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ANALYSIS OF COMPUTED TOMOGRAPHY IMAGING FEATURES IN DIAGNOSIS OF ALLERGIC FUNGAL RHINOSINUSITIS VERSUS NON-FUNGAL CHRONIC RHINOSINUSITIS

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Abstract

Background: *Allergic Fungal Rhinosinusitis (AFRS) and Non-Fungal Chronic Rhinosinusitis (NFCRS) are distinct subtypes of chronic rhinosinusitis with differing treatments and prognoses. Early and accurate radiological distinction is critical. This study aimed to compare computed tomography (CT) imaging characteristics of AFRS and NFCRS to identify key distinguishing features.*

Methods: *A comparative cross-sectional study was conducted at the CT Scan Center, DHQ Hospital, Kasur, over four months. A total of 100 patients with clinically confirmed chronic rhinosinusitis were enrolled (15 AFRS, 85 NFCRS). Demographic, clinical, and CT imaging parameters were analyzed using the Chi square test ($p < 0.05$ significant).*

Results: *Most participants were male (61%) and aged 21–40 years (55%). Nasal obstruction was the most common symptom (88%), predominantly in NFCRS. CT findings showed highly significant associations with final diagnosis ($p = 0.001$). Moderate hyperdense sinus content was exclusive to AFRS (100%), while its absence was seen in 97.5% of NFCRS. Severe heterogeneous opacification (64% in AFRS), moderate sinus expansion (53% in AFRS), severe bony remodeling (38% in AFRS), and moderate to severe lamina papyracea erosion (100% in AFRS) were strongly associated with AFRS. Mild to moderate calcifications were exclusive to AFRS. Unilateral disease favored NFCRS (95%), whereas bilateral involvement was more common in AFRS (21%; $p = 0.039$).*

Conclusion: *CT imaging is essential for distinguishing AFRS from NFCRS. Hyperdense sinus content, severe heterogeneous opacification, sinus expansion, bony erosion, internal calcifications, multiple sinus involvement, and bilateral disease are highly suggestive of AFRS. These features improve diagnostic precision and guide appropriate clinical management.*

INTRODUCTION

Chronic rhinosinusitis (CRS) is one of the most prevalent chronic inflammatory disorders affecting the respiratory tract worldwide, with an estimated prevalence of 10–12% in the general population. The condition is defined by persistent inflammation of the nasal and paranasal sinus mucosa lasting at least 12 consecutive weeks,

accompanied by symptoms such as nasal obstruction, mucopurulent discharge, facial pressure or pain, and hyposmia. Beyond its physical manifestations, CRS imposes a substantial socioeconomic burden due to prolonged morbidity, frequent outpatient visits, loss of productivity, and increased healthcare expenditures. Moreover, patients often experience diminished quality of life, sleep disturbances, difficulty concentrating, and psychological distress including anxiety and depression. The prevalence is notably higher in humid and industrialized regions, and the condition remains a leading cause of otolaryngology outpatient consultations globally [1–3].

Among the various phenotypic classifications of CRS, two clinically relevant subtypes are Chronic Rhinosinusitis with Nasal Polyps (CRSwNP) and Chronic Rhinosinusitis without Nasal Polyps (CRSsNP). However, a more distinctive and immunologically unique subtype is Allergic Fungal Rhinosinusitis (AFRS), first recognized as a separate clinical entity in the late 20th century. AFRS is a non invasive form of fungal rhinosinusitis characterized by a type I hypersensitivity reaction to environmental fungal antigens in immunocompetent individuals. It predominantly affects young adults with atopy or allergic tendencies and is defined pathognomonically by the presence of thick, viscous "allergic mucin" rich in eosinophils, Charcot Leyden crystals, and scattered fungal hyphae. This allergic mucin accumulates within the sinuses, leading to chronic inflammation, pressure induced sinus expansion, bony remodeling, and in severe cases, orbital complications, proptosis, or facial deformity [4–6].

The geographic distribution of AFRS is strongly influenced by warm and humid climates, which facilitate fungal sporulation. High incidences have been reported in the southern United States, Saudi Arabia, Sudan, India, and Pakistan. Despite this, the true prevalence of AFRS in Pakistan remains underreported due to limited diagnostic resources, lack of awareness among general practitioners, and significant clinical overlap with other forms of CRS. Consequently, many patients are misdiagnosed as having simple CRS or are identified only after substantial anatomical changes and complications have already occurred [7–9].

The diagnosis of AFRS requires a combination of clinical, radiological, and histopathological assessment. Among imaging modalities, non contrast computed tomography (CT) of the paranasal sinuses is the gold standard, offering superior delineation of sinus anatomy, disease extent, and bone involvement. Characteristic CT findings in AFRS include heterogeneous hyperdense sinus contents (the so called "double density sign"), sinus expansion, thinning or erosion of bony walls, and remodeling of adjacent structures. In contrast, Non Fungal Chronic Rhinosinusitis (NFCRS) typically demonstrates uniform mucosal thickening or opacification without significant hyperdense foci or bony alterations [10–13].

Unfortunately, reliable differentiation based solely on clinical symptoms or endoscopic findings is challenging, as both AFRS and NFCRS present similarly with nasal blockage, discharge, and facial pressure. This diagnostic ambiguity frequently leads to misclassification, inappropriate medical therapy, delayed surgical intervention, and disease recurrence. In Pakistan and other South Asian nations, where advanced laboratory and immunological testing are often inaccessible or unaffordable, CT based radiological distinction becomes even more critical. The management of AFRS differs fundamentally from that of NFCRS: AFRS typically requires surgical removal of allergic mucin via Functional Endoscopic Sinus Surgery (FESS) combined with systemic corticosteroid therapy, whereas NFCRS may respond to medical management alone. Therefore, early and accurate differentiation directly impacts treatment outcomes, recurrence rates, and patient quality of life [14–16].

Despite the clinical importance of AFRS and its unique imaging characteristics, comparative research on radiological distinction between AFRS and NFCRS in South Asian populations is conspicuously lacking. Most available literature originates from Western countries with different environmental and demographic profiles. To bridge this diagnostic gap, the present study was

designed to systematically compare CT imaging features of AFRS and NFCRS in a Pakistani cohort, aiming to identify key radiological markers that can reliably differentiate these two conditions in routine clinical practice.

