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The role of uncinate process in odontogenic rhinosinusitis: a case-controlled radiologic anatomy study

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ABSTRACT

Objective: This study aimed to assess the uncinate process (UP) behavior in patients with unilateral odontogenic rhinosinusitis (UOR) and to compare it with a control group of healthy patients. It also aimed to investigate if these modifications could have a clinical role in UOR.

Methods: We retrospectively analyzed the head computed tomography (CT) scans of 21 patients with UOR and 53 healthy subjects. A total of 2 independent observers calculated UP inclination on each side with a reproducible anatomical model. All the data were statistically analyzed to assess significant differences between sides and groups.

Results: All the patients with UOR showed antero-medialization of the UP. A significant difference was seen in the mean UP deviation values between the diseased sides of UOR and the control groups and between the healthy and diseased sides in patients with UOR. There were no significant differences in UP inclination when comparing all healthy sinuses.

Conclusion: Patients with UOR show antero-medialization of the UP with an unclear cause-effect relationship. This study provides a reproducible model for anatomical CT study of the nasal cavities. It remains open to debate whether odontogenic disease is the cause of the UP antero-medialization and whether this deviation has a role in maintaining odontogenic disease and spreading it to other sinuses.

Keywords: Nasal Cavity, sinusitis, maxillary sinuses, tomography X-Ray computed, nasal surgical procedures

Introduction

The middle meatus is one of the most important regions of the nasal cavity from a physiological and pathological point of view. This area houses several fundamental anatomic structures defining the ostiomeatal complex (OMC), which includes the uncinate process (UP), the hiatus semilunaris, the ethmoid bulla, the ethmoid infundibulum, and the frontal recess. All these structures contribute to the ventilation and drainage of the anterior ethmoid, frontal, and maxillary sinuses; and any obstruction at this level can predispose a person to sinonasal inflammation, involving the whole anterior sinus compartment (1).

The UP is unanimously considered a pivotal landmark in endoscopic sinus surgery (ESS). Uncinectomy is a basic step to warrant the appropriate ventilation of the ethmoid cells, the maxillary sinus, and often, of the frontal sinus (2, 3). Conversely, though, the physiological functional role of the UP is not completely clear. Some authors have suggested it acts as a spoiler, diverting the air away from the anterior compartment during inspiration and toward the anterior compartment (more specifically, toward the maxillary sinus) during expiration (4). Others have suggested that its role lies in its rich glandular network, allowing drainage and ventilation of the maxillary and the frontal sinuses (5).

A possible role of UP in the development of maxillary infection is debated, even denied by some authors (6). Nevertheless, several studies have reported that UP anterior medialization significantly associates with chronic rhinosinusitis (CRS), jeopardizing maxillary sinus ventilation and drainage (7). More specifically, UP medialization has been reported in 8.6% of patients with CRS (presumably including patients with odontogenic sinusitis) (8). Despite these data, we still lack even a

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merely hypothetical cause-effect relationship between UP medialization and CRS. We still do not know whether UP medialization should be considered an effect, a co-cause of chronic sinonasal pathology, or just an incidental finding. This uncertainty stems from 2 reasons: first and foremost, no study has provided a solid and reproducible anatomical method to analyze these anatomic alterations; and second, CRS is usually bilateral thus making intrasubject measurement - in a homogeneous population - extremely difficult (9).

Therefore, we aimed to establish a solid relationship between UP deviation and sinus pathology and to address these 2 aforementioned issues. The primary end point of our study was to compare UP deviation in healthy versus diseased patients. The secondary end point was to compare the different UP deviations between healthy and diseased sides in the same diseased patients. We employed a reproducible radiographic method to assess the UP deviation in a homogeneous population of patients with unilateral sinus disease. The measurement technique was based on computed tomography (CT) and is described in detail in the methods section. The homogeneous population of choice was comprised patients with unilateral odontogenic rhinosinusitis (UOR). Odontogenic rhinosinusitis is a well-defined rhinosinusitis subgroup; and when unilateral, automatically grants control data from the unaffected side. Furthermore, data from patients with UOR were compared with those of healthy subjects of similar age using the same anatomical method.

Methods

Owing to its retrospective nature, the study was granted exemption from the institutional review board of our hospital, and no specific informed consent was necessary. CT scans from patients diagnosed with UOR at the otolaryngology, oral, or maxillofacial surgery departments were included in this retrospective study. All the patients were recruited from our general teaching hospital, and the suspicion of UOR was posed by a specialist of 1 of the 3 aforementioned departments. Because of the persistence of symptoms for more than 3 months, the UOR could be defined as chronic.

