the department of radio diagnosis at A.C.S Medical College, Vellapanchavadi, from 2022 to 2024.

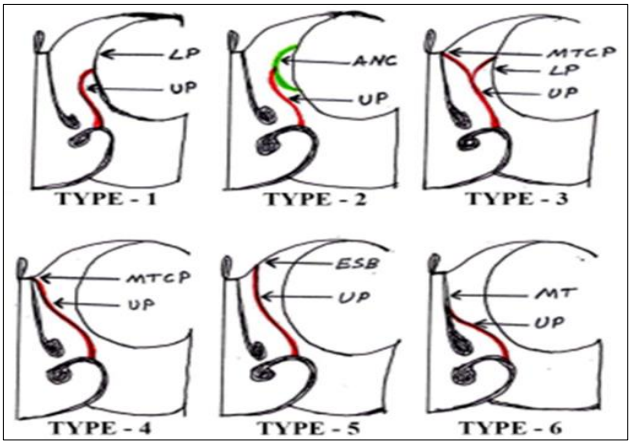

Figure 1: A pictorial representation of Landsberg and Friedmann classification.

All the CT paranasal sinus images of 1 mm thickness were included using a multi-slice scanner. All images were analysed in good resolution. The type of superior insertion of UP was observed in coronal cuts of CT scan images, and classification was done based on the Friedmann and Landsberg classification system (Figure 1) and tabulated. The corresponding variations in the frontal sinus outflow tract were noticed, and their effect on frontal sinusitis was recorded. Sinusitis of the frontal sinus was in guidance with EPOS 2020 (mucosal changes within the ostiomeatal complex or sinuses). Data was analysed using statistical package for the social sciences (SPSS) software version 27, and the results were tabulated.

RESULTS

The study was conducted among 100 patients (200 sides); the age group of the study population was around 18-68 years. Both sexes were found to be equally distributed. The mean age was found to be 37 years. Data analysed from the study population showed that type 2 was the most common of uncinate attachments (39.5%), followed by type 1 (26.5%). The least common variant was type 5 (4%). Our data showed that a medial-type frontal sinus drainage pathway was observed in 78.5% of patients, and a lateral-type frontal sinus drainage pathway was observed in 21.5%.

Among 200 sides of CT PNS observed in 100 patients, sinusitis was present in 23.5% of our study population. Type 1 variant in the attachment of the superior process of uncinate had a 23% contribution to sinusitis, and type 2 had a 25% contribution to the occurrence of sinusitis. Type 6 SAUP had nil contribution to sinusitis. The medial frontal sinus drainage pathway type contributes 24% to

sinusitis with a significant p value of 0.010. Both sexes had near equal incidence of sinusitis, around 25%.

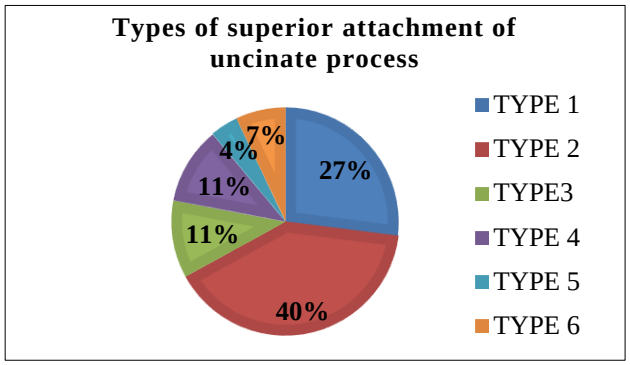

Figure 2: Pie diagram representation of varying attachment of superior attachment of uncinate process.

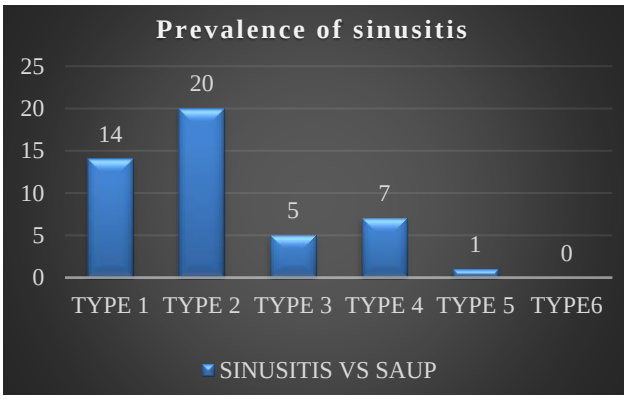

Figure 3: Representation of prevalence of sinusitis among varying superior attachment of uncinate process (SAUP).

DISCUSSION

Past decades have seen various advancements in endoscopic sinus surgeries. Yet, the approach to the frontal sinus is a challenge for surgeons due to its complex and unpredictable anatomy in spatial relation to surrounding structures.[2] Surrounded by various bony plates that determine the limit and shape of frontal recess, the superior attachment of the uncinate process is vital. Stammberger et al described three possible extensions of the uncinate process: lamina paprisea, skull base, and middle concha.[7] They also described classifications based on shape, attachment, hypertrophy, and pneumatisation. They failed to mention other possible variations and combinations. But Landsberg and Friedman in 2001 described six variations in the superior attachment of the uncinate process.[8] The impact of superior attachment of uncinate in producing sinonasal pathology stands debatable, and there is a lacunae about its attachments. Previous studies have analysed variations in age, sex, and morphology but failed to evaluate their association with variations in the frontal sinus drainage pathway and its effect on frontal sinusitis.

