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SPECTRUM OF PARANASAL SINUS AND NASOLACRIMAL DRAINAGE SYSTEM LESIONS DIAGNOSED ON ROUTINE COMPUTED TOMOGRAPHY SCANNING OF THE BRAIN AND THEIR CLINICAL IMPLICATIONS

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ABSTRACT

Background: Paranasal sinus and nasolacrimal drainage system lesions are rarely diagnosed using routine brain computed tomography (CT) evaluations. Detecting random findings can be associated clinically with different levels of headache or vague symptoms, whereas brain CT results do not show abnormalities or other intracranial lesions. This study evaluated incidental lesions of the paranasal sinuses and nasolacrimal system detected on routine brain computed tomography scans. Further, the study aims to identify and categorize these lesions, analyze their radiological findings, and assess their clinical relevance.

Materials and Methods: Research data were retrospectively collected from 26 patients (16 males and 10 females) aged 4–74 years to detect incidental findings within the paranasal sinus and nasolacrimal duct regions on routine brain CT exams.

Results: Radiological findings in the paranasal sinus and nasolacrimal duct region on a routine computed tomography scan of the brain were documented in this study. A total of two cases presented with acute sinusitis, while multiple cases had chronic rhinosinusitis along with deviated nasal septum (n=3); four cases had sinonasal polyposis, n=15 cases showed sinus mucosal thickening, and one case displayed pansinusitis. The additional detectable findings included hyperdense foci in the maxillary sinus, bony nasal spurs affecting two patients, and one case of atrophic rhinitis. Nasomaxillary sutural diastasis as a result of trauma. Rare anomalies, including reversed middle turbinate and molar root protrusion into the maxillary sinus floor (n=3), maxillary sinus hypoplasia, and persistent nasopalatine canal, were observed during the examination. The evaluation of duct patency and surrounding soft tissue structures proved useful for diagnosis, as shown in one patient with nasolacrimal duct obstruction.

Conclusion: Brain CT scans done for medical indications often incidentally detect significant radiological findings in the paranasal sinuses and nasolacrimal structures. Comprehensive evaluation of these regions supports better diagnosis while influencing surgical strategy and helps identify additional study requirements.

Keywords: Computed tomography, paranasal sinuses, nasolacrimal drainage system, lesion.

INTRODUCTION

The paranasal sinuses (PNS) and nasolacrimal drainage system are in close proximity to the anterior cranial fossa, orbit, and upper aerodigestive tract and exist anatomically and functionally as important structures.[1] Four distinct paranasal sinuses exist in the skull and facial bones, including the maxillary, ethmoidal, frontal, and sphenoidal sinuses, to maintain their structure as air-filled cavities.[2] The nasal mucosa develops into these cavities embryologically through invagination before their complete growth finishes during early adulthood.[3] The nasolacrimal drainage system consists of three parts: the nasolacrimal duct, canaliculi, and lacrimal sac, draining tears from the eye surface into the nasal cavity. The treatment pathway for tears becomes compromised when there is an obstruction or inflammatory disease in this system, thus affecting drainage performance with repeated infections and epiphora manifestation.[4] In this scenario, computed tomography (CT) imaging procedure provides more than mere mucosal and opacity assessment to assess bone destruction, anatomical features, and pathology extension to nearby spaces, including orbits and cranial cavities.[5]

CT imaging is a fundamental tool for brain pathology analysis because it obtains fast data acquisition while providing high-resolution images showing clear bone features. CT scans, which include paranasal sinuses and their surrounding structures, can detect various abnormal findings during examinations. The PNS appears on normal CT brain examinations as a secondary target of imaging.[6] CT brain scans often reveal incidental findings of both sinus and nasolacrimal system abnormalities. CT brain images detect various extracranial findings, from regular tissue swelling and fluid-filled cysts to dangerous conditions, including fungal attacks and bone injuries.[7] Such lesions appear at different frequencies and present across various ranges, depending on patient age, immune condition, and exposure variables.[8]