A definitive clinical diagnosis of UOR was made according to the criteria proposed by Felisati et al. (10, 11); all the patients included in the rhinosinusitis group had a diagnosis of sinonasal odontogenic rhinosinusitis, with a multidisciplinary agreement between ENT and dentist/maxillofacial surgeons and a unanimous agreement on the odontogenic focus. All the patients underwent clinical evaluation (both otolaryngological and dental), nasal endoscopy, and appropriate imaging for diagnostic purposes. Moreover, a clear etiological and chronological relationship between the odontogenic focus and the sinonasal complication was needed for inclusion in the study. Odontogenic rhinosinusitis is known to have, occasionally, bilateral odontogenic foci or induce pathological changes over time in the contralateral side also (12, 13). Therefore, patients with bilateral conditions at the time of presentation were excluded from this study to avoid any error in data collection.

Main Points:

- The uncinate process (UP) can act as a spoiler for air passing in the nasal cavities or be a host for glandular networks, and little is known about its role during sinus infections.
- A scheme of axis passing through UP and medial line reference points can be useful in systematic anatomical study of paranasal sinuses/lateral wall of the nose.
- UP deviation in UOR is significantly more evident than in healthy sinuses.

The control group was randomly selected from healthy subjects undergoing plain head CT scan for medical purposes including, but not limited to, headache, nonsinonasal surgical planning, or generic clinical evaluation. These patients had no clinical symptoms or radiological signs of sinonasal disease. Patients with a history of facial skeleton dysmorphisms or traumas, head surgical procedures (including ESS), recurrent nasal polyps, or cystic fibrosis were excluded from the control group.

The control group included 53 subjects (27 men and 26 women) aged 16 to 82 years (mean 42 ±18 years). The UOR group comprised 21 patients (9 men and 12 women) aged 16 to 73 years (mean 51±14 years) (Table 1). An unpaired *t*-test between the single ages of the subjects in the 2 groups was performed because of their heterogeneity, and no systematic differences were found ($p>0.05$).

Each patient underwent a plain head CT scan with a 64-row multi-detector CT (VCT, General Electric Healthcare, WI), receiving a 1.9 mSv effective dose. The scanner has a 512×512 matrix, accounting for a 0.49 mm×0.49 mm spatial resolution in the sagittal-coronal plane and a 0.625 mm gap between consecutive axial slices. Only native axial images were used for measuring purposes to avoid processing artefacts. No patient either from the study group or from the control group received specific medication (systemic or topical) in preparation for the scan. According to the results of the CT scans, there were 12 (57.1%) cases of maxillary sinusitis, 7 (33.4%) of ethmoid-maxillary sinusitis, and 2 (9.5%) ofpansinusitis.

To define UP deviation, 3 CT axial scans were selected for each patient using the Osirix DICOM viewer (Pixmeo, Bernex, Switzerland). Irrespective of the type of UP attachment at its uppermost portion (14), we chose the first and the last axial sections (proceeding cranio-caudally) in which UP was clearly detectable along its entire antero-posterior length. These sections were marked as scans 1 and 3, respectively. A further scan, selected numerically as the middle CT scan according to the reference numbers of scans 1 and 3, was selected and marked as scan 2 (Figure 1A-C).

UP inclination was calculated for each section and side as the angle between the straight line connecting the anterior and the posterior part of the UP and the axis of symmetry passing

Table 1. Demographics of the study population

Characteristics	Control group	Case group
Number of subjects	53	21
Men %	50.90	42.90
Women %	49.10	57.10
Age (years)	42±18	51±14

Figure 1. a-c. Computed tomography axial scans of the uppermost portion (a), intermediate, (b), and most caudal part (c) of uncinate process