2. METHODS

2.1. Study Design and Setting

A comparative cross sectional study was conducted at the CT Scan Center, District Headquarters (DHQ) Hospital, Kasur, over four months.

2.2. Sample Size and Sampling

Using Cochran's formula (expected proportion 7%, 95% confidence interval, 5% margin of error), a sample of 100 patients was calculated. Non probability purposive sampling was employed.

2.3. Participants

- **Inclusion:** Patients undergoing non contrast CT of paranasal sinuses with clinical/radiological features of AFRS or NFCRS.
- **Exclusion:** Fungal ball, invasive fungal sinusitis, facial fractures, prior sinus surgery, immunocompromised states, poor image quality, sinonasal tumors.

2.4. CT Imaging and Evaluation

High resolution non contrast CT scans (axial and coronal planes, 1–3 mm slices) were interpreted by an experienced radiologist for:

- Mucosal thickening
- Hyperdense sinus content (absent/mild/moderate/severe)
- Heterogeneous opacification
- Sinus expansion
- Bony remodeling
- Lamina papyracea erosion
- Calcifications
- Multiple sinus involvement
- Laterality (unilateral/bilateral)

2.5. Ethical Approval

Institutional ethical approval was obtained. Patient data were anonymized, and confidentiality was maintained.

2.6. Statistical Analysis

Data were analyzed using SPSS version 27. Categorical variables were compared using the Chi square test. A p value < 0.05 was considered statistically significant.

3. RESULTS

The data were collected from the CT Scan Center of District Headquarters (DHQ) Hospital, Kasur. A total of 100 respondents participated in the study. Among them, 61% (n = 61) were male, while 39% (n = 39) were female, indicating a higher ratio of male attendees with respect to age distribution, the majority of participants (55%, n = 55) possessed to the 21–40 years age group and this was followed by the 41–60 years age group, which comprised 23% (n = 23) of the total sample. Participants aged 1–20 years accounted for 16% (n = 16), whereas the smallest proportion was observed in the 61–80 years age group, representing only 6% (n = 6) of the respondents. Overall, the findings demonstrate that most study participants were young to middle aged adults, with relatively fewer elderly individuals included in the sample.

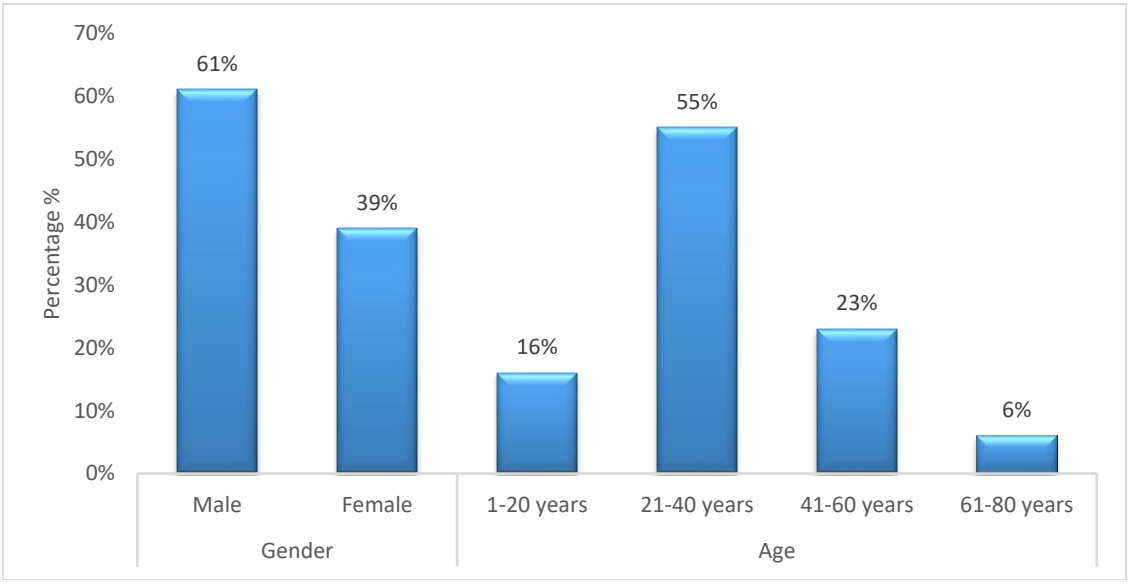

Figure 1. Illustrates the demographic distribution of the study participants based on gender and age groups.

By similarity of clinical features among patients identified with AFRS and non fungal chronic rhinosinusitis (NFCRS), nasal blockage was the most common presenting symptom, observed in 88% of the patients, with a higher frequency in NFCRS cases (74%) compared to AFRS (14%). Nasal discharge was present in 33% of patients, predominantly in the NFCRS group (26%), while facial pain was reported in 35% of cases, again more common in NFCRS patients (31%). A history of allergy or asthma was noted in 16% of patients, with distribution of 6% in AFRS and 10% in NFCRS. Loss of smell (6%) and sneezing/itching (14%) were less frequently reported but were comparatively higher among NFCRS patients. The Chi square test established a statistically significant association among clinical profile variables and final diagnosis ($p < 0.05$). This means that the distribution of the symptoms including nasal obstruction, nasal discharge, facial pain, allergy/asthma history, loss of smell, and sneezing/itching have significant differences between AFRS and NFCRS patients. The results indicate that these clinical characteristics, especially nasal obstruction and facial pain are stronger related to NFCRS, whereas allergic history displays a relative prominence among cases of AFRS. Therefore, clinical presentation plays a significant role in differentiating between AFRS and NFCRS

Table 1. Clinical Profile vs Final Diagnosis.

Clinical Profile vs Final Diagnosis Crosstab						
Variables			Final Diagnosis		Total	P Value
			AFRS	NFCRS		
Clinical Profile	History Allergy Asthma	No	9	75	84	<0.05
		Yes	6	10	16	
	Nasal Obstruction	No	1	11	12	
		Yes	14	74	88	
	Nasal Discharge	No	8	59	67	
		Yes	7	26	33	
	Facial Pain	No	11	54	65	
		Yes	4	31	35	

	Loss of Smell	No	14	80	94	
		Yes	1	5	6	
	Sneezing Itching	No	11	75	86	
		Yes	4	10	14	

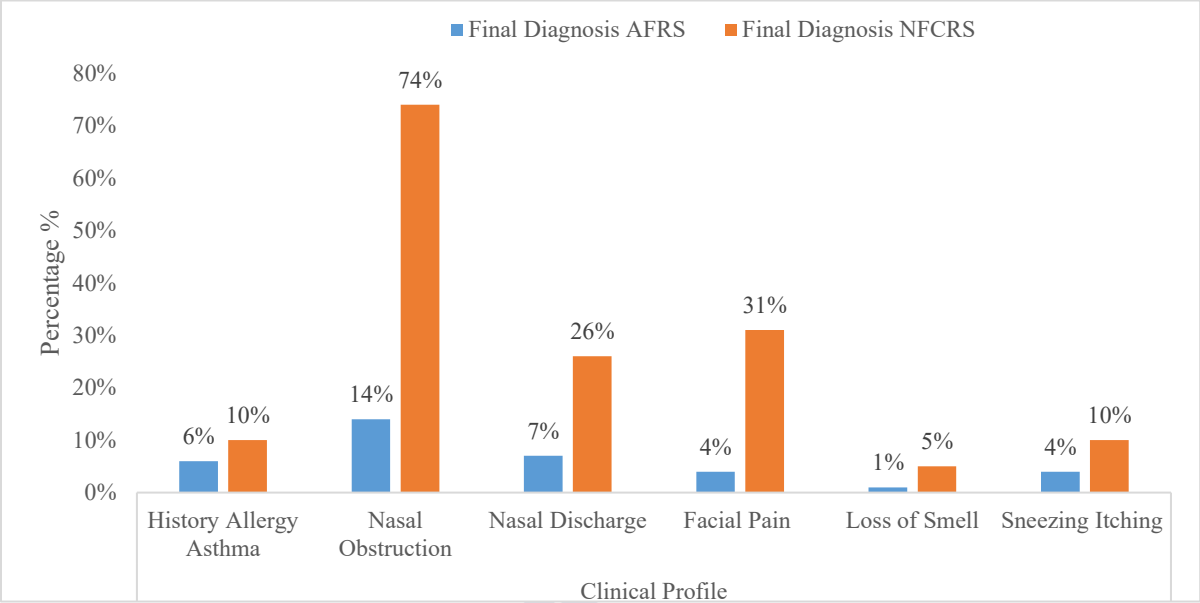

Figure 2. Comparison of clinical profile features between AFRS and NFCRS based on final diagnosis.

By comparing the frequency of hyperdense sinus content in patients with AFRS and NFCRS, a marked difference was observed between the two diagnostic groups. Moderate hyperdense sinus content was found exclusively in AFRS patients (100%, n = 5), whereas none of the NFCRS cases showed moderate hyper density. Severe hyperdense sinus content was also more frequently observed in AFRS patients (71.4%, n = 5) compared to NFCRS patients (28.6%, n = 2). In contrast, absence of hyperdense sinus content was predominantly noted in NFCRS cases (97.5%, n = 79) as compared to AFRS (2.5%, n = 2). The Chi square test showed a highly statistically considerable association among hyperdense sinus content and final diagnosis (p = 0.001). Since the p value is lesser than 0.05, this indicates a strong relationship between the presence and severity of hyperdense sinus content and AFRS. These findings provide clear evidence that increasing hyper density on CT imaging is significantly associated with AFRS rather than NFCRS and can serve as an important radiological marker in differentiating between the two conditions

Table 2. Hyperdense Sinus Content vs Final Diagnosis.

Hyperdense Sinus Content vs Final Diagnosis Crosstabulation					
Variables		**Final Diagnosis**		**Total**	**P Value**
		AFRS	NFCRS		
Hyperdense Sinus Content	Absent	2	79	81	0.001
	Mild	3	4	7	
	Moderate	5	0	5	

	Severe	5	2	7	
Total		15	85	100	

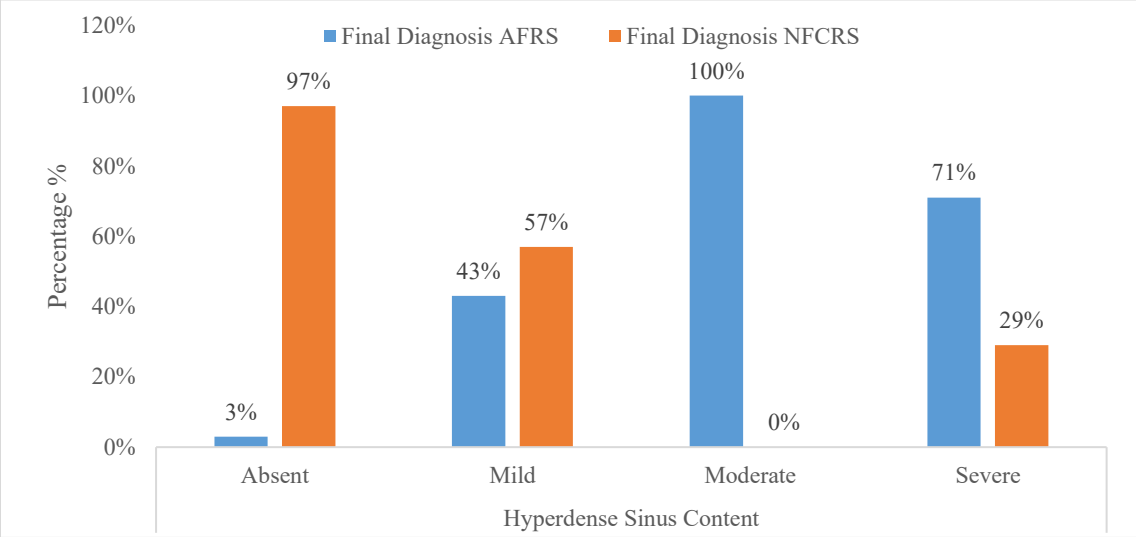

Figure 3. Distribution of hyperdense sinus content vs final diagnosis.

