Original Article

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Computed Tomography Study of Paranasal Sinuses Pathologies

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Abstract

Introduction: The application of computed tomography (CT) in the paranasal sinuses study has allowed the detail assessment of inflammation, cysts, benign, and malignant conditions. CT has increased the accuracy of patient management with a consequent decrease in morbidity and mortality. The purpose of this study is to determine the role and efficacy of CT scan in diseases of the paranasal sinus. This was the cross-sectional prospective study of 1½ years duration.

Aims and Objective: To evaluate the various pathologies affecting the paranasal sinuses on CT and study various physiological variants.

Materials and Methods: This was cross-sectional prospective study conducted at RKDF Medical College from June 2014 to December 2015. A total of 110 patients of varied age group presenting with symptoms and signs of paranasal sinus diseases were included in the study. Imaging diagnosis was confirmed either by histopathology or by positive response to treatment.

Results: In our study, paranasal sinuses pathologies were more common in male (62%) compare to female population (33%). Most common age group affected by the paranasal sinuses pathologies was 11-30 years age group (45.5%) and least common age group was less than 10 years (<2%). The most common paranasal sinuses pathologies in our study were inflammatory (60%) followed by neoplastic (33%) and miscellaneous (7%). Most commonly affected paranasal sinuses in descending order were maxillary (86%), ethmoidal (54%), frontal (31%), and sphenoidal (21%). Common anatomical variants observed in our study were deviated nasal septum (40%), concha bullosa (43%), agar nasi cells (59%), Haller cells (16%), and Onodi cells (31%).

Conclusion: CT scan depicts both soft tissue and bony details of nose and paranasal sinuses thereby accurately detect various pathologies affecting the paranasal sinuses. Various important anatomical variants can be easily detected on CT of paranasal sinuses.

Key words: Computed tomography, Histopathological diagnosis, Paranasal sinuses

INTRODUCTION

The head and neck radiology, similar to that of other subspecialties in radiology, began with the discovery of the X-ray in 1895 by Wilhelm Konrad Roentgen (1845-1923). Another early investigator was Caldwell (1870-1918), who became fascinated by X-rays only 2 years after Roentgen's discovery. In 1903, he wrote one of the first textbooks on diagnostic and therapeutic radiology. His interest in head and neck radiology is reflected by a view of the paranasal sinuses that still bears his name, "the Caldwell view," which is a depiction of the ethmoid and frontal sinuses that include both orbits. In 1914, Waters and Waldron, two British radiologists, introduced a projection that defined the paranasal sinuses and facial bones to greater advantage. At the present time, the waters view is still being used to survey sinus disease and facial fractures.

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An important historic achievement occurred in 1972 with the introduction of computed tomography (CT) by Godfrey Hounsfield of Great Britain. The foundation for CT was based on mathematic equations that had been formulated in 1963 and 1964 by Cormack, a Professor of Physics at Tufts University in Boston. The development of spiral CT in the past few years has allowed a shorter examination time and thinner sections, with the capability of three-dimensional reconstruction. Most recently, multi-detector row CT with increased spatial resolution, with

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a section thickness as small as 0.5 mm and acquisition capabilities of 16 images per second, has been developed.

Diseases of paranasal sinuses are a major health problem. Most of the times physical examination is nonspecific and radiological evaluation has been relied on as an aid in confirming the diagnosis. Traditionally, plain radiographs were the modality of choice in the evaluation of paranasal sinuses. In recent years, because of technologic advancements in imaging, CT has supplanted conventional radiography as the primary diagnostic modality and has also contributed in the change in therapeutic approach. Standard plain radiographs still have a limited role in the imaging of the paranasal sinuses and are used as the initial technique before the application of CT. The refinement of CT technology has resolved the traditionally difficult problem of identifying lesions of the paranasal sinuses. It has also allowed improved accuracy in evaluating the soft tissues about the sinuses. The improvement in tissue resolution that CT offers over plain films allows evaluation of subtle changes of soft tissues, bones and air containing spaces. The ability of CT to image the bony details as well as soft tissues is the greatest advantage over previous radiographic modalities. Furthermore, coronal and axial CT scanning has dramatically improved the imaging of the anatomy of the paranasal sinus. CT excellently displays the bony architecture and its mucosal covering as well as the narrow air channels of the osteomeatal complex. CT accurately depicts the boundaries between the paranasal sinuses, the orbit and the intracranial compartment and also the relationship between the optic nerve, cavernous sinus, carotid artery and fifth cranial and vidian nerves to the sphenoid sinuses. Contrast media helps evaluate the vascularity and contrast enhancing characteristics of lesions, giving clues to the histology and extent of abnormality.