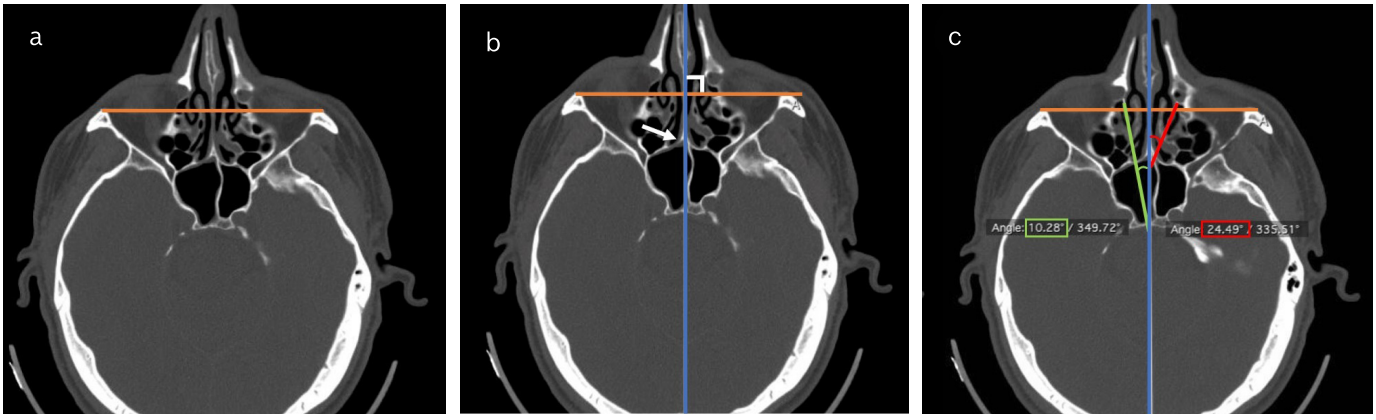

Figure 2. a-c. Diagram showing the uncinate process (UP) inclination calculation. (a) The bizygomatic line is found (orange line). (b) The second step includes the identification of the axis of symmetry of the skull (blue line), considered a line perpendicular to the bizygomatic line passing through sphenoidal rostrum (white arrow). (c) Measurement of UP inclination as an angle between the axis of symmetry and the straight line connecting the antero-superior and the postero-inferior part of the UP (green and red lines)

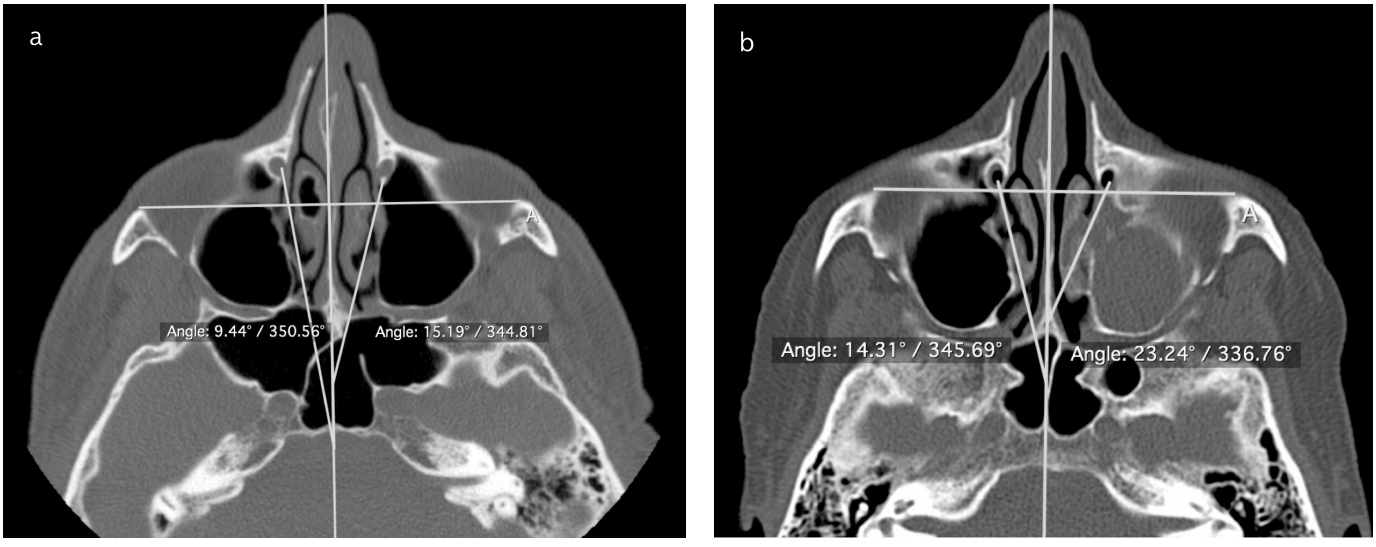

Figure 3. a, b. Comparison of computed tomography axial scans of control (a) and unilateral odontogenic rhinosinusitis groups (b).

through the sphenoidal rostrum and perpendicular to the bizygomatic line (Figure 2A-C).

Mean angular value, angular standard deviation, and confidence limits (99%) were evaluated using the rectangular components of the angles for each section, side, and group separately.

