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RIMSHA AJMAL

SU91-MSAHW-S24-013

FAHS

**Analysis of Computed Tomography Imaging Features in Diagnosis of Allergic
Fungal Rhinosinusitis Versus Non-Fungal Chronic Rhinosinusitis**



SUPERIOR UNIVERSITY

Thesis Submitted to

The Superior University Lahore

In Partial Fulfillment of the

Requirement for the Degree of

Master of Science in Allied Health Sciences

By

(RIMSHA AJMAL)

Roll No. SU91-MSAHW-S24-013

Session: 2024-2026

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Supervisor Name: Zubair sharif

Designation: Lecturer

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This is to certify that the research work presented in this thesis, titled “**Analysis of Computed Tomography Imaging Features in Diagnosis of Allergic Fungal Rhinosinusitis Versus Non-Fungal Chronic Rhinosinusitis**” was conducted by “**Rimsha Ajmal**” under the supervision of “**Zubair Sharif**”

No part of this thesis has been submitted anywhere else for any other degree. This thesis is submitted to the Faculty of Allied Health Sciences, The Superior University, Lahore in partial fulfillment of the requirements for the degree of Master of Science in the field of “**Allied Health Sciences**” in Faculty of Allied Health Sciences at The Superior University, Lahore.

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DEDICATION

In the name of ALMIGHTY ALLAH, the most Gracious and the most Merciful, thanks and praise to ALLAH due to his abundant blessings and guidance in my life. I owe it to Him, because He bestowed me with strength, patience and perseverance to have the completion of this thesis. The challenges and the chances throughout the way have not only formed my perceptions but also made me more proficient at what I do and made me a better individual in general.

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I pray to Allah to bless my supervisor, my parents long, healthy and prosperous life and give me the wisdom and strength to work towards the improvement of human life.

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LIST OF ABBREVIATIONS

(Abbreviations not explained in the text)

AFRS	Allergic Fungal Rhinosinusitis
NFCRS	Non-Fungal Chronic Rhinosinusitis
CRS	Chronic Rhinosinusitis
CT	Computed Tomography
PNS	Paranasal Sinuses
NCCT	Non-Contrast Computed Tomography
ENT	Ear, Nose and Throat
HU	Hounsfield Unit
IRB	Institutional Review Board
MRI	Magnetic Resonance Imaging

ABSTRACT

Certain radiological characteristics assist distinguish (AFRS) from (NFCRS), a unique subtype of chronic rhinosinusitis. Due to variations in treatment and prognosis, early and precise distinction is crucial.

The goal is to evaluate the computed tomography (CT) imaging characteristics of AFRS and NFCRS and pinpoint important radiological distinctions that support diagnosis. Over the course of four months, this comparative cross-sectional study was conducted out at the District Headquarters Hospital's CT Scan Center in Kasur. There were 85 occurrences of NFCRS and 15 incidences of AFRS among the 100 individuals with clinically confirmed chronic rhinosinusitis. Clinical, CT imaging, and demographic characteristics were examined. The Chi- square test was utilized to determine statistical associations, with $p < 0.05$ considered significant.

The majority of participants were male (61%) and aged 21–40 years (55%). Nasal obstruction was the most common symptom (88%), predominantly in NFCRS patients ($p < 0.05$). CT findings demonstrated highly significant associations with final diagnosis ($p = 0.001$). Moderate hyperdense sinus content was observed exclusively in AFRS patients (100%), while absence of hyper-density was predominantly seen in NFCRS (97.5%). Severe heterogeneous opacification (64%), moderate sinus expansion (53%), severe bony remodeling (38%), and moderate to severe erosion of the lamina papyracea (100%) were strongly associated with AFRS. Mild to moderate calcifications were exclusively observed in AFRS, whereas unilateral disease favored NFCRS (95%), and bilateral involvement showed greater association with AFRS (21%) ($p = 0.039$).

In summary, CT imaging is essential for distinguishing AFRS from NFCRS. AFRS is highly suggested by characteristics including hyperdense sinus content, severe heterogeneous opacification, sinus enlargement, bone erosion, internal calcifications, numerous sinus involvement, and bilateral illness. A thorough assessment of CT results improves diagnostic precision and supports suitable clinical management techniques.