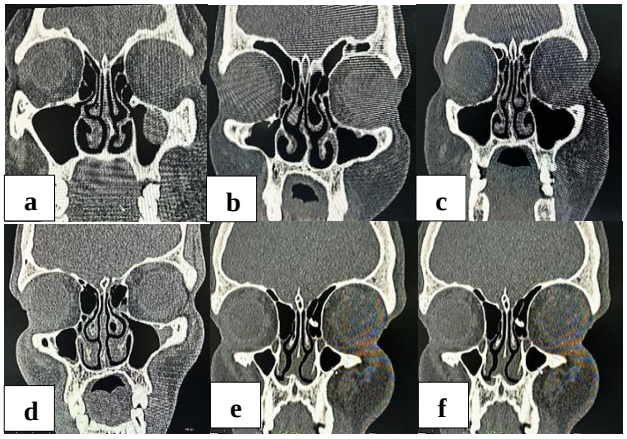

Figure 4: Computed tomography of paranasal sinuses depicting varying attachment of uncinate process: (a) left uncinate process attached to lamina paprycea (LP); (b) right uncinate process attachment to agger nasi cell (ANC); (c) right uncinate attachment into lamina papyracea and junction of middle turbinate with cribiform plate (MTCP); (d) left uncinate attachment into the junction of middle turbinate with cribriform plate (MTC); (e) left uncinate shows attachment to ethmoidal skull base (ESB); and (f) right uncinate shows attachment to middle turbinate (MT).

In accordance with the present study, 100 patients were analysed for variations in the superior attachment of the uncinate process, and it was found that type 2 was the most common SAUP (39.5%) followed by type 1 (26.5%), both of which had the medial type of drainage of the frontal sinus. This followed a study conducted by Arun et al in India with 100 patients who observed that type 2 (18%) was the second most common attachment of the uncinate process.[9] A Taiwanese study by Liu et al also found that type 2 was the most common secondary to type 1.[10] They also suggested that variations of uncinate attachment are strongly associated with varying ethnicity. Patla et al in their study of 100 CT found that type 6 was the most common and insertion to middle turbinate causes sinus mucus recirculation and therefore contributes to frontal sinusitis.[12] Among 100 patients, 33% showed bilaterally similar attachment.

When the UP inserts into the lamina papyracea, the ethmoid infundibulum closes superiorly to form a blind pouch called recessus terminalis. Hence, the frontal recess ultimately communicates with the middle meatus. Frontal recess practically opens into the middle meatus in the case of terminal recess, where it is limited by the UP laterally and the lateral side of the middle turbinate medially (SAUP types 1-3). When the UP inserts into the skull base, the middle turbinate, or the junction of the middle turbinate with the cribriform plate, the frontal recess drains to the middle meatus through the ethmoid infundibulum (SAUP types 1-4). These findings emphasized that the superior attachment of the UP determines the anterior, lateral, or medial boundaries of the frontal recess and the drainage

pattern of the frontal sinus.[11] In this study, 78% of patients had the medial type of frontal outflow tract, and 21.5% had a lateral type of outflow. This well suits type 2 SAUP as it is the most common attachment aiding in medial types of drainage.

The mucosal lining of the nose and paranasal sinuses is contiguous, and rhinitis generally precedes sinusitis. Hence, the term rhino sinusitis has begun to be used instead of sinusitis.[11] In the medial type of frontal sinus outflow tract, a direct connection between the frontal recess and middle meatus is seen, so the nasal cavity makes it easier for rhinogenic infections to reach the frontal sinus. In the lateral outflow tract, the UP acts as an anatomic barrier between the middle meatus and frontal recess, which causes the frontal sinus outflow tract to open to the ethmoid infundibulum.[11,12]

This physiologic process may play a role in the pathogenesis of frontal sinusitis in individuals with frontal sinus outflow tract medial to the UP due to the lack of an anatomical barrier against ascending irritants, allergens, and rhinogenic infection.[11] This may cause hypoventilation of the sinus and a tendency toward sinusitis.[11,12] There was a predominance of sinusitis among patients with the medial type of frontal sinus outflow tract (25%) with a significant p value of 0.010. Type 2 SAUP, which was found to be common, contributes around 25% to the development of frontal sinusitis. Type 1 SAUP, the second commonest, holds an almost equal percentage (23%) in contribution to frontal sinusitis. Among both sexes, males had a higher incidence of sinusitis but had poor association. Still, there tends to be an ongoing debate on varying uncinate attachments and their effects on frontal sinusitis.

Table 1: Types of superior attachment of uncinate process in percentage.

Authors	Types of superior attachment of uncinate process in %					
	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
Turgut et al[11]	63	63	3	12	14	8
Vinay et al[1]	19	36	5	2	8	20
Present study	26	39	11	11	4	7

Limitations

The contribution to frontal sinusitis is multifactorial, divided into anatomical and mucosal obstruction. The presence or absence of frontal recess cells, including agger nasi, supraorbital ethmoid cells, frontal cells, frontal bulla cells, suprabullar cells, and interfrontal sinus septal cells has an additive effect on the causation of frontal sinusitis, which this study failed to analyse. Stammberger et al proposed varying attachment of the uncinate process and commented on the varying appearance and pneumatisation of UP and its effect on sinusitis, which was not considered in this study.

CONCLUSION

The evolving and ongoing advancements in endoscopic nasal surgeries have warranted the need to understand the varying intricate anatomy in correspondence with the frontal sinus. Uncinate process, with its varying superior attachment, influences the frontal sinus outflow tract and may contribute to the development of frontal sinusitis. Awareness of the possible variations in the attachment of the uncinate process is vital in the preoperative planning process, which will serve as a road map to surgeons and aid in preparedness for intraoperative complications.

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