Radiology Section

Evaluation of Sinonasal Diseases by Computed Tomography

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ABSTRACT

Introduction: Computed Tomography (CT) plays an important diagnostic role in patients with sinonasal diseases and determines the treatment. The CT images clearly show fine structural architecture of bony anatomy thereby determining various anatomical variation, extent of disease and characterization of various inflammatory, benign and malignant sinonasal diseases.

Aim: To evaluate sensitivity and specificity of CT in diagnosis of sinonasal diseases and to characterise the benign and malignant lesions with the help of various CT parameters. Also, to correlate findings of CT with histo-pathological and diagnostic nasal endoscopy/ Functional Endoscopic Sinus Surgery (FESS) findings.

Materials and Methods: In this hospital based prospective study 175 patients with symptomatic sinonasal diseases were evaluated by clinical diagnosis and 16 slice Multi Detector Computed Tomography (MDCT). The details of findings of nasal endoscopy, Functional Endoscopic Sinus Surgery (FESS), histopathological examination and fungal culture were collected in all those cases where those investigations were done. All those findings were correlated with CT findings and statistical analysis was done by using Test statistics (sensitivity, specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) and accuracy), Chi-Square test and Z-test for single proportions. Software used in the analysis was SPSS 17.0 version and graph pad prism 6.0 version and p < 0.05 was considered as statistically significant.

Results: CT diagnosis had higher sensitivity, specificity, PPV and NPV in diagnosing various sinonasal diseases in comparison to clinical diagnosis. On correlating CT diagnosis with final diagnosis, congenital conditions have 100% sensitivity and specificity. Chronic sinusitis has 98.3% sensitivity and 97.8% specificity. For fungal sinusitis the sensitivity was 60% and specificity was 99.3%. Polyps have sensitivity of 94.4% and specificity of 98.1%. Benign neoplasms have sensitivity of 90.9% and specificity of 99.2%, malignant neoplasms have sensitivity of 94.1% and specificity of 99.3%. The p-value in all instances was <0.05, i.e. <0.0001 indicating the significance of the findings.

Conclusion: CT is the modality of choice in imaging the sinonasal region for evaluating various congenital, inflammatory, benign and malignant pathologies and associated complications thereby planning the further management of the patient. CT is the best modality of choice for evaluating the bone erosion or destruction. The potential pitfalls to differentiate on CT are fungal sinusitis and dense secretions.

Keywords: Diagnostic nasal endoscopy, Functional endoscopic sinus surgery, Sinonasal pathologies

INTRODUCTION

Sinonasal imaging has progressed in an orderly fashion as each generation of imaging modality has advanced gradually on the domain of the former generation. New generation of imaging modalities have completely changed the picture of sinonasal imaging. Previously plain radiography was most commonly done, now it's been replaced by Computed Tomography (CT) as per endoscopic sinus surgeon requirement for greater anatomic precision [1].

The nasal passage and paranasal sinuses plays host to a wide spectrum of diseases and conditions which can be collectively termed as sinonasal disease. The sinonasal pathologies include broad spectrum of conditions ranging from inflammatory to neoplasms, both benign and malignant. The radiological evaluation of sinonasal diseases is very essential as the clinical findings in these cases may be non-specific [2,3]. Available imaging techniques include plain radiography, CT, Magnetic Resonance Imaging (MRI), and Positron Emission Tomography (PET).

Each of these modalities has certain advantages and disadvantages. The plain films are no longer considered to be a part of the primary imaging armamentarium as they give only an outline of the anatomy and underlying pathology [4]. The CT and MRI have the advantage of being able to show fine anatomic detail in serial tomographic section, thus, eliminating the gross volume averaging inherent in plain films [4].

CT has become the investigation of choice for radiological diagnosis of nasal and sinus diseases [5] as CT images clearly show air spaces, opacified sinuses and fine structural architecture of bony anatomy. Multidetector CT (MDCT) allows assessment of the patency of sinonasal passages and shows the effect of anatomic variants, inflammatory disease or both on patency. MDCT can show anatomic structures that are not visualised by physical examination or diagnostic nasal endoscopy and is, hence, the study of choice for the surgeon who is considering functional endoscopic sinus surgery [6].