Among all CT incidental findings, sinusitis was the most frequently discovered diagnosis for acute and chronic conditions. Chronic rhinosinusitis exists as an entity that produces persistent thickened mucosa and obstructed sinuses or polyp formation exceeding a 12-week duration, yet frequently shows no manifestations besides facial discomfort, smell loss, and head pain.[9] Mucous retention cysts often appear on CT imaging as dome-shaped, well-defined opacities that develop in the sinus floor.[10] Most mucous retention cysts do not show symptoms, but they are rarely distinguished from cancer-like conditions.[10]

Fungal sinusitis affects immunocompromised patients and causes severe health consequences, which lead to death.[11] CT imaging for allergic fungal sinusitis can show hyperdense foci in the sinus, whereas invasive fungal sinusitis reveals bone erosion with further orbital and intracranial spread.[11] Therefore, a brain imaging examination is a life-saving procedure. It makes it possible to detect fungal infections in asymptomatic patients or those who undergo CT scans for other reasons.[12]

During an asymptomatic condition, nasal tumors are rarely reported. Still, they must be evaluated, especially when the patients have solitary sinus fillings, bone destruction, or substantial tissue masses in the same area.[13,14] Squamous cell carcinoma, adenocarcinoma, and esthesioneuroblastoma initiate development within the nasal cavity or ethmoid sinuses before spreading to orbital areas and the anterior cranial fossa.[15] CT proves essential during the stages of initial detection as well as staging and surgical treatment planning.[5,10,13] Both osteomas and inverted papillomas present diagnostic and therapeutic challenges because they tend to invade locally and recur.

Routine brain CT images minimally visualize the nasolacrimal drainage system, but it is partially visible during coronal and sagittal reconstructions. Nasolacrimal duct obstruction (NLDO) develops with natural causes and is a result of trauma, inflammation, cancerous cells, or congenital disabilities.[16] CT imaging of NLDO shows one of three findings, including dilation of the lacrimal sac and increased density of the nasolacrimal duct, while sometimes displaying soft tissue alterations.[17] Accidental detection of such features leads to ophthalmological evaluation; health care providers can intervene before complications develop into dacryocystitis or orbital cellulitis.

Anatomical variants of the paranasal sinuses and nasal cavity, including concha bullosa alongside Haller cells and deviated nasal septum, affect sinus drainage and ventilation, increasing susceptibility to sinusitis.[18] Functional endoscopic sinus surgery (FESS) and orbital procedures require knowledge of anatomical variants because these variations frequently remain symptomless. Therefore, it is necessary to recognize these pathologies in neurology, otolaryngology, ophthalmology, and emergency medicine. Imaging studies can prevent misdiagnosis in such cases because atypical facial pain and headaches typically indicate sinus diseases. CT may reveal an occult anatomical cause of unexplained epiphora and recurrent periocular infection.

The investigation analyzes incidental paranasal sinus and nasolacrimal drainage system lesions detected during brain CT examinations performed for non-rhinologic causes. This research methodically investigates incidental findings to emphasize the need for a comprehensive imaging evaluation of all included body structures, regardless of the initial reason for patient selection. This investigation defines lesion occurrences and their varieties while showing connections to possible medical repercussions and establishing a vital gap in

typical diagnostic imaging approaches. Therefore, this study has three main research objectives: (1) to evaluate and describe incidental paranasal sinuses and nasolacrimal system lesions during routine brain CT examinations; (2) to discuss the radiological aspects of these findings; and (3) to examine the implications regarding patient care management.

MATERIALS AND METHODS

This retrospective observational study was conducted between 2023 and 2024 in the radiology department of a secondary care hospital serving a diverse population from semi-urban, rural, and industrial areas. The study included patients from both the outpatient and inpatient departments. The study examined paranasal sinus and nasolacrimal drainage system findings that were seen on the routine CT scan of the brain. A general radiologist reviewed all brain CT images that included facial regions.

Patient Selection: The current study analyzed 26 patients who underwent CT brain scan for neurological examination and produced additional findings in their paranasal cavity and nasolacrimal space. The patient population comprised individuals aged 4–74 years. Among the patient population, there were 16 males and 10 females. In this study, symptoms related to the ENT or eyes were either absent or vague in the patients.