Measurements were carried out independently by 2 trained operators (1 surgeon and 1 anatomist), for each section and side in the 2 groups (Figure 3 a, b).

Statistical analysis

After confirming the normal distribution of measurements in the 3 groups (Skewness and Curtosis were respectively −0.56

and 0.74 for the UOR diseased side, −0.81 and 0.47 for the UOR healthy side, and −0.41 and 0.81 for the control group), we statistically analyzed the collected data using parametric tests.

The paired *t*-test was used to assess differences between the independent observer measurements. After ruling out any significant inter-operator difference, we assessed the symmetry of UP inclination. The evaluation was carried out between opposing sides in all patients using the paired *t*-test and between diseased and healthy sides using the unpaired *t*-test.

All statistical analyses were performed using the The Statistical Package for Social Sciences version 21.0 software (IBM Corp.; Armonk, NY, USA). Values of $p<0.05$ were considered to indicate statistical significance.

Results

Mean angle, angular standard deviation, and confidence limits (99%) for each section and side are shown for the control and UOR groups in Tables 2 and 3, respectively. All the patients with UOR showed antero-medialization. A significant difference was present in the mean UP deviation values between the diseased sides of the UOR and control groups and between healthy and diseased sides in the patients with UOR. There were no significant differences in the UP inclination comparing all the healthy sinuses.

Statistical differences between the independent observer measurements were ruled out by a paired *t*-test that showed no systematic differences ($p>0.05$). The comparison between the UP deviation in the control group and the diseased sides of patients with UOR revealed significant differences. The mean angles in sections 1, 2, and 3 were 12.07°, 18.2°, and 7.84°, respectively in the control group, whereas they were 21.85°, 30.29°, and 25.0°, respectively, in the diseased sides of patients with uor. the p values calculated independently for each section were $p=0.0025$, $p<0.0001$, and $p<0.0001$, respectively (Table 4).

Table 2. Mean angular values, angular standard deviations, and confidence limits for each section and side (control group)

Control population measures: Section	right side	Left side
First		
Mean angle	8.95°	12.07°
Angular standard deviation	3.76°	4.09°
Confidence limits (99%)	2.99° <-> 14.91°	5.64° <->18.50°
Second		
Mean angle	15.63°	18.21°
Angular standard deviation	2.76°	2.49°
Confidence limits (99%)	11.26°<-> 20.00°	14.29° <-> 22.12°
Third		
Mean angle	7.30°	7.84°
Angular standard deviation	2.57°	2.60°
Confidence limits (99%)	3.14° <-> 11.47°	3.67° <->12.01°

The comparison of the different UP deviations between the healthy and diseased sides in the same patients with UOR revealed a significant difference between the 2 sets of data. The mean angles of UP deviation on the healthy side were 9.8°, 19.88°, and 13.09°, respectively, whereas they were 21.85°, 30.29°, and 25.01°, respectively, on the diseased one. The p values calculated independently for each section were $p=0.001$, $p=0.02$, and $p=0.02$, respectively (Table 5).

Table 3. Mean angular values, angular standard deviations, and confidence limits for each section and side in UOR group

UOR population measures: Section	Healthy side	Diseased side
First		
Mean angle	9.81°	21.85°
Angular standard deviation	3.91°	3.80°
Confidence limits (99%)	-1.62° <-> 21.24°	11.06° <-> 32.64°
Second		
Mean angle	19.88°	30.29°
Angular standard deviation	2.23°	2.31°
Confidence limits (99%)	13.54° <-> 26.22°	23.82° <-> 36.76°
Third		
Mean angle	13.09°	25.01°
Angular standard deviation	2.76°	3.12°
Confidence limits (99%)	5.04° <-> 21.14°	16.14° <-> 33.88°

UOR: Unilateral odontogenic rhinosinusitis

Table 4. Statistical analysis between control and diseased sides (UOR group). The comparison has been made by using an unpaired t-test that demonstrated significant differences between the 2 sets of data

	First section	Second section	Third section
Mean angle (control patients)	12.07°	18.21°	7.84°
Mean angle (diseased side)	21.85°	30.29°	25.01°
p	.0025	<.0001	<.0001

UOR: Unilateral odontogenic rhinosinusitis

Table 5. Statistical analysis of the healthy and diseased sides in the same patients with diseased UOR. The comparison has been made by using a paired t-test that demonstrated significant differences between the 2 sets of data

	First section	Second section	Third section
Mean angle (control patients)	9.81°	19.88°	13.09°
Mean angle (diseased side)	21.85°	30.29°	25.01°
p	p=0.001	p=0.02	p=0.02

UOR: Unilateral odontogenic rhinosinusitis

The comparison between sides of the control and healthy UOR groups revealed no statistically significant difference among them, showing p=0.898 for first sections, p=0.20 for the second, and p=0.11 for the third sections.

