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Is the anatomical Narrowing Between the Middle Turbinate and Lamina Papyracea as a Risk Factor for Orbital Abscess Formation

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Abstract

Objective

The aim of this study was to investigate whether anatomical narrowing between the middle turbinate and lamina papyracea may predispose patients to orbital abscess formation.

Methods

This retrospective study included 37 pediatric patients diagnosed with orbital abscess secondary to rhinosinusitis. Radiological measurements were obtained from paranasal sinus computed tomography (CT) scans. The distance between the middle turbinate and lamina papyracea was measured on both the abscess side and the contralateral non-abscess side in the same patient.

Results

The middle turbinate–lamina papyracea distance was significantly smaller on the abscess side compared with the contralateral side (8.1 ± 2.2 mm vs 9.6 ± 2.5 mm, p = 0.001). ROC analysis demonstrated a significant association between this anatomical distance and orbital abscess formation (Area Under the Curve (AUC) = 0.293, p = 0.002). A middle turbinate–lamina papyracea distance of approximately 7 mm appeared to represent a clinically relevant threshold for increased risk of orbital abscess formation.

Conclusion

A reduced distance between the middle turbinate and lamina papyracea may represent an anatomical risk factor facilitating the spread of infection from the ethmoid sinus to the orbit. Radiological evaluation of this anatomical relationship may help identify patients at increased risk for orbital abscess formation.

INTRODUCTION

Orbital complications remain among the most serious consequences of acute rhinosinusitis, particularly in pediatric populations [1, 2]. Although the widespread use of antibiotics has reduced their incidence, orbital abscess continues to represent a potentially severe condition that may lead to vision loss or intracranial complications if not recognized and treated promptly [3]. The ethmoid sinuses are most frequently implicated in orbital complications due to their close anatomical relationship with the orbit [4]. The lamina papyracea forms the medial wall of the orbit and represents one of the thinnest bony structures of the craniofacial skeleton. Because of its delicate structure, infection originating from the ethmoid sinus may spread into the orbit through bone erosion, congenital dehiscence, or valveless venous channels [5, 6].Several anatomical variations of the sinonasal cavity have been implicated in the

pathophysiology of sinusitis and its complications [7]. Variations involving the middle turbinate, such as concha bullosa or paradoxical curvature, may alter airflow and impair drainage of the osteomeatal complex [8, 9]. However, the spatial relationship between the middle turbinate and the lamina papyracea has received limited attention in the literature. A narrowed anatomical corridor between these structures may impair ethmoid sinus ventilation and facilitate the spread of infection toward the orbit [10]. Quantitative radiological evaluation of this anatomical relationship may therefore provide additional insight into mechanisms contributing to orbital complications. Computed tomography (CT) remains the primary imaging modality for evaluating sinonasal anatomy and orbital complications of rhinosinusitis [11, 12]. CT imaging provides excellent visualization of bony structures and allows objective measurement of anatomical relationships within the sinonasal cavity. The aim of the present study was to investigate whether anatomical narrowing between the middle turbinate and lamina papyracea represents a risk factor for orbital abscess formation in pediatric patients with rhinosinusitis. Additionally, we sought to determine a radiological cut-off value for this distance that may predict an increased risk of orbital abscess formation.

MATERIALS AND METHODS

Study design and patient population

This retrospective study included patients diagnosed with orbital abscess secondary to acute rhinosinusitis between 2021 and 2025 at a tertiary referral center. The study protocol was approved by the local institutional ethics committee. Patients with available paranasal sinus computed tomography (CT) scans were included. Patients with previous sinonasal surgery, craniofacial anomalies, or inadequate imaging quality were excluded. A total of 37 patients were included in the study. Demographic characteristics including age and sex were recorded.

Radiological measurements

Paranasal sinus CT scans were evaluated on a digital radiological Workstation. The distance between the middle turbinate and lamina papyracea was measured on axial CT sections at the level where the middle turbinate was best visualized. Measurements were obtained on the orbital abscess side and the contralateral non-abscess side. All measurements were recorded in millimeters (mm).

Statistical analysis

Statistical analyses were performed using SPSS software (IBM Corp., Armonk, NY, USA). Normality of the data distribution was assessed using the Shapiro–Wilk test. Because the variables were not normally distributed, non-parametric statistical tests were used. The Wilcoxon signed-rank test was applied to compare measurements between the abscess side and the contralateral non-abscess side. Receiver operating characteristic (ROC) curve analysis was performed to evaluate the diagnostic performance of the middle turbinate–lamina papyracea distance in predicting orbital abscess formation. The optimal

cut-off value was determined according to the best balance between sensitivity and specificity. A p value < 0.05 was considered statistically significant

RESULTS

A total of 37 patients were included. The age range was 2–18 years, with a mean age of 9.1 ± 4.2 year **(**Table 1**)**. The mean middle turbinate–lamina papyracea distance was 8.1 ± 2.2 mm on the abscess side and 9.6 ± 2.5 mm on the contralateral non-abscess side. The difference between the two sides was statistically significant (**p = 0.001** (Table 2**).** ROC analysis demonstrated a statistically significant relationship between the middle turbinate–lamina papyracea distance and orbital abscess formation. The area under the curve (AUC) was 0.293 (95% CI: 0.173–0.413, p = 0.002) **(**Fig. 1**).** The optimal cut-off value was approximately **7** mm, below which the risk of orbital abscess formation increased, with a sensitivity of approximately 70% and a specificity of approximately 80%.

Table 1
Comparison of the Middle Turbinate–Lamina Papyracea Distance Between the Abscess Side and the Non-Abscess Side.

Side	**N**	**Min–Max (mm)**	**Mean ± SD (mm)**	**p**
Abscess side	37	4.53–14.9	8.1 ± 2.2	0.001
Non- Abscess side	37	4.98–16.8	9.6 ± 2.5	
Wilcoxon signed-rank test; p < 0.05 was considered statistically significant. N: number of patients; SD: standard deviation; mm: millimeter.				

Table 2
Demographic Data of the Study Population

Variable	**Value**
Number of patients	37
Age range	2–18 years
Mean age	9.1 ± 4.2
Median age	10
Gender	18 Female / 19 Male
Values are presented as mean ± standard deviation or median (range). Age is expressed in years.	

DISCUSSION

Orbital complications remain among the most serious consequences of acute rhinosinusitis, especially in the pediatric age group, in whom the ethmoid sinuses are frequently implicated because of their close anatomical relationship with the orbit. Large clinical series and reviews have consistently shown that

orbital involvement represents a substantial proportion of severe sinusitis-related complications in children and may progress to subperiosteal abscess, orbital abscess, visual compromise, and even intracranial extension if diagnosis or treatment is delayed [1, 4]. The relatively young age of affected patients in many published series also supports the concept that pediatric anatomy may be particularly permissive for spread of infection from the ethmoid compartment into the orbit [1, 2]. The anatomical basis for this pattern is well established. The lamina papyracea forms the medial orbital wall and is one of the thinnest bony partitions in the craniofacial skeleton. Because of this delicate barrier, inflammatory disease arising from the ethmoid sinus may extend into the orbit through direct bony erosion, congenital or acquired dehiscence, or thrombophlebitic spread through valveless venous channels [3, 5, 6]. This classic concept has been emphasized for decades and remains central to current radiologic and otolaryngologic understanding of orbital complications of rhinosinusitis. In practical terms, any local anatomical feature that increases inflammatory load within the ethmoid labyrinth or decreases the effective separation between sinonasal and orbital compartments may reasonably increase the likelihood of orbital spread. A major strength of the present study is that it moves beyond a simple description of orbital abscess and focuses on a specific, measurable anatomical relationship: the distance between the middle turbinate and lamina papyracea. Although prior work has examined sinonasal anatomic variants such as concha bullosa, paradoxical middle turbinate, septal deviation, agger nasi cells, Haller cells, and osteomeatal complex obstruction, the exact middle turbinate–lamina papyracea interval itself has received little direct attention as a quantitative risk marker for orbital abscess formation [7–11]. This makes our study not merely confirmatory, but hypothesis-generating in a relatively underexplored anatomical domain. The relationship between sinonasal anatomy and inflammatory disease, however, is complex. Classic CT studies by Bolger and Earwaker demonstrated that anatomic variants are common, often coexist, and do not by themselves establish disease causation [7, 8]. That point is important and should be acknowledged clearly the presence of an anatomic variant is not equivalent to pathology. Nevertheless, those same studies also showed that combinations of septal, middle turbinate, and anterior ethmoid-region variations may create recognizable obstructive patterns affecting drainage pathways. In other words, anatomy may not be deterministic, but it can still be permissive or predisposing. Our findings fit well within this framework we are not claiming that a reduced middle turbinate–lamina papyracea distance independently causes orbital abscess, but rather that this narrowing may create a local anatomical environment that facilitates impaired ventilation, secretion stasis, and eventual extension of infection toward the orbit. This interpretation is further supported by pediatric literature specifically addressing orbital complications. Çelik et al. evaluated children with acute rhinosinusitis-related orbital complications and demonstrated significant side-to-side differences in Lund–Mackay scores and osteomeatal complex obstruction, with higher rates of some adjacent anatomical findings such as lower turbinate hypertrophy and agger nasi cells on the complicated side [9]. Their results support the broader concept that local anatomic variability in structures neighboring the drainage pathways can influence where complications occur. Our study extends that concept by suggesting that narrowing of the middle turbinate–lamina papyracea corridor may represent another such local factor, particularly relevant to ethmoid-related orbital spread. The potential pathophysiologic mechanism deserves emphasis. A reduced distance between the middle