Imaging Technique: A non-contrast CT brain scan was performed on a multidetector-row computed tomography (MDCT) scanner. Helical data were acquired and post-processing was performed, followed by multiplanar reconstruction (MPR) in the coronal and sagittal planes to enhance visualization of the brain as well as PNS and orbital anatomy. The PACS (Picture Archiving and Communication System) was used for archiving and reporting these studies. Research shows MDCT demonstrates excellent spatial resolution for detailed analysis of bony anatomy and air-fluid levels; therefore, it is widely applied for paranasal sinus and orbital studies.[19]

Data Analysis: Computed tomographic scan images were evaluated for brain abnormalities, with an additional focus on identifying abnormalities in the paranasal sinuses and nasolacrimal drainage system. The general radiologist evaluated each lesion for its anatomical position, structural form, tissue density, and any related morphological changes. The study grouped the diagnoses as shown in Table 1and 2. The patency of the nasolacrimal ducts was evaluated along with the type of content present-air, fluid, or fat. A thorough analysis was then performed to identify any changes in fat tissue attenuation in the perilacrimal sac region or signs of lacrimal dysfunction. In cases with atypical imaging characteristics, differential diagnosis was considered.

Ethical Considerations: This retrospective study received ethical approval from the hospital's institutional review board. Because the study was retrospective in design, patient consent was not required, but ethical approval was needed. The anonymization of images and data occurred according to the Helsinki Declaration standards and data protection laws. To ensure confidentiality, all patient identifiers were excluded from the analysis.

RESULTS

Patient Demographics: Twenty-six patients were included in this study. The study sample included 16 males and 10 females aged 4–74 years. Imaging analysis revealed various unnoticed abnormalities that simultaneously affected paranasal sinus structures and nasolacrimal duct system elements.

Paranasal Sinus Abnormalities: The paranasal sinus region showed evidence of multiple and varied lesions on CT brain study. The two patients were diagnosed with acute sinusitis based on the presence of air-fluid levels and mucosal thickening.

Chronic rhinosinusitis was more prevalent in the patients studied. Among these patients, three exhibited a deviated nasal septum (n=3), while four presented with sinonasal polyposis (n=4; specifically, three involved the maxillary sinuses, and one was localized to the nasal cavity), as shown in Figure 2. Mucosal thickening was observed in one or more sinuses of 15 patients (n=15), and pansinusitis was identified in one of these patients.

In one patient, the presence of hyperdense foci within the maxillary sinus could be attributed to the accumulation of thick, moist secretions or possibly secondary fungal infection. Bony nasal spurs were observed in two patients. One case of atrophic rhinitis was identified, and it was characterized by marked atrophy and bony resorption of the superior, middle, and inferior turbinates on CT scan. Research studies have confirmed that incidental analyses of nasal cavity and sinus structures on brain scans frequently reveal mucosal diseases and septal deviations.[20,21]

In one patient with a history of trauma, nasomaxillary sutural diastasis was identified, and 3D CT reconstruction confirmed the widening of the suture. In addition, one case of reversed middle nasal turbinate was identified, and three patients exhibited molar roots extending into the maxillary sinus floor. Individual cases of maxillary sinus hypoplasia and persistent nasopalatine canal were also observed. Rare anatomical deviations like middle turbinate abnormalities, that limit endoscopic visualization carry clinical significance and must be considered before performing endoscopic sinus surgeries.[22] These cases are listed in Table 1.

Various lesions of the nasolacrimal duct system are presented in Table 2. Six cases of lacrimal sac lesions were observed, including two cases of

unilateral traumatic lacrimal sac tears, two cases of unilateral air within the lacrimal sac, and one case in which air adjacent to the lacrimal sac was included in the differential diagnosis. One case of air in the left lacrimal sac was associated with a recent history of trauma, while two additional cases were related to lacrimal sac dysfunction. An additional case involved air in the subcutaneous region adjacent to the right lacrimal sac, with an associated fracture line extending into the lamina papyracea, prompting consideration in the differential diagnosis. Normal variations and lesions affecting nasolacrimal duct patency are detailed in Table 2. Normal variations included nasolacrimal ducts that were either air-filled or fluid-filled. However, two cases of unilateral fat-filled nasolacrimal ducts were observed, which were attributed to orbital fat herniation following regional trauma. Fat attenuation in the medial peri-lacrimal sac region was preserved in all 26 patients.