Discussion

Our results indicate an undebatable relationship between UP displacement and UOR. There is a significant difference between the affected and healthy sides in patients with UOR. A medialized UP was associated with an inflammatory process in all the patients in our patient series. Furthermore, we found no patients with medialized UP in a healthy sinus. This striking difference is further strengthened if we consider that the 2 sets of deviation values (healthy and diseased sinuses) fall into 2 completely different ranges. In our opinion, these data prove an inflammation-medialization relationship. To our knowledge, this is one of the first studies to provide an objective evaluation of this phenomenon and the first to focus on OUR (15).

This objectivation represents a significant step forward when compared with the simple random observations reported in other studies. Different authors have reported a constant variability of UP inclination, but without any correlation to the infection process or specific conditions (16, 17) except for the recently published study by Hervochon et al. (15).

A significant shortcoming of our study was the inability to ascertain whether UP medialization could be considered a cause or a consequence of the infection process. Lacking data on the preinfection inclination of the UP, we could not conclusively establish this relationship. Moreover, our hypothesis, supported by the lack of medialized UP in healthy sinuses, is that the UP gets displaced medially as a consequence of the infection process, as has been shown in other sinusal pathologies (18-20).

Going beyond the cause-effect relationship, we hypothesized that the UP medialization may also affect the OMC drainage of other sinuses (ethmoid and frontal sinuses), favoring the spread of the infection there starting from the maxillary focus. Such a hypothesis is further strengthened by literature reports associating medial deviation of UP and ethmoidal rhinosinusitis (7).

Although our findings prove that the anterior medialization of UP is an inexorable event during UOR, it is still not well-known if this angular inclination is fully reversible when the medical approach is effective. Unfortunately, owing to the frequency of healed patients being lost to follow up, it is difficult to apply these data to a clinical setting. Our preliminary observation hints that a significant medialization of UP creates a complete closure of OMC, further limiting the efficacy of any medical treatment. Because of lack of data on the preinfection inclination of UP, it is quite difficult to consider the role of UP as a risk factor for UOR in a healthy patient. Nevertheless, if we assume that UP medialization is a sign of irreversible sinus pathology, we could use it to select patients who would respond to surgical treatment only, forgoing non-beneficial medical treatment. Currently, this is only an idea and needs additional studies.

Our study had some limitations. First, the control group was not recruited in a dental clinic, but from a general hospital radiological database. This meant that there was a lack of uniformity regarding what the dental issues were. Another limitation was that because of the retrospective nature of the study and the characteristic of the control group, it was not possible to collect a complete clinical history of the patients, and consequently adjust the statistical analysis for other risk factors for odontogenic sinusitis, such as smoking, obesity, or diabetes.

Our results point to the fact that in patients with UOR, an antero-medialization of UP is noticeable; however, we cannot say for certain if it is a cause or a consequence of odontogenic focus. We can only speculate that odontogenic disease may be a cause of UP antero-medialization, and this improper deviation may have a role in the progression of odontogenic disease and its spread to other sinuses. We chose to analyze UP deviation in UOR; and therefore, cannot imply that antero-medialization of UP has a pivotal role in all forms of CRS. Additional studies are needed to establish if a UP deviation occurs in every type of CRS and to what extent its deviation plays a direct role in the disease. Although definitive data is absent, our study emphasizes how the evaluation of UP, a fundamental structure of the ostiomeatal complex, is important in the evaluation of especially patients with odontogenic sinusitis.

Ethics Committee Approval: Due to its retrospective nature, the study was granted exemption from the institutional review board of ASST Santi Paolo e Carlo Hospital.

Informed Consent: Informed consent is not necessary due to the retrospective nature of this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Supervision – C.P., G.F., C.D.; Design – L.D.P., A.V., A.M.S., G.F., C.D.; Supervision – C.P., P.L., G.F., C.D.; Resources – G.F., C.D.; Materials – A.V., L.D.P..; Data Collection and/or Processing – A.V., L.D.P.; Analysis and/or Interpretation – A.V., L.D.P., A.M.S., P.L.; Literature Search – L.D.P., A.V., A.M.S., C.P., G.F., C.D..; Writing Manuscript – L.D.P., A.V., A.M.S., A.B., C.P., G.F., C.D.; Critical Review – A.M.S., A.B.

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

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