The aims and objective of this study is to determine the role and efficacy of CT scan in diseases of paranasal sinus and study of various physiological variants.

MATERIALS AND METHODS

The present prospective study was conducted at RKDF Medical College from June 2014 to December 2015.

Study Area

The study area includes Bhopal city and district with peripheral small towns/villages.

Study Population

A total of 110 patients of varied age group presenting with symptoms and signs of paranasal sinus diseases were included in the study.

Inclusion Criteria

- Patients referred for CT of paranasal sinuses, who were suspected to have paranasal sinus disease.
- Patients who were suspected to have some paranasal sinus pathology on conventional radiographs and were then referred for CT of paranasal sinuses.

Exclusion Criteria

- Patients presenting with trauma to face
- Patients with contrast allergy
- Patients who were lost to follow-up without a definite diagnosis.

Equipment used

Spiral CT, Siemens Somatom, Siemens Medical Systems, Forchiem, Germany.

CT scan of paranasal sinuses (PNS) requires imaging of the anatomy into coronal and axial planes. A lateral 256 mm scout scan was first obtained at 120 kVp and 100 mA. Routinely axial scanning was done in supine position. Reformatting in coronal and sagittal planes was done using software provided.

Direct coronal imaging was done whenever deemed necessary either by referring physician or by the radiologist. For direct coronal imaging, the patient was kept in prone position or in supine position with the head of the patient free leading edge of the table of the scanner. The gantry angle used in case of coronal imaging was perpendicular to the plane of hard palate. 3 mm sections from anterior margin of nose to the posterior margin of sphenoid sinus were taken.

Final imaging diagnosis correlated with histopathological confirmation or treatment response.

OBSERVATIONS AND RESULTS

CT scan was performed in 110 patients who presented with history, symptoms, and signs of the paranasal sinuses pathologies. The results are enumerated in Tables 1-8.

DISCUSSION

The varied etiology of the diseases of PNS forms the basis of their evaluation. The lack of specificity in clinical examination and the imprecise result of conventional radiography render CT as the modality of choice other than magnetic resonance imaging.

In the present study, 110 patients were evaluated for their various symptoms pertaining to PNS. The gender ratio in this study was 2.05:1 (male:female) (Table 1).

Table 1: Gender distribution

Gender	*N* (%)
Female	36 (32.73)
Male	74 (67.27)
Grand total	110 (100)

Table 2: Age and gender distribution

Age distribution	Female	Male	Total
1-10	1	1	2
11-20	6	19	25
21-30	6	19	25
31-40	8	10	18
41-50	6	10	16
51-80	9	15	24
Grand total	36	74	110

Table 3: Etiopathological distribution of case

Etiology	Female	Male	Total	Percentage
Inflammatory	21	45	66	60
Sinusitis	14	26	40	
Polyposis	6	12	18	
Other	1	6	7	
Neoplastic	12	24	36	32.7
Miscellaneous	3	5	8	7.3
Grand total	36	74	110	100

Table 4: Age distribution of pathologies

Age range	Inflammatory	Neoplastic			Miscellaneous
		Benign	Malignant	Total	
1-10	0	0	1	1	1
11-20	14	5	3	8	3
21-30	19	3	0	3	3
31-40	13	1	4	5	0
41-50	8	2	6	8	0
51-80	12	1	10	11	1
Grand Total	66	12	24	36	8

Table 5: Various sinuses involved

Sinus involved	*N* (%)
Maxillary	95 (86.36)
Ethmoidal	59 (53.63)
Frontal	34 (30.9)
Sphenoids	23 (20.9)

Table 6: Sinuses involved in various pathologies

Sinus involved	Inflammatory	Neoplastic			Miscellaneous
		Benign	Malignant	Total	
Maxillary	59	6	23	29	7
Ethmoidal	33	8	16	24	2
Frontal	21	4	7	11	2
Sphenoids	10	5	6	11	2

Table 7: CT features of benign and malignant neoplasms

CT parameter	Benign (*n*=12) (%)	Malignant (*n*=24) (%)
Sinus size increased	8 (66.6)	14 (58.3)
Erosions	7 (58.3)	24 (100)
Thinning	2 (16.6)	5 (20.8)
Sclerosis	1 (8.3)	1 (4.1)
Extensions in at least one region	4 (33.3)	23 (95.8)

CT: Computed tomography

Table 8: Anatomical variants

Anatomical variant	Total (%)
DNS	44 (40)
Concha bullosa	48 (43.6)
Agger nasi	65 (59.1)
Haller cells	18 (16.3)
Onodi cells	34 (30.9)
EEB	9 (8.2)
PMT	15 (13.6)
DUP	12 (10.9)
PUP	4 (3.6)

DNS: Deviated nasal septum, EEB: Enlarged ethmoid bulla, PMT: Paradoxical middle turbinate, DUP: Deviated uncinate process, PUP: Pneumatized uncinate process

The etiologic distribution of the lesions was inflammatory (60%), neoplastic (32.7%), and miscellaneous (7.3%). Thus, the inflammatory disease was found to be the most frequently occurring pathology affecting the PNS. The incidence of neoplasms increases sharply after age of 40 years (Table 4). There is another peak in teen age due to increase in incidence of angiofibroma and rhabdomyosarcoma at this age.