CT also plays an important role in excluding the existence of aggressive infections or neoplasms with features of extra-sinus extension, osseous destruction and local invasion. MRI can be done in cases of complications of sinusitis, extra sinus extension of malignancy and to evaluate intracranial extension [6]. CT is superior to MRI in evaluating fine bone details, fibro-osseous lesions of PNS and sinofacial trauma.

CT aids in the diagnosis and management of recurrent and chronic sinonasal disease by determining the distribution and extent of disease. CT is best at defining the complex sinonasal anatomy and anatomic variations that are inaccessible by physical examination or endoscopy because of its 3D high resolution [7].

CT is the investigation of choice for pre-operative evaluation of the nasal cavity and paranasal sinuses and is the gold standard for description of inflammatory sinus disease resulting from obstruction [8]. Coronal CT images closely correlates with the surgical approach [9]. Therefore, CT is the preferred study for Functional Endoscopic Sinus Surgery (FESS) because coronal images mimic the appearance

of the sinonasal cavity from the perspective of the endoscope [10].

CT helps in the diagnosis of the anatomic variations that may lead to intra-operative and post-operative FESS complications and reduces the mortality and morbidity of patients. A combination of CT and diagnostic endoscopy has become the mainstay in evaluation of the sinonasal diseases. Hence, CT has immense value and offers standard imaging of sinonasal diseases [11]. This study was conducted to characterise various benign and malignant sinonasal lesions with the help of various CT parameters and correlate CT finding with histo-pathological findings and diagnostic nasal endoscopy/ functional endoscopic sinus surgery and evaluate sensitivity and specificity of CT in diagnosis of sinonasal diseases (in cases where those investigations were done).

MATERIALS AND METHODS

This hospital based prospective study was carried out in Department of Radio diagnosis of AVBRH hospital from August 2014 to May 2016. Institutional Ethical Approval was obtained for the study.

The sample size was calculated by the formula nSe = $Z^2_{\alpha/2}$ Sen (1-Sen) ÷ d^2 × Prev

For α= 0.05, $Z_{\alpha/2}$ is inserted by 1.96; Sen and Prev are the pre-determined values of sensitivity and prevalence of disease respectively and d as the precision of estimate (i.e., the maximum marginal error) is pre-determined by clinical judgment of investigators [12].

The pre-determined values of sensitivity were 89.4% (the overall sensitivity of CT obtained in previous study [11]) and prevalence of disease 20.8 (prevalence of sinonasal diseases in AVBRH hospital, Wardha). Marginal error was d 0.10.

1.96x 1.96 x .894 x.106/ 0.10x 0.10 x 0.208 = 175

The 175 patients with clinically suspected sinonasal pathologies referred to Department of Radio diagnosis from ENT Department were included in the study. Patients with allergy to contrast agent and pregnant women were excluded from the study. Informed consent from the patients was received.

CT machine and techniques

The CT was done using Philips 16 Slice BRILLIANCE 190P MDCT and images were acquired in both axial and coronal planes. Post contrast study was done in those who required further evaluation.

Patient position was supine for axial and coronal sections. Slice thickness for axial and coronal planes was 3mm and inter-space was 3mm, exposure factors used were 120kvp and 60 mAs. Scan time was 1.5sec. Soft tissue window level and width (50/200) and bone window level and width (350/2500). Contrast agent Omnipaque 350 was used if indicated and consent was obtained from the patient.

CT findings were evaluated in all the patients and characterisation of the various sinonasal lesions were done with the help of various CT parameters.

Out of 175 patients, 154 patients had further undergone either nasal endoscopy/FESS or histopathological examination and rest 21 were treated medically.

Clinical diagnosis and CT diagnosis was correlated with final diagnosis which was obtained on basis of nasal endoscopy/FESS and histopathological findings in these 154 patients.

Statistical analysis was done by using descriptive and inferential statistics using Test statistics (sensitivity, specificity, PPV, NPV and accuracy). Chi-Square test and Z-test for single proportions. Software used in the analysis was SPSS 17.0 version and graph pad prism 6.0 version and p < 0.05 was considered as statistically significant. Our study included 110 males and 65 females aged between 6 months and 85 years, as all the patients with suspected sinonasal pathologies presented during the specified period of study were included without taking age as criteria for exclusion. The most common symptom with which the patients presented were nasal obstruction and nasal discharge. On basis of CT findings,

the various sinonasal pathologies were categorised into congenital/ developmental, inflammatory and neoplastic conditions.