Table 1: Summary of Paranasal Sinus Lesions

Paranasal sinus region		Diagnosis	Ct scan findings	No cases were observed
1.	Sinusitis	Acute sinusitis		2
		Chronic rhinosinusitis	a)DNS	3
			b)Polyposis	4
			--within sinuses	3
			--isolated nasal cavity region	1
			c) Hyperdense foci within the maxillary sinus	1
			d)bony nasal spur	2
			e)mucosal thickening in sinuses	15
			f) pansinusitis	1
			g) Atrophic rhinitis	1
2.	Trauma	Nasomaxillary sutural diastasis	Diastasis of the nasomaxillary suture on 3D reconstruction	1
3.	Congenital	reversed middle nasal turbinate	Paradoxical middle turbinate is seen bilaterally on CT study.	1
		molar tooth projecting into the floor of the maxillary sinus	molar roots protruding into the maxillary sinus	3
		hypoplasia of the maxillary sinus	Mild hypoplasia, normal uncinate process, and well-developed infundibulum	1
		persistent nasopalatine canal	-Single opening(Foramina of Stenson) seen at nasal fossa -A canal connecting the incisive foramen (located in midline in the hard palate) to the nasal cavity.	2

Table 2: Table 2: Lesions investigated in nasolacrimal duct system region

Nasolacrimal duct system lesions	Diagnosis	Ct findings and the underlying etiology	Cases
1)Lacrimal sac lesions	lacrimal sac tear	lacrimal sac tear due to trauma	2
	Air-filled lacrimal sac	Air in the lacrimal sac due to trauma	1
		Air in the lacrimal sac due to lacrimal sac dysfunction	2
		Presence of subcutaneous air adjacent to lacrimal sac(differential diagnosis)	1
2)Normal variation	Patency of nasolacrimal duct(normal status)	air-filled nasolacrimal duct	33
	Patency of nasolacrimal duct (normal status)	fluid-filled nasolacrimal duct	11
3) Abnormal nasolacrimal duct	Patency of nasolacrimal duct-Traumatic status	fat-filled nasolacrimal duct	2
4)Fat attenuation in the medial peri-lacrimal sac region	Normal fat attenuation	Normal fat attenuation with no fat stranding or fluid attenuation	26

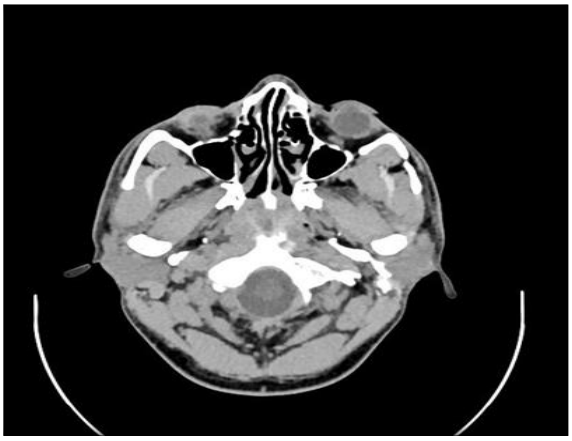

Figure 1: Axial image of the skull vault at the level of the skull base showing the presence of air in the left lacrimal sac

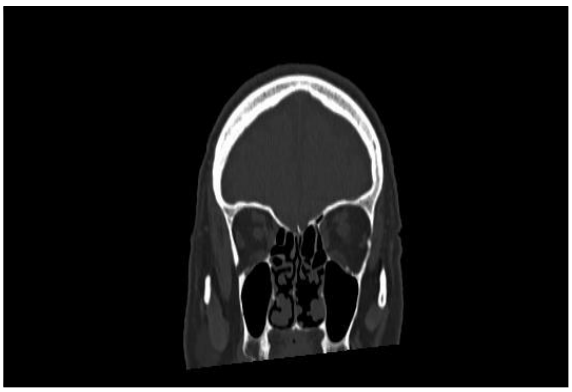

Figure 2: Coronal reconstruction of the skull vault showing polyposis in the bilateral nasal cavities