Acute sinusitis was diagnosed when there was air fluid level, enhancing mucosal thickening. Chronic sinusitis showed decrease in sinus size with sclerosis and thickening of the walls. Considering the inflammatory etiology of the various sinuses, the following was the percentage affection of individual sinuses. Maxillary (89.4%), frontal (31.8%), sphenoids (15.2%), ethmoidal (50%). Thus, maxillary sinus was most commonly involved and sphenoid sinus was least involved in inflammatory conditions. In the study conducted by Smith and Brindley,[1] maxillary sinus was involved in 55.5% of cases, ethmoidal air cells were involved in 46.5% of cases, frontal sinus in 30%, and sphenoid in 20%. Similarly, Maru and Gupta[2] reported maxillary sinus to be the most frequently involved sinus in inflammatory lesions (70.4%) followed by ethmoids (52.4%), frontal (48.3%), and sphenoid sinuses (40.8%). Zinreich *et al.*[3] published in his study that the maxillary sinus involvement was the most frequent in inflammatory lesions, i.e., 65% followed by ethmoid cells 40%, frontal sinus in

34%, and sphenoid sinus in 29% of cases. Kopp *et al.*[4] in his study of 105 cases of aspergillosis of paranasal sinuses or nasal fossa detected the characteristic CT features of foci of increased attenuation in affected paranasal sinuses. He also found that mycosis was always unilateral, and the maxillary sinus was infected in almost all cases. On the basis of similar findings, we were able to diagnose one case of fungal sinusitis involving maxillary sinus.

Airless sinus filled with mucoid density material, expanding the sinus with thinning of sinus walls is diagnostic of mucocele. One case of frontal mucocele, one case of frontoethmoid and two cases of maxillary mucocele were observed in our study. Zizmor *et al.*[5] found that mucocele most commonly occur in frontal sinus (60-65%) followed by ethmoid sinuses. In the present study, frontal and maxillary sinus involved in equal proportion.

We were able to diagnose allergic fungal sinusitis in two patients. There were characteristic findings of bilateral hyperdense polypoidal masses with expansion, remodeling and thinning of bony walls of sinuses. Mukherji *et al.*[6] emphasized on similar findings. He studied 43 patients of allergic fungal polyposis and concluded that it is more common in young male patients and commonly has bilateral involvement.

In the present study, 36 cases were diagnosed to have neoplastic lesions. 24 of them were detected to be malignant in nature depending on the enhancement pattern of the lesion, the presence of bony destruction and finally the extension of the lesion into various adjacent vital anatomical structures. In the present study, bony erosion was seen in all the 24 (100%) malignant masses and thus found to be most valuable CT criteria for the diagnosis of malignancy. However, 58.3% of benign neoplasms also showed bone erosions (Table 7).

In 95% of malignant neoplasms extension to one of the adjacent regions was present, compared to 33.3% in benign neoplasms. Rests of the criteria like increase in size of the sinus, thinning of walls, sclerosis did not differed much between the benign from malignant masses and not found to be useful in differentiating the two. We were able to demonstrate the precise location and extension of the tumors. Histological types could not be discriminated on imaging (CT) in most of the cases. Similar was emphasized by many authors including Peter Som *et al.*,[7] who concluded that it is not possible to diagnose tumor in the absence of bone destruction.

Graber *et al.*[8] used similar criteria to detect malignant tumors in 15 patients. He characterized malignant tumors in paranasal sinuses on CT scan by their nonhomogeneous structure, destructed bony margins of the sinuses and infiltration into neighboring regions. Graber depicted the precise location and extension of the tumors. Thus, helping in their exact staging and finally in the management of these tumors.

Considering the involvement of sinuses by various neoplasms in the present study, maxillary sinus was involved in 80.5% of cases, ethmoids in 66.6%, frontal in 30.5%, and sphenoid in 30.5% of cases. In a study conducted by Dolan and Smoker,[9] they noted similar findings, wherein maxillary sinus was the most frequently involved sinus affected by intrinsic or nearby or metastatic neoplasms, as seen in our study. According to the study conducted by Parsons and Hodson,[10] the tumor extension was most common into the region of orbit and into the pterygoid region. The two authors studied 15 cases of histologically proven malignancy, to evaluate their extension into adjacent anatomic structures. This was similar to our study where intraorbital and infratemporal fossa extension of the neoplastic lesions was found to be most common.

Two cases of inverted papilloma were diagnosed; CT showed middle meatus involvement along with the extension of the lesion to maxillary sinus, eroding the turbinates on the same side. Thus, we reemphasized the findings quoted by Lund and Lloyd.[11] They studied 60 patients of histologically proved inverted papilloma retrospectively and concluded that mass in the middle meatus of nasal cavity extending into adjacent maxillary antrum is highly suggestive of the tumor.

Total six cases of histologically proven angiofibroma were studied by us. All of them were males of age group between 15 and 25 years and presented with epistaxis. It is similar to Barnes *et al.*,[12] who stated that angiofibroma occurs almost exclusively in young males. Typical site of origin near pterygopalatine fossa and sphenopalatine foramen with widening of pterygopalatine fossa and strong contrast enhancement were the diagnostic criteria used by Som *et al.*[13] We found these criteria to be diagnostic. However, in one of our patient, the pterygopalatine fossa was not widened. Many of these angiofibromas extended into infratemporal fossa (66.6%) and sphenoid sinus (66%). Apostol and Frazell,[14] observed that sphenoid sinus is involved in 61% of the cases. Intracranial extension into middle cranial fossa was found in one patient (16.6%); similar was observed by Barnes *et al.*[12] The differential diagnosis of angiofibroma includes fibrosed antrochoanal polyp and angiomatous polyp.

Abrahams and Glassberg[15] observed that many of the maxillary sinus pathologies are related to dental disease. In the present study, four cases related to dental pathologies were encountered. All of them involved maxillary sinus. CT is diagnostic of osseous and fibro-osseous lesions. Four cases of fibrous dysplasia, two of osteomas and one of ossifying fibroma were diagnosed. Frontal sinus was involved in both the osteomas and is the most common site of osteoma as studied by Fu and Perzin,[16] Both fibrous dysplasia and ossifying fibroma showed expansion and ground glass appearance. Because there is overlap in imaging appearance of Fibrous dysplasia and ossifying fibroma, Commins *et al.*,[17] suggested the term benign fibro-osseous lesion.

In our study, we came across some anatomical variants. Almost all types of anatomical variants were diagnosed. In descending order of their occurrence, we found agger nasi in 59.1%, concha bullosa in 43.6%, deviated nasal septum (DNS) in 40%, Onodi in 30.9%, Haller cells in 16.3%, paradoxical middle turbinate in 13.6%, deviated uncinate process in 10.9%, enlarged ethmoid bulla in 8.2%, and pneumatized uncinate process (PUP) in 3.6% of cases.

DNS causes decrease in the critical area of osteomeatal complex predisposing it to obstruction and related complications. It was found to be the one of the common anatomical variants in our study (40%). It was more than that of 38% reported by Asruddin *et al.*[18] Agger nasi cells lie anterior to the anterosuperior attachment of middle turbinate and frontal recess. This is the most common variant found in our study. These cells were present in 59.1% of cases in our study as compare to 48% of cases studied by Asruddin *et al.*[18] Concha Bullosa has been implicated as an etiological factor in the causation of chronic sinusitis due to compromise in the space of middle meatus region as quoted by Tonai and Baba;[19] Onodi cells are the extension of the posterior ethmoidal cells into the sphenoid sinus lying medial to optic nerve. The chances of injury to optic nerve are increased when the bony canal of the nerve is lying dehiscent. The incidence of Onodi cells was found to be 30.9% in our study. Another study that closely matched with the incidence in our study was conducted by Driben *et al.*,[20] where the incidence was 39%. Haller cells may narrow the adjacent ostium of the maxillary sinus, especially when they become infected. The incidence of Haller cells in our study was 16.3% as compared to 16% reported by Dua *et al.*[21]

CONCLUSION

CT scan evaluates both soft tissue and bony details of nose and paranasal sinuses. Due to complex anatomy, radiographic evaluation of paransal sinuses has major limitations and hence cost-effective CT is most common and widely used investigation to study the various PNS diseases. A wide spectrum of disease affecting the sinonasal cavities can be detected by CT with high accuracy in diagnosis of inflammatory conditions and their complications. It is also a very sensitive modality for detection, accurate localization and determination of exact extent of paranasal sinus neoplasms; hence is essential for preoperative evaluation. Various important anatomical variants can also be easily detected on CT of paranasal sinuses.

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