RESULTS

Age distribution of patients is shown in [Table/Fig-1]. Sex distribution is shown in [Table/Fig-2]. All the 175 patients who had undergone CT, were categorised according to aetiology into congenital/ developmental, inflammatory and neoplastic based on CT findings as shown in [Table/Fig-3]. The maxillary sinus was most commonly affected sinus. Most common anatomical variations were Deviated Nasal Septum (DNS) and concha bullosa. The distribution of inflammatory cases is shown in [Table/Fig-4]. The most common inflammatory pathology was sinusitis [Table/Fig-5] followed by sinonasal polyps [Table/Fig-6a,b].

Out of the 38 neoplastic pathologies, 21 were diagnosed as benign and 17 as malignant on CT as shown in [Table/Fig-7]. The distribution of benign and malignant cases is shown in [Table/Fig-8,9].

The most common benign pathology was nasopharyngeal angiofibroma [Table/Fig-10a,b] followed by inverted papilloma [Table/Fig-11a-c]. The most common malignant pathology found

Age in years	Number (N=175)			Percentage
	Male	Female	Total	
0-10	3(1.71%)	1(0.57%)	4	2.29
11-20	17(9.71%)	11(6.29%)	28	16.00
21-30	26(14.86%)	18(10.29%)	44	25.14
31-40	24(13.71%)	16(9.14%)	40	22.86
41-50	14(8%)	9(5.14%)	23	13.14
51-60	14(8%)	6(3.43%)	20	11.43
61-70	7(4%)	3(1.71%)	10	5.71
>70	5(2.86%)	1(0.57%)	6	3.43
Mean ±SD	110(62.86%)	65(37.14%)	175	100.00
2-value	2.48, p-value=0.92, NS, p>0.05			

[Table/Fig-1]: Age-wise distribution of patients.

Sex	Number of patients	Percentage
Male	110	62.86
Female	65	37.14
Total	175	100.00

[Table/Fig-2]: Sex-wise distribution of patients.

Aetiology	Number of cases	Percentage
Congenital/ developmental	3	1.71%
Inflammatory	135	77.14%
Neoplastic	37	21.14%
Total	175	100%

[Table/Fig-3]: Characterisation of the various sino nasal lesions on basis of CT parameters.

| Inflammatory/ infective	Number of cases	Percentage	Z-value
Sinusitis (other than fungal)	71	40.57%	10.93,S
Sinonasal polyps	41	23.43%	7.32,S
Sinusitis + polyps	15	8.57%	4.05,S
Fungal	4	2.29%	2.02,S
Mucocele	1	0.57%	1.00,NS
Rhinoscleroma	2	1.14%	1.42,NS
Total	134	76.57%	23.92,S

[Table/Fig-4]: Distribution of cases with inflammatory aetiology.

in present study was squamous cell carcinoma of maxillary sinus [Table/Fig-12a-c]. All of them were histologically proven.

CT had diagnosed bone involvement in all the cases as shown in [Table/Fig-13]. Correlation of CT findings with final diagnosis

[Table/Fig-5]: Bilateral pansinusitis.
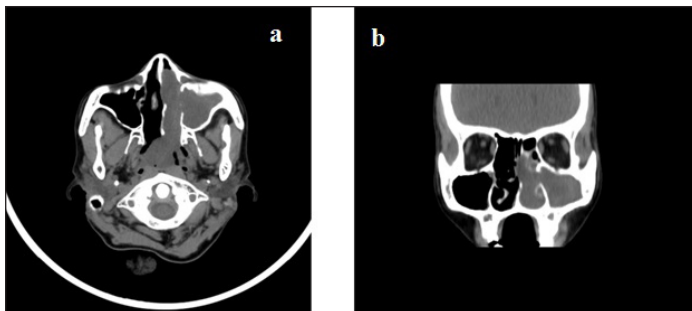
[Table/Fig-6a & b]: Left antrochoanal polyp: Axial and coronal CT image showing homogeneous soft tissue attenuating mass extending from antrum to choana with widening of maxillary ostium.

Type of lesion	Number of cases	Percentage
Benign	21	12.00%
Malignant	17	9.71%
Total	38	21.71%

**[Table/Fig-7]:** Distribution of neoplastic cases.

Type of lesion	Number of cases	Percentage	Z-value
Nasopharyngeal angiofibroma	7	4.00%	2.70,S
Fibrous dysplasia	4	2.29%	2.02,NS
Inverted papilloma	4	2.29%	2.02,NS
Capillary haemangioma	3	1.71%	1.75,NS
neurofibroma	1	0.57%	1.00,NS
Ivory osteoma	1	0.57%	1.00,NS
Squamous papilloma	1	0.57%	1.00,NS

[Table/Fig-8]: Distribution of cases of benign neoplasms.

Type of malignancy	No of cases	Percentage
Squamous cell carcinoma of maxilla	8	4.57
Nasopharyngeal carcinoma	4	2.29
Nasal carcinoma	5	2.86

**[Table/Fig-9]:** Distribution of cases of malignant neoplasms.
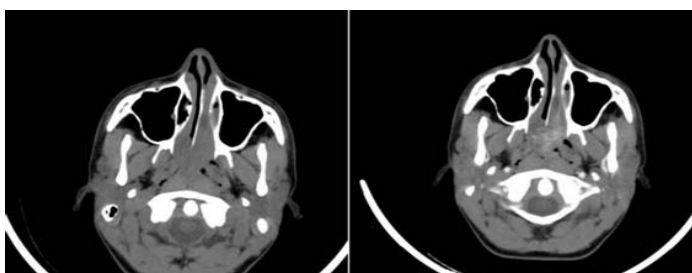
[Table/Fig-10a & b]: Nasopharyngeal angiofibroma: Axial plain and post contrast CT shows soft tissue attenuating mass in nasopharynx widening the sphenopalatine foramen and showing intense post contrast enhancement.

which is obtained from histopathological findings, diagnostic nasal endoscopy/FESS is shown in [Table/Fig-14].

DISCUSSION

Recently CT has become the best diagnostic modality for evaluation of nasal cavity, paranasal sinuses and for demonstrating various sinonasal diseases. Acute sinus infection is evaluated by clinical assessment, whereas, persistent sinus disease refractory to medical therapy is investigated by CT [13-16]. This was a prospective correlational descriptive clinical study carried out on
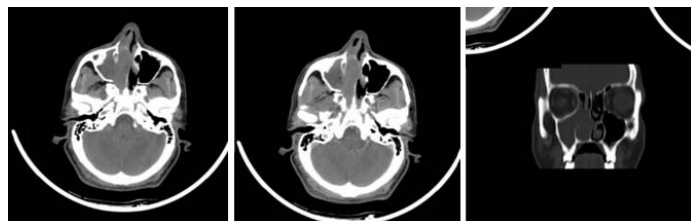
[Table/Fig-11a, b & c]: Right inverted papilloma: Axial and Coronal CT shows lobulated soft tissue attenuating mass in right nasal cavity extending into maxillary sinus with adjacent bony remodeling.
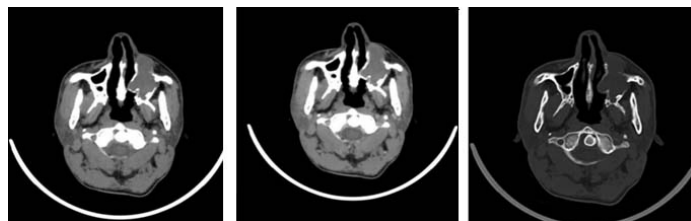
[Table/Fig-12a, b&c]: Squamous cell carcinoma: CT images show soft tissue enhancing mass in left maxillary sinus with bony destruction of surrounding walls and extra sinus extension.

Bone involvement	Number	Percentage	Sensitivity	Specificity
In clinical diagnosis	3	1.71	12%	97.35%
CT Diagnosis	25	14.29	100%	100%
Final diagnosis	25	14.29	-	-

[Table/Fig-13]: Bone involvement.

Parameters	Sensitivity	Specificity	PPV	NPV	Accuracy	p-value	Result
Congenital	100%	100%	100%	100%	100%	0.0001	Significant
Chronic sinusitis	98.3%%	97.8%	96.77%	98.91%	98.05%	0.0001	Significant
Fungal sinusitis	60%	99.3%	75.0%	98.67%	98.05%	0.0001	Significant
Polyp	94.4%	98.1%	94.44%	98.31%	97.40%	0.0001	Significant
Other inflammatory conditions	90.9%	99.3%	90.91%	99.30%	98.70%	0.0001	Significant
Benign neoplasms	90.9%%	99.2%	95.24%	98.50%	98.05%	0.0001	Significant
Malignant neoplasms	94.1%	99.3%	94.12%	99.27%	98.70%	0.0001	Significant

[Table/Fig-14]: Correlation of CT with final diagnosis -an evaluation.

175 symptomatic sinus diseased patients who had undergone CT imaging of paranasal sinuses in both coronal and axial sections. In present study, the patient's age ranged between 6 months - 85years which was consistent with study done by Harika Surapaneni et al., and Nepal A et al., [17,18]. Most patients were in the 2nd and 3rd decades of their life with male: female ratio of 1.6:1 which is comparable to study done by Bist S et al., [19].

Most common sinus involved was maxillary sinus followed by anterior ethmoid, posterior ethmoid, frontal and sphenoid sinuses. Present study correlates well with studies done by Suthar et al., [20] Chaitanya CS et al., [11] Kushwah APS et al., where maxillary sinus was most commonly involved [21]. In all the studies sphenoid was least involved, which is also observed in the present study. Commonest pattern of inflammation was osteomeatal unit pattern followed by sinonasal polyposis which was also observed in study by Maru YK et al., [22].

The various sinonasal pathologies diagnosed on CT are classified based on their imaging features. Most common sinonasal pathology in present study was inflammatory (77.14%) followed by benign neoplastic (12%) and malignant lesions (9.7%). Similar findings were also found in studies done by Vijay Prabhu et al., Khan N et al., Vikas Dhillon et al., [23-25]. The most common inflammatory pathology was sinusitis followed by polyps [Table/Fig-4], which was also found

in study done by Azzam MA, Salami et al., [26] accounting to 33.3% and 20% resepectively. Sinusitis was also most common in study doneby Vijay Prabhu et al., accounting to 56% [23].

The most common benign pathology was nasopharyngeal angiofibroma [Table/Fig-6] which was also seen in study done by Mohammed A. Gomaa et al., [27]. The most common malignant pathology was squamous cell carcinoma of maxillary sinus [Table/Fig-7] which was also seen in studies done by in Azzam MA. Salami et al., study [26], Mohammed A. Gomaa and Hammad MS and Chow et al., [27,28].

Sensitivity and specificity of CT in diagnosing fungal sinusitis was 60% and 99.3% respectively. The sensitivity of CT in diagnosing fungal sinusitis as described in literature was 76% by Zenreich SJ et al., which was a retrospective study [29]. However, CT plays a major role in diagnosing invasive nature of fungal sinusitis like extra sinus spread to adjacent structures, bone destruction or erosion.

In this study CT detected the bone destruction or erosion in all the 25 patients, which was confirmed on endoscopy/FESS. The sensitivity and specificity of CT to detect involvement of bone such as bone erosion or destruction was 100%. Therefore, the CT has definite advantage over the MRI in assessing the involvement of bones. The p-value in all instances was <0.05 i.e., <0.0001, indicating the significance of the findings.

Thus, CT plays an important role in diagnosing and also in adding important findings for the better management of the patients with sinonasal diseases.

LIMITATION

The potential drawback of CT in the present study was noted in diagnosis of invasive fungal sinusitis. However, the invasiveness and extent of the disease was correctly diagnosed on CT. Early sinonasal polyps were missed on CT which were diagnosed on diagnostic nasal endoscopy.

CONCLUSION

This study emphasizes the significant role of CT in diagnosis and characterisation of various sinonasal diseases. It proves the better sensitivity and specificity of CT in evaluation of various sinonasal pathologies in symptomatic patients for the diagnosis, staging and thereby better planning of management. CT is the best modality of choice for evaluating osteomeatal complex anatomy, variations and for assessing bony changes in various sinonasal diseases.

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