By comparing the frequency of heterogeneous opacification in patients with AFRS and NFCRS, a clear difference was observed between the two diagnostic groups. Mild heterogeneous opacification was predominantly seen in NFCRS patients (94%, n = 29), with only a small proportion of AFRS cases (6%, n = 2). Similarly, moderate heterogeneous opacification was more frequent in NFCRS (88%, n = 28) compared to AFRS (12%, n = 4). In contrast, severe heterogeneous opacification was markedly associated with AFRS, where the majority of cases belonged to the AFRS group (64%, n = 9), while fewer cases were diagnosed as NFCRS (36%, n = 5). Notably, all cases with absent heterogeneous opacification were diagnosed as NFCRS (100%, n = 23). The Chi square test proved a highly statistically considerable association among heterogeneous opacification and final diagnosis (p = 0.001). Since the p value is lesser than 0.05, this confirms a significant relationship between the severity of heterogeneous opacification and AFRS. These findings pointed that increasing severity of heterogeneous opacification on CT imaging is significantly associated with AFRS and may serve as an important radiological indicator in differentiating AFRS from NFCRS.

Table 3. Heterogeneous Opacification vs Final Diagnosis.

Heterogeneous Opacification vs Final Diagnosis Crosstabulation					
Variables		**Final Diagnosis**		**Total**	**P Value**
		AFRS	NFCRS		
Heterogeneous Opacification	Absent	0	23	23	0.001
	Mild	2	29	31	
	Moderate	4	28	32	
	Severe	9	5	14	

Total	15	85	100	

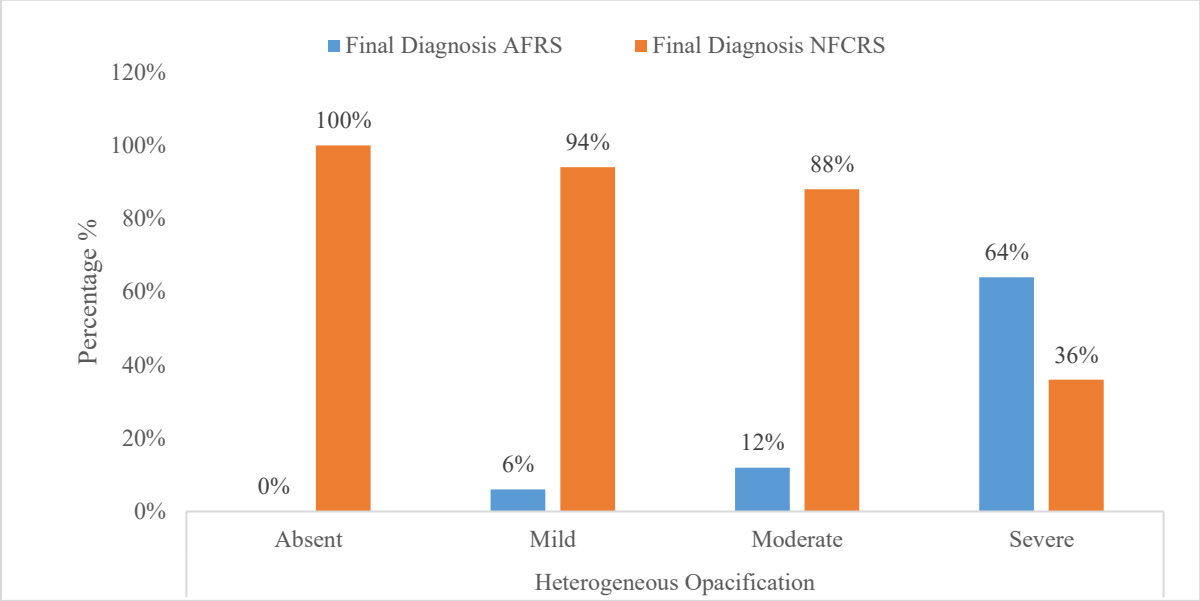

Figure 4. Distribution of Heterogeneous Opacification vs final diagnosis.

Comparison of sinus expansion between AFRS and NFCRS patients demonstrated a distinct distribution pattern across both diagnostic groups. Absence of sinus expansion was predominantly observed in NFCRS patients (96%, n = 70), whereas only a small proportion of AFRS cases showed no expansion (4%, n = 3). Mild sinus expansion was more frequent in NFCRS (70%, n = 7) compared to AFRS (30%, n = 3). In contrast, moderate sinus expansion was more commonly associated with AFRS, accounting for 53% (n = 8) of cases, while 47% (n = 7) were diagnosed as NFCRS. Severe sinus expansion was equally distributed between AFRS and NFCRS patients (50% each, n = 1). Overall, increasing severity of sinus expansion showed a trend toward greater association with AFRS. The Chi square test concluded a highly statistically considerable association among sinus expansion and final diagnosis (p = 0.001). As the p value is less than 0.05, this confirms a significant relationship between the degree of AFRS and sinus expansion . These findings suggest that increasing sinus expansion on CT imaging is significantly associated with AFRS and may serve as a useful radiological feature in differentiating AFRS from NFCRS.

Table 4. Sinus Expansion vs Final Diagnosis.

Sinus Expansion vs Final Diagnosis Crosstabulation					
Variables		**Final Diagnosis**		**Total**	**P Value**
		AFRS	NFCRS		
Sinus Expansion	Absent	3	70	73	0.001
	Mild	3	7	10	
	Moderate	8	7	15	

	Severe	1	1	2	
Total		15	85	100	

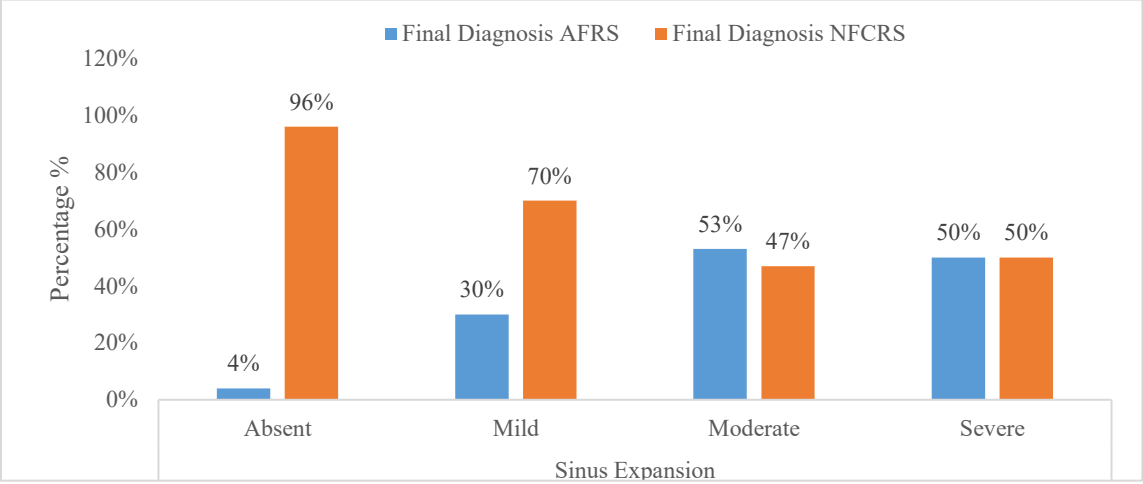

Figure 5:.Distribution of Sinus Expansion (absent to severe) in relation to final diagnosis.

Analysis of bony remodeling revealed a notable difference between AFRS and NFCRS patients. Absence of bony remodeling was observed exclusively in NFCRS cases (100%, n = 16), with no AFRS patient showing this finding. Mild bony remodeling was predominantly associated with NFCRS (92%, n = 24), while only a small proportion of AFRS cases (8%, n = 2) demonstrated mild changes. Moderate bony remodeling was found entirely in NFCRS patients (100%, n = 24). In contrast, severe bony remodeling showed a relatively higher proportion of AFRS cases (38%, n = 13), although NFCRS cases (62%, n = 21) were still more frequent in absolute number. The Chi square test established a highly statistically considerable association among bony remodeling and final diagnosis (p = 0.001). As the p value is less than 0.05, this confirms a significant relationship between the severity of bony remodeling and AFRS. These findings suggest that while absent to moderate bony remodeling favors NFCRS, the presence of severe bony remodeling increases the likelihood of AFRS and may serve as an important radiological feature in differentiating between the two conditions on CT imaging.

Table 5. Bony Remodeling vs Final Diagnosis.

Bony Remodeling vs Final Diagnosis Crosstabulation					
Variables		**Final Diagnosis**		**Total**	**P Value**
		AFRS	NFCRS		
Bony Remodeling	Absent	0	16	16	0.001
	Mild	2	24	26	
	Moderate	0	24	24	
	Severe	13	21	34	
Total		15	85	100	

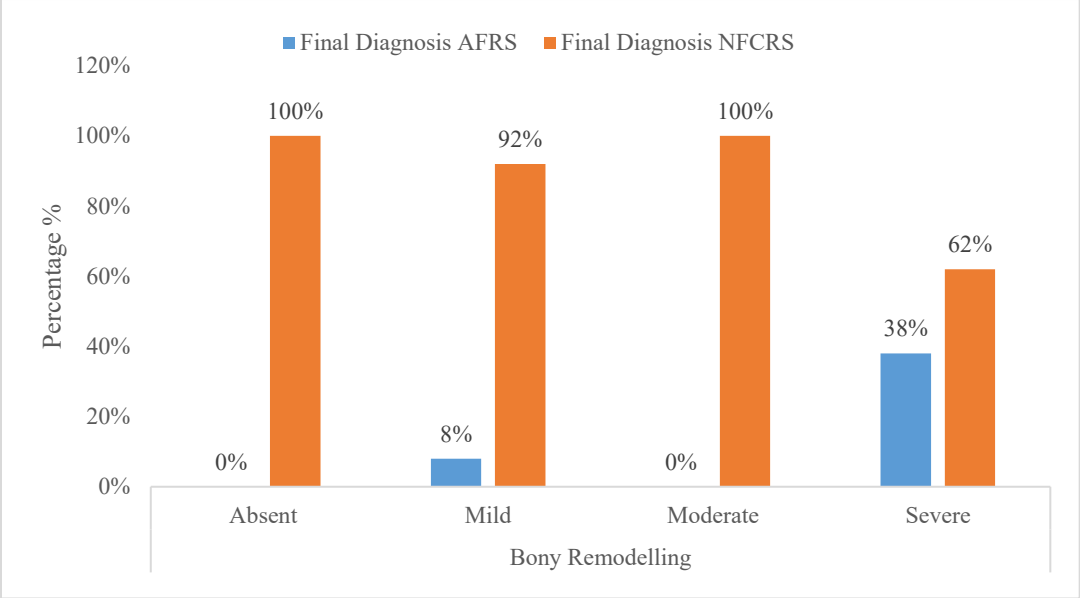

Figure 6. Distribution of Bony Remodeling vs final diagnosis.

Evaluation of erosion of the lamina papyracea demonstrated a strong association with AFRS. Absence of lamina papyracea erosion was predominantly observed in NFCRS patients (90%, n = 84), whereas only 10% (n = 9) of AFRS cases showed no erosion. Mild erosion was more frequently seen in AFRS patients (67%, n = 2) compared to NFCRS (33%, n = 1). Notably, all cases with moderate (100%, n = 3) and severe erosion (100%, n = 1) were exclusively diagnosed as AFRS, with no NFCRS cases demonstrating these findings. These results indicate that the presence and increasing severity of lamina papyracea erosion on CT imaging are highly suggestive of AFRS rather than NFCRS. The Chi square test revealed a highly statistically considerable association among lamina papyracea erosion and final diagnosis (p = 0.001). As the p value is lesser than 0.05, this states a significant relationship among the degree of bony AFRS and erosion. These findings strongly support that moderate to severe erosion of the lamina papyracea is a key radiological marker in differentiating AFRS from NFCRS.

Table 6. Erosion Lamina Papyracea vs Final Diagnosis.

Erosion Lamina Papyracea vs Final Diagnosis Crosstabulation					
Variables		**Final Diagnosis**		**Total**	**P Value**
		AFRS	NFCRS		
Erosion Lamina Papyracea	Absent	9	84	93	0.001
	Mild	2	1	3	
	Moderate	3	0	3	
	Severe	1	0	1	
Total		15	85	100	

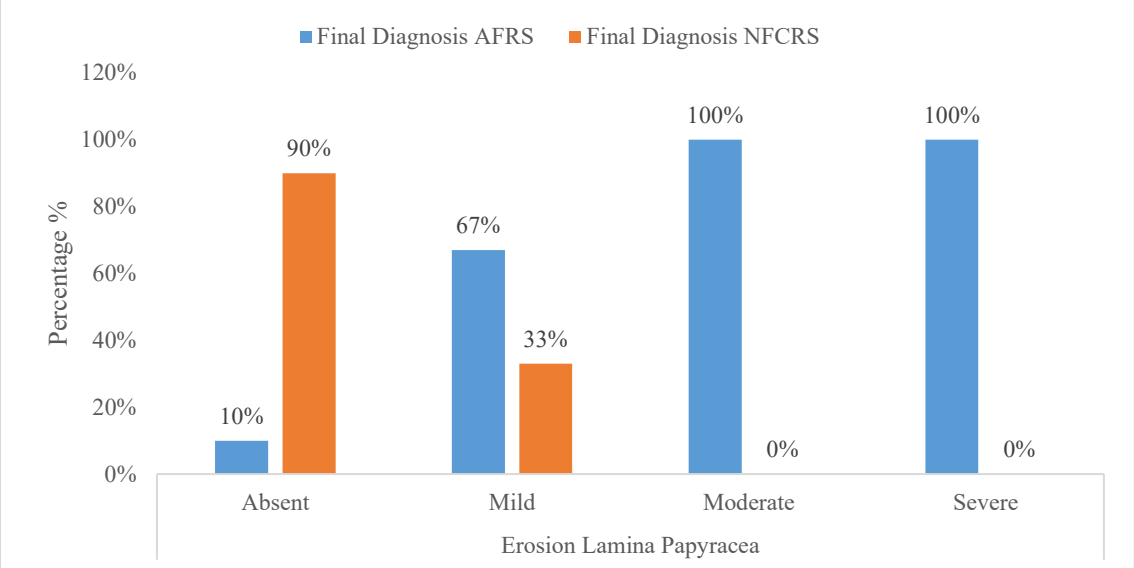

Figure 7. Distribution of Erosion Lamina Papyracea vs final diagnosis.

Assessment of multiple sinus involvement revealed a distinct difference between AFRS and NFCRS groups. Absence of multiple sinus involvement was observed exclusively in NFCRS patients (100%, n = 16), with no AFRS cases in this category. Mild involvement was predominantly associated with NFCRS (92%, n = 24), while only a small percentage of AFRS patients (8%, n = 2) demonstrated mild disease. The cases of moderate multiple sinus involvement were observed in the cases of NFCRS (100% n = 24). Conversely, severe multiple sinus involvement had a relatively higher percentage of AFRS cases (38%, n = 13), although NFCS cases (62%, n = 21) were more common in absolute numbers. The Chi square test revealed that there was a very statistically considerable relationship among multiple sinus involvement and final diagnosis (p = 0.001). As the p value is lesser more than 0.05, this confirms a considerable association among the extent of sinus involvement and AFRS. These results indicate that, although absent to moderate multiple sinus involvement is favored by NFCRS, severe involvement is more likely to achieve AFRS and can be useful as a radiological indicator to differentiate between AFRS and NFCRS when multiple sinus involvement is severe.

Table 7. Multiple Sinus Involvement vs Final Diagnosis.

Multiple Sinus Involvement vs Final Diagnosis Crosstabulation					
Variables		**Final Diagnosis**		**Total**	**P Value**
		AFRS	NFCRS		
Multiple Sinus Involvement	Absent	0	16	16	0.001
	Mild	2	24	26	
	Moderate	0	24	24	
	Severe	13	21	34	
Total		15	85	100	

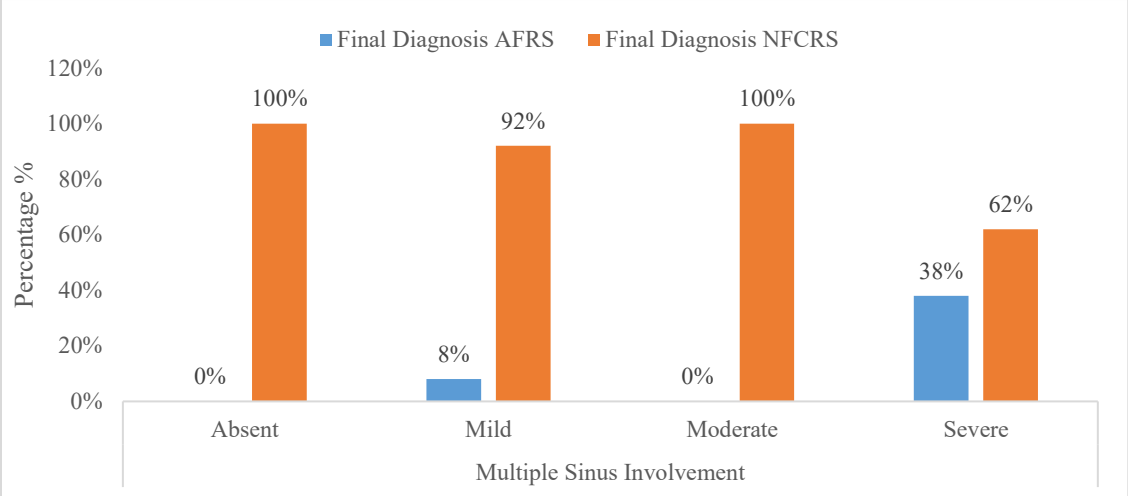

Figure 8. Distribution of Multiple Sinus Involvement vs final diagnosis.

Calcifications assessment showed that there is a definite difference between AFRS and NFCRS groups. Lack of calcifications was mostly found in NFCRS patients (89% or n = 82, out of 92), but not in AFRS patients (11% or n = 10, out of 92). no calcifications. Only AFRS patients (100% n= 2) showed signs of mild calcifications with no corresponding NFCRS cases. On the same note, the moderate calcifications were completely correlated with AFRS (100%, n = 3). In contrast, severe calcifications were noted only in NFCRS patients (100%, n = 3). The Chi square test concluded a very statistically considerable relationship among calcifications and final diagnosis (p = 0.001). Since the p value is lower than 0.05. It confirms that there is significant relationship between the pattern of calcifications and AFRS. These results point to a strong preference of a diagnosis of AFRS on CT scan images as compared to the absence of mild to moderate calcifications or severe calcifications.

Table 8. Calcifications vs Final Diagnosis.

Calcifications vs Final Diagnosis Crosstabulation					
Variables		**Final Diagnosis**		**Total**	**P Value**
		AFRS	NFCRS		
Calcifications	Absent	10	82	92	0.001
	Mild	2	0	2	
	Moderate	3	0	3	
	Severe	0	3	3	
Total		15	85	100	

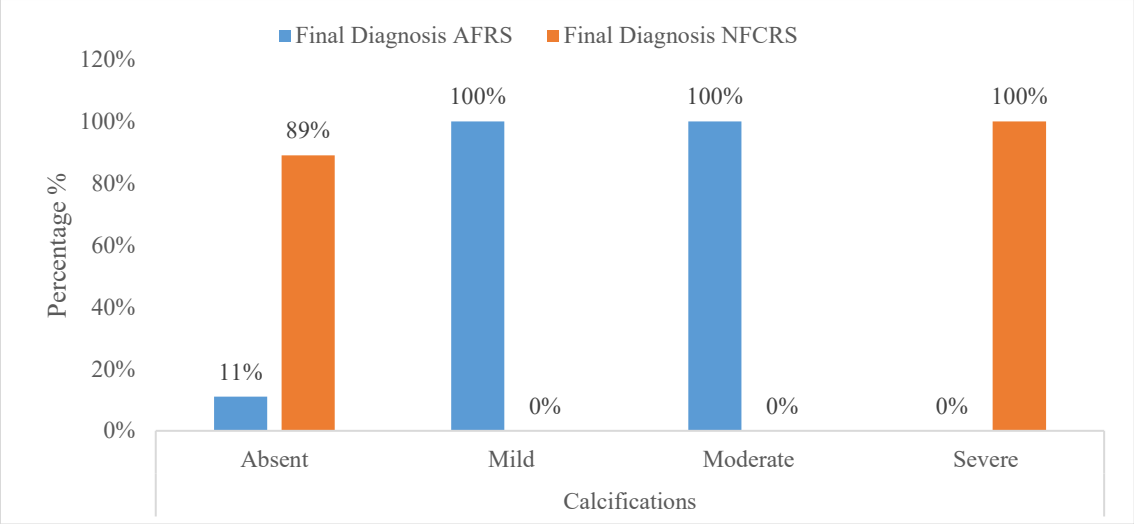

Figure 9. Distribution of Calcifications vs final diagnosis.

Assessment of unilateral or bilateral sinus involvement demonstrated a notable difference between AFRS and NFCRS groups. Unilateral disease was predominantly observed in NFCRS patients, accounting for 95% (n = 35) of unilateral cases, while only 5% (n = 2) were diagnosed as AFRS. In contrast, bilateral involvement showed a relatively higher association with AFRS, where 21% (n = 13) of bilateral cases were AFRS compared to 79% (n = 50) NFCRS. The Chi square test revealed a statistically considerable association among sinus involvement and final diagnosis (p = 0.039). As the p value is less than 0.05, this confirms that unilateral sinus involvement favors a diagnosis of NFCRS, whereas bilateral disease is more suggestive of AFRS on CT imaging.

Table 9. Unilateral or Bilateral vs Final Diagnosis.

Unilateral or Bilateral vs Final Diagnosis Crosstabulation					
Variables		**Final Diagnosis**		**Total**	**P Value**
		AFRS	NFCRS		
Unilateral or Bilateral	Unilateral	2	35	37	0.039
	Bilateral	13	50	63	
Total		15	85	100	

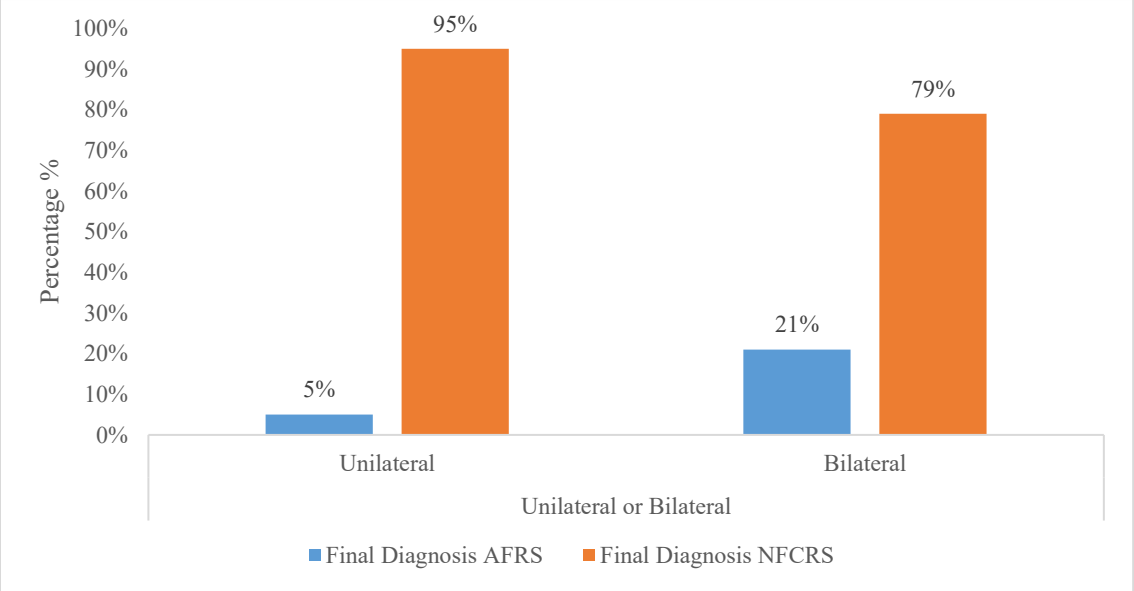

Figure 10. Distribution of unilateral and bilateral sinus involvement vs final diagnosis.

4. DISCUSSION

The present study was conducted to analyze and compare computed tomography (CT) imaging features in patients diagnosed with Allergic Fungal Rhinosinusitis (AFRS) and Non Fungal Chronic Rhinosinusitis (NFCRS), with the primary aim of identifying key radiological distinctions that facilitate accurate differentiation. CT imaging remains the modality of choice for evaluating chronic rhinosinusitis due to its superior ability to delineate sinus anatomy, disease extent, and bony alterations. In resource limited settings like Pakistan, where laboratory and immunological testing are often inaccessible, CT based distinction becomes even more critical for guiding appropriate clinical management.

In our study, the majority of participants were male (61%) and belonged to the 21–40 years age group (55%), which aligns with previous literature indicating that AFRS and NFCRS predominantly affect young to middle aged adults. Dhanani et al. (2021) reported a similar mean age of 37.3 years in their Pakistani cohort, while Salamah et al. (2020) found a mean age of 33.6 years in Saudi Arabian patients with AFRS [17,18]. This consistent demographic pattern suggests that CRS subtypes significantly impact the economically productive segment of the population, thereby amplifying socioeconomic consequences.

Clinically, nasal obstruction was the most common presenting symptom (88%), observed more frequently in NFCRS (74%) than AFRS (14%). A history of allergy or asthma was noted in 16% of patients but showed relatively greater association with AFRS (6% vs 10% in NFCRS). These findings support the established etiological role of atopy and type I hypersensitivity in the pathogenesis of AFRS, as highlighted by Kim et al. (2022) and Cameron et al. (2023) [19,20]. The significant p values (<0.05) for all clinical variables confirm that although symptoms overlap, certain features like allergic history can provide diagnostic clues when combined with radiological evidence.

The most striking radiological finding in our study was hyperdense sinus content, which demonstrated a highly significant association with AFRS ($p = 0.001$). Moderate hyperdensity was observed exclusively in AFRS patients (100%), and severe hyperdensity was also more prevalent in AFRS (71.4%) compared to NFCRS (28.6%). Conversely, absence of hyperdense material was seen in 97.5% of NFCRS cases. These results are consistent with the observations of Bracanovic et al. (2021) and Alsalem et al. (2024), who reported that hyperattenuating sinus contents often termed the "double density sign" represent a characteristic feature of AFRS due to the presence of allergic mucin mixed with fungal debris and inflammatory

cells [21,22]. Therefore, the presence of moderate to severe hyperdense sinus content on CT should strongly raise suspicion for AFRS.

Heterogeneous opacification similarly provided clear differentiation between the two groups. Severe heterogeneous opacification was strongly associated with AFRS (64% of cases), whereas mild to moderate opacification was more common in NFCRS. Notably, all cases with absent heterogeneous opacification were diagnosed as NFCRS (100%). This pattern aligns with the pathophysiology of AFRS, wherein thick allergic mucus, fungal elements, and inflammatory exudates create a non uniform, heterogeneous appearance on CT imaging. Our findings corroborate those of Chen et al. (2024) and Wang et al. (2022), who emphasized that heterogeneous intrasinus densities are a hallmark of AFRS [23,24].

Sinus expansion and bony remodeling were also significantly associated with AFRS ($p = 0.001$). Moderate sinus expansion was seen in 53% of AFRS cases, and severe bony remodeling was more frequent in AFRS (38%) than NFCRS (24.7%). These observations are consistent with the chronic pressure effects induced by accumulated allergic mucin, which causes expansion of sinus cavities and remodeling of adjacent bony walls without actual fungal invasion. Salamah et al. (2020) reported sinus expansion in 35.3–51.2% and bony remodeling in 20.6–37.2% of their AFRS cases, closely matching our results [25].

Perhaps the most definitive radiological marker identified was erosion of the lamina papyracea. Moderate and severe erosion were observed exclusively in AFRS patients (100% each), while mild erosion was also more common in AFRS (67% vs 33% in NFCRS). The Chi square test confirmed a highly significant association ($p = 0.001$). This finding underscores the aggressive but non invasive nature of AFRS, wherein bone erosion results from prolonged pressure and remodeling rather than direct fungal invasion. Yadav et al. (2023) and Roland et al. (2023) similarly reported that bony erosion, particularly of the lamina papyracea, is a key feature distinguishing AFRS from other forms of CRS and is associated with higher risk of orbital complications [26,27].

Calcifications provided another discriminating feature. Mild and moderate calcifications were seen only in AFRS (100% each), whereas severe calcifications were observed only in NFCRS. This aligns with the work of Yamauchi et al. (2017), who noted that intrasinus calcifications are more frequently detected in fungal sinusitis, though their study found MDCT (84.2%) superior to CBCT (46.2%) for detecting such calcifications [28]. The presence of mild to moderate calcifications should therefore prompt consideration of AFRS.

Regarding disease laterality, unilateral involvement strongly favored NFCRS (95% of unilateral cases), while bilateral disease showed greater association with AFRS (21% vs 79% in NFCRS; $p = 0.039$). This pattern is consistent with the diffuse, inflammatory nature of AFRS, which tends to involve multiple sinuses bilaterally, whereas NFCRS often remains localized. Cha et al. (2023) similarly reported unilateral lesions in 80.4% of fungal rhinosinusitis cases, though their cohort included fungal balls, which may account for the higher unilateral predominance [29].

5. CONCLUSION

CT imaging is indispensable for differentiating AFRS from NFCRS. The presence of hyperdense sinus content, severe heterogeneous opacification, sinus expansion, bony remodeling, lamina papyracea erosion, mild to moderate calcifications, multiple sinus involvement, and bilateral disease strongly favors AFRS. Conversely, the absence of these features with unilateral disease suggests NFCRS. Systematic evaluation of these CT signs enhances diagnostic accuracy and guides appropriate clinical management.

6. LIMITATIONS

- Single center design and small sample size (n=100) limit generalizability.
- No histopathological, microbiological, or immunological correlation.
- Cross sectional design prevents assessment of disease progression.

- Inter observer variability was not evaluated.

7. RECOMMENDATIONS

- Routine use of CT imaging should be standard for distinguishing AFRS from NFCRS.
- Radiologists should be trained to identify key features: hyperdense contents, calcifications, sinus expansion, bony remodeling, and lamina papyracea erosion.
- Future multi center studies with larger sample sizes are needed to validate these findings.
- CT findings should be correlated with histopathology, fungal cultures, and immunological tests for definitive diagnosis.
- A standardized CT reporting system should be developed to reduce inter observer variability.

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