DISCUSSION

The recognition of essential anatomical and functional characteristics from the nasolacrimal duct system is vital for diagnosing and treating lacrimal disorders linked to traumatic incidents or variations in human structure. Furthermore, the current study showed nasolacrimal and paranasal sinus abnormalities that appeared incidentally during routine brain CT scans for neurological indications. Furthermore, cross-sectional imaging is an excellent diagnostic tool for identifying otherwise unperceived important pathology.

Nasolacrimal Duct System and Trauma

It has previously been shown that the region accommodating the nasolacrimal duct exhibits distinctive weakness because it can sustain traumatic injuries that produce both air-filled lacrimal sacs and subcutaneous air next to the lacrimal sac, as shown in this study. Multiple clinical studies have reported that facial trauma, especially when involving lamina papyracea fractures, directly causes damage to the lacrimal drainage system.[23,24] Patent Duct as well as both partial and complete ductal obstructions, were also detected. The recorded incidence matches earlier evidence, which showed that NLD dysfunction might exist below detectable levels as an active pathologic process.

Fat Attenuation and Lacrimal Function: The current study showed that medial periorbital fat attenuation maintained its normal CT attenuation in all cases examined with CT imaging. The fat around the lacrimal sac provides protection and support to the lacrimal drainage system,[25] and facilitates tear drainage and support during lacrimal drainage operations. Fat preservation indicates the absence of tissue inflammation that threatens ductal drainage function. Previous studies have confirmed that orbital fat acts as a vital structure for maintaining the proper functionality of the nasolacrimal system.

Functional Implications of Paranasal Sinus Abnormalities: Current Research shows that milder forms of paranasal sinus lesions are seen predominantly in the form of chronic rhinosinusitis and rarely more severe lesions to congenital lesions are noted. In a large previous study revealed a high frequency of reported radiologic abnormalities in paranasal sinuses in asymptomatic patients.[26] Therefore ,in asymptomatic patients should be clinically correlated with radiological findings of intracranial abnormality with additional abnormalities in extracranial regions like paranasal sinuses.This study provides additional knowledge about the link between evaluation of routine brain imaging and additional assessment of paranasal sinuses and nasolacrimal duct system. Furthermore, the findings confirms that CT technology could help identify structural and functional issues at early stages

Clinical Relevance and Diagnostic Implications: Medical practitioners should evaluate the nasolacrimal drainage system and paranasal sinuses during brain computed tomography (CT) examinations for all cases. An in-depth evaluation of the nasolacrimal drainage system and the paranasal sinuses is crucial because of the complex anatomy of the sinuses, which are near common structures that are affected by traumatic injuries.[27, 28]

In addition, a new protocol will be implemented to provide early diagnosis and direct intervention. Research findings validate the recommendation to establish teamwork between radiologists, ophthalmologists, and ENT specialists to evaluate and treat these lesions.

Future Directions: A detailed study of the relationship between fat attenuation changes in the peri-lacrimal sac region and tear duct function needs indepth research on a large sample representation using advanced imaging. The development of dual-energy CT and MRI with dacryocystographic imaging studies provides detailed insights into tissue composition and pathology, leading to better evaluation of obstructive pathology and subtle fat attenuation differentiation.[29,30] Two diagnostic tools, along with data from this research, could enhance both diagnostic methods and patient results.

CONCLUSION

The current study showed that routine brain CT scans detect incidental nasolacrimal and paranasal lesions. Additionally, computed tomographic imaging is valuable for revealing subtle traumatic and congenital abnormalities that might otherwise go undiagnosed. Normal nasolacrimal duct patency and preserved fat tissue attenuation in the peri-lacrimal sac region support the diagnostic value of soft tissue markers during CT imaging evaluations. This research contributes valuable knowledge about the structures and diseases of the paranasal sinuses and lacrimal system, supporting improved medical diagnosis, interdisciplinary care, and ongoing research for enhanced patient outcomes.

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