turbinate and lamina papyracea may reflect a relatively crowded lateral nasal wall and ethmoid interface. Such crowding may alter airflow and mucociliary clearance, narrow the functional drainage space adjacent to the middle meatus, and promote retention of inflammatory secretions within the anterior ethmoid region. Once inflammatory pressure and bacterial burden increase in this compartment, the orbit becomes vulnerable because the medial orbital wall is both thin and anatomically contiguous with the diseased ethmoid cells. Thus, in susceptible patients, orbital abscess may be understood not simply as a microbiologic event, but as the result of infection occurring within an anatomically unfavorable corridor. This concept is concordant with broader literature linking middle turbinate and osteomeatal complex variations to altered drainage physiology, even when associations with sinusitis are not uniform across all studies [7, 8, 10, 11]. Another point strengthening our interpretation is that we compared the abscess side with the contralateral non-abscess side within the same patient. This design reduces the confounding effect of many interindividual variables, including age, systemic inflammatory response, and general craniofacial size. In our cohort, the mean middle turbinate–lamina papyracea distance was significantly smaller on the abscess side than on the non-abscess side supporting the idea that the relevant risk signal is local and side-specific rather than merely patient-specific. In our study, the raw area under the curve (AUC) appeared paradoxically low at first glance. However, this reflects the inverse direction of the variable, as smaller distances were associated with a greater risk of orbital abscess. In our cohort, a middle turbinate–lamina papyracea distance of approximately 7 mm appeared to represent a clinically relevant threshold for increased risk of orbital abscess formation. Therefore, a middle turbinate–lamina papyracea distance below about 7 mm may be considered a radiologic marker of increased orbital abscess risk. This interpretation is an inference from your ROC coordinate table and should be reported as approximate. From a clinical standpoint, the implication is not that every child with a narrow distance will develop an orbital abscess, nor that this measurement should replace established clinical and radiologic assessment. Rather, this parameter may help refine risk stratification. In a child with acute rhinosinusitis and early orbital findings, the presence of a markedly reduced middle turbinate–lamina papyracea distance may alert the clinician to a more permissive local anatomy for orbital extension. This may be particularly useful when interpreted together with disease burden, side-specific ethmoid involvement, osteomeatal complex obstruction, and other anatomical findings. Prior radiographic work has similarly suggested that structural factors such as lamina papyracea dehiscence may correlate with more severe clinical courses or greater need for intervention [12]. Our findings should also be interpreted in the context of the broader sinonasal anatomy literature. Some studies have found weak or inconsistent relationships between isolated anatomical variants and sinusitis, whereas others have emphasized that disease risk may be driven more by the cumulative effect of adjacent narrowing, drainage pathway compromise, and local inflammatory burden than by any single named variant [7–11]. This is exactly why the present measurement may be useful: rather than labeling a categorical variant, it captures the functional spatial relationship between two key structures bordering the ethmoid–orbital interface. In that sense, the middle turbinate–lamina papyracea distance may be more directly relevant to local crowding than simply documenting whether concha bullosa or paradoxical curvature is present. This study has limitations. Its retrospective design and relatively small sample size limit generalizability. In addition, the measurement was performed on CT at the level where the middle turbinate was best

visualized, which is practical but may still be influenced by slice selection and individual anatomical asymmetry. The ROC-derived cut-off should therefore be viewed as preliminary rather than definitive. Nonetheless, the paired side-to-side design, statistically significant difference between abscess and non-abscess sides, and biologically plausible anatomical rationale all support the validity of the main observation.

Conclusion

The present findings support the hypothesis that anatomical narrowing between the middle turbinate and lamina papyracea may contribute to orbital abscess formation by creating a crowded, less favorable drainage environment adjacent to the ethmoid sinus and the medial orbital wall. Our results are in line with the broader literature showing that local sinonasal anatomy influences the pattern and severity of orbital complications, while also offering a more specific and quantifiable parameter that may be incorporated into future radiologic risk assessment model.

Abbreviations

CT
Computed tomography
ROC
Receiver operating characteristic
AUC
Area under the curve
SD
Standard deviation.

Declarations

Compliance with Ethical Standards

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

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Başakşehir Çam and Sakura City Hospital (Approval No: KAEK-11/10.09.2025.337). Due to the retrospective nature of the study, the requirement for informed consent was waived by the ethics committee.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing Interests

The authors declare that they have no competing interests.

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Authors' contributions

A.B. conceived and designed the study. A.B. and B.G. collected the data. E.E. performed radiological evaluations. A.B. and O.C. performed the statistical analysis. A.B. drafted the manuscript. O.Ö. critically revised the manuscript. All authors read and approved the final manuscript.

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Not applicable.

Ethical Approval:
This study was conducted in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments. Ethical approval was obtained from the Institutional Review Board of Başakşehir Çam and Sakura City Hospital (Approval No:28, Date: 07.01.2026).

Informed Consent:
Written informed consent was obtained from all individual participants included in the study.

Clinical Trial Number: Not applicable.

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Figures

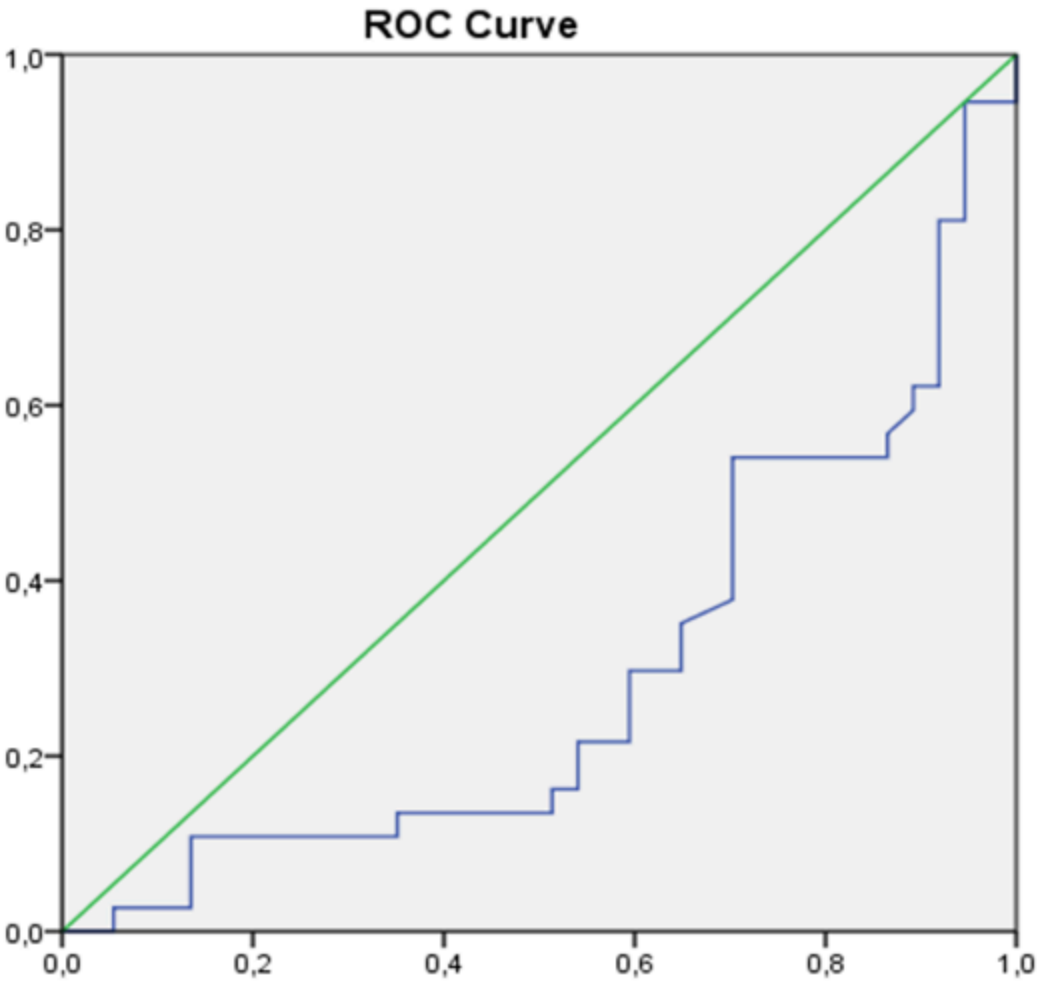


Figure 1

Receiver operating characteristic (ROC) curve demonstrating the diagnostic performance of the middle turbinate–lamina papyracea distance for predicting orbital abscess formation. The area under the curve (AUC) was 0.293 (95% CI: 0.173–0.413, p = 0.002).