Chapter 1

INTRODUCTION

Due to its high prevalence, protracted duration, and significant socioeconomic burden, CRS is one of the most common chronic inflammatory disorders affecting the respiratory tract and a major worldwide health concern.[1] It is characterized by inflammation of the nose and paranasal sinuses that lasts for at least 12 weeks in a row and is followed by symptoms such as nasal congestion or obstruction, mucopurulent nasal discharge, pressure or pain in the face, and diminished or absent sense of smell. In addition to having an adverse effect on physical health, the illness seriously lowers quality of life by interfering with sleep, focus, and day-to-day activities.[2]

According to epidemiology, 10–12% of the general population has CRS, with higher prevalence found in humid and industrialized areas. It significantly raises both direct and indirect healthcare expenditures and is regarded as one of the main reasons for outpatient visits in otolaryngology clinics.[3] Long-term medicine, frequent medical visits, and surgical procedures are frequently necessary for patients, which raises healthcare costs and reduces productivity. CRS causes psychological stress in addition to its physical symptoms, which can result in anxiety, sadness, and decreased social contact because of recurrent and persistent symptoms.[4]

Clinically speaking, there are two main forms of CRS: CRSwNP and CRSsNP. Based on immunological, microbiological, and etiological variables, several subgroups have been discovered within these phenotypes. AFRS, a non-invasive kind of fungal rhinosinusitis marked by a kind I hypersensitivity reaction to fungal antigens in the environment, is one of the most distinctive and clinically relevant subtypes.[5] AFRS is currently acknowledged as a unique subtype of eosinophilic CRS, having been initially identified as a distinct clinical entity in the late 20th century. Immunocompetent young adults with atopy or allergy symptoms are most frequently affected. Thick, extremely viscous "allergic mucin," which is rich in degenerating eosinophils, Charcot-Leyden crystals, and dispersed fungal hyphae, is what defines it.[6] This allergic mucin causes the surrounding bony walls to remodel and the sinuses to enlarge due to persistent inflammation. In extreme circumstances, the illness may spread outside of the sinuses and result in orbital problems, proptosis, or facial deformities as a result of bone erosion and pressure

effects.[7] Because fungal spores flourish in warm, humid climates, AFRS is especially common there. The southern United States, Saudi Arabia, Sudan, India, Pakistan, and other nations have reported high incidences, indicating that geographic and climatic conditions are important in its pathogenesis.[8]

Due to a lack of diagnostic resources, general practitioners' ignorance, and the clinical presentation overlap with other forms of CRS, the true prevalence of AFRS in Pakistan is still underreported. As a result, many cases are either misdiagnosed as simple CRS or are only identified at a later stage, after substantial anatomical alterations and problems have already taken place.[9] A combination of radiographic, histological, and clinical assessment is needed to diagnose AFRS. The most important imaging technique among them is paranasal sinus computed tomography (CT). CT is a crucial tool for both diagnosis and preoperative planning because it offers superior delineation of sinus anatomy, the degree of illness, and bone involvement.[10]

Heterogeneous patches of hyper-density within the sinuses, commonly known as the "double-density sign," are characteristic CT findings of AFRS. These areas include allergic mucus scattered with fungal debris and inflammatory components. Additional radiographic characteristics that can differentiate AFRS from non-fungal CRS include sinus extension, thinning or erosion of bone walls, and remodeling of nearby structures.[11] Non-fungal CRS, on the other hand, usually shows uniform mucosal thickening or opacification, frequently without hyperdense foci or notable bony alterations. However, it is difficult to distinguish between AFRS and non-fungal CRS based only on symptoms because both conditions have comparable clinical signs, such as nasal blockage, nasal discharge, and facial pressure. Misclassification frequently results from this diagnostic overlap, especially in areas with few sophisticated laboratory and imaging resources.[12]

Because of these difficulties, proper diagnosis and treatment of CRS subtypes depend heavily on CT-based radiological distinction. Since the treatment of AFRS is very different from that of non-fungal CRS, accurate diagnosis is essential. Surgical removal of allergenic mucin is usually necessary for AFRS. (Functional Endoscopic Sinus Surgery, FESS) in conjunction with systemic corticosteroid therapy to manage the inflammatory and allergic reaction, while non-fungal CRS may benefit from standard

medical treatment on its own.[13]

Comparative research on the radiological distinction between AFRS and non-fungal CRS in South Asian populations is conspicuously lacking, despite the clinical importance of AFRS and its unique imaging characteristics. The bulk of the literature that is now accessible comes from Western nations, which have very different patient populations and climates. Furthermore, delayed diagnosis, repeated treatment failures, and disease recurrence are all caused by radiologists' and ENT specialists' lack of knowledge about unique CT findings of AFRS in Pakistan.[14]

In order to close this diagnostic gap, the current investigation compares the CT imaging characteristics of individuals with AFRS and non-fungal CRS in a South Asian context. The goal of this research is to improve patient outcomes by facilitating earlier surgical planning, improving diagnosis accuracy, and identifying particular CT characteristics that differentiate the two disorders.[15] The current work focuses on using CT imaging analysis to radiologically distinguish between non-fungal CRS and AFRS. In patients who report with persistent sinonasal symptoms, the study aims to evaluate, compare, and pinpoint particular CT imaging features that can accurately differentiate between these two clinically similar illnesses.[16]

The climate, ecology, and healthcare systems in Pakistan, the South Asian country where this study is being undertaken, are very different from those in the West. The warm, humid climate of Pakistan fosters the growth of fungi, which may have an impact on the frequency and manifestation of AFRS. [17] In spite of this, little local research has been done to describe and contrast the imaging characteristics of AFRS and non-fungal CRS. Patients who visit the radiology and otolaryngology (ENT) departments at tertiary care hospitals, where diagnostic imaging is frequently employed for assessment and surgery planning in chronic sinus illnesses, make up the majority of the research population.[18] The project attempts to produce context-specific radiological data that reflect the distinct epidemiological and environmental factors impacting disease trends in South Asia by concentrating on this geographical population. Given the high prevalence of fungal sinus illnesses, this geographical focus is very important. and the lack of diagnostic tools in many regions of the nation.[19] The study's main diagnostic method for assessing chronic rhinosinusitis (CRS) is paranasal sinus Non-Contrast Computed Tomography (NCCT). In

order to distinguish AFRS from non-fungal CRS, CT imaging provides thorough visualization of sinus architecture, mucosal disease extent, skeletal alterations, and the presence of hyperdense material.[20]

Characteristic CT features, such as patterns of sinus opacification (homogeneous vs. heterogeneous), the presence or absence of hyperdense areas (the "double-density sign"), sinus expansion and remodeling, bony erosion or thinning, laterality (unilateral vs. bilateral involvement), and the degree of disease across affected anatomical sites, are the main focus of the analysis. The study intends to identify important radiological markers that can function as trustworthy indicators for differentiating AFRS from non-fungal CRS during normal diagnostic workups by comparing these characteristics.[21]

Patients who have had CT imaging as part of their diagnostic evaluation and have been clinically and radiologically diagnosed with chronic rhinosinusitis (CRS) will be included in the study. Patients of all ages, both male and female, will be taken into consideration as long as they fulfil the requirements for CRS diagnosis according to accepted clinical guidelines, which include symptoms lasting at least 12 weeks.[22] Patients who attend tertiary care facilities with integrated radiology and ENT services will make up the study population. Acute sinus infections, invasive fungal sinusitis, post-traumatic or post-surgical sinus alterations, and immunocompromised condition are among the exclusion criteria. In order to establish a clear comparative framework, these criteria guarantee that the study solely concentrates on non-invasive forms of CRS, specifically Allergic Fungal Rhinosinusitis (AFRS) and non-fungal CRS.[23]

The duration of the data collecting period is predetermined (e.g., one year; the precise duration will be detailed in your Methodology chapter). All qualified patients who fit the inclusion criteria and have access to CT scans will be assessed within this time limit.[24] Skilled radiologists will use standardized criteria to analyses and interpret CT scans. To detect imaging patterns that significantly differ between the two groups, the results will next be statistically compared.[25] Thematically, the study focuses on comparative analysis and radiological pattern detection. Investigating histopathological or microbiological results is not the study's goal.

In-depth but instead emphasizes CT-based imaging discrimination as a useful diagnostic strategy, which is particularly helpful in situations where sophisticated laboratory or

immunological testing might not be easily accessible. Additionally, by linking imaging characteristics with the most likely subtype of CRS, this research aims to close the clinical and radiological gap and assist otolaryngologists in establishing more precise preoperative diagnosis and choosing the best course of therapy.[26]

Despite being thorough, the study had a number of limitations. It ignores invasive fungal infections and malignant lesions and only concentrates on non-invasive forms of CRS. MRI, histology, and immunological testing are not included in this study because the diagnostic focus is on CT imaging.[27] Because the study was conducted in a hospital, the results may not be as applicable in community settings. Even while the sample size is adequate for comparison study, it might not accurately reflect all geographical differences across the nation. Notwithstanding these drawbacks, the study offers insightful information about the radiological differences between AFRS and non-fungal CRS and lays the groundwork for future multicenter or multidisciplinary research in the area.[28]

Worldwide, chronic rhinosinusitis (CRS), especially its fungal and allergic forms, continues to be a clinical and diagnostic issue. The quality of life is greatly impacted by its chronic and recurrent nature, which leads to prolonged morbidity, frequent medical visits, and a huge financial burden on individuals and healthcare systems. The effects of CRS are significantly more severe in areas like South Asia, where fungal development is encouraged by the environment and access to healthcare is still uneven. Due to its different pathophysiology, aggressive behavior, and greater recurrence rate, AFRS has become a separate subtype of CRS that requires special treatment. A type I hypersensitivity response to fungal antigens that causes eosinophilic inflammation and the buildup of allergic mucus in the sinuses is the hallmark of AFRS. Despite being a non-invasive condition, AFRS differs from other types of CRS in that it often causes sinus extension, bony remodeling, and orbital problems. However, reliable distinction based only on symptoms or endoscopic results becomes challenging because AFRS and non-fungal CRS present similarly in terms of nasal blockage, discharge, and face pain. This diagnostic uncertainty frequently leads to inappropriate or delayed treatment, raising the possibility of problems and recurrence.

The gold standard imaging technique for assessing CRS is still computed tomography (CT) of the paranasal sinuses. It offers vital details on the type of sinus opacification, bone

integrity, and the anatomical extent of the disease. Heterogeneous hyperdense contents (the "double-density sign"), extension of affected sinuses, and regions of bone weakening or erosion are among the characteristic CT findings associated with AFRS. On the other hand, non-fungal CRS typically manifests as consistent thickening of the mucosa without substantial bone loss. When correctly read, these radiological patterns enable physicians to differentiate between AFRS and non-fungal CRS and adjust the treatment strategy appropriately. Since laboratory and immunological tests are frequently unavailable or too expensive, radiographic diagnosis is the main method of distinguishing CRS subtypes in many underdeveloped nations, including Pakistan. Therefore, better knowledge of certain CT imaging signals becomes essential for increasing diagnostic precision in healthcare settings with limited resources.

The treatment of AFRS is very different from that of non-fungal CRS. While AFRS usually necessitates FESS to remove allergic mucus and fungal debris, followed by systemic corticosteroid therapy to suppress the underlying allergic response, conventional CRS frequently responds well to medical therapy. Incomplete clearance, chronic illness, or an early return could arise from failing to identify AFRS prior to surgery. In order to direct surgical planning and prevent problems, precise preoperative diagnosis based on CT findings is crucial. Furthermore, AFRS typically affects younger people—often in their prime working years—leading to a protracted illness course with serious psychological and financial ramifications. The disease's recurring nature can lead to social disengagement, mental misery, and chronic weariness, underscoring the significance of early discovery and all-encompassing treatment.

The prevalence of AFRS is higher in Pakistan and nearby South Asian nations due to their warm, humid atmosphere, which is perfect for fungal growth. In spite of this, the illness is still underdiagnosed and understudied in this area. Due to a lack of standardized diagnostic procedures or knowledge of the distinctive imaging characteristics of AFRS, many healthcare facilities are frequently misclassified as non- CRS caused by fungus. As a result, patients frequently receive repeated medical treatment without experiencing long-term recovery. By comparing CT imaging characteristics of AFRS and non-fungal CRS particularly in a South Asian population, our work fills this regional research vacuum. The findings will aid in the development of context-specific diagnostic

standards, allowing medical professionals to diagnose patients more quickly and accurately. For radiologists and ENT surgeons working in district healthcare facilities and tertiary hospitals, who primarily rely on imaging for clinical decision-making, this is particularly pertinent.

From a scientific standpoint, by providing a comparative radiological examination between AFRS and non-fungal CRS—an area that is still largely unexplored in South Asian medical research—this study adds to the expanding body of knowledge on CRS. The results will improve medical education in the area by helping radiologists, ENT specialists, and residents identify unique imaging characteristics that are frequently missed. Additionally, this study establishes the foundation for future research into cutting-edge imaging methods like high-resolution CT, radiomics, or AI-based diagnostic models by finding important CT-based factors linked to AFRS.

The main goal of this study is to better distinguish between AFRS and non-fungal CRS by identifying, contrasting, and characterizing their CT imaging characteristics. The project aims to improve diagnostic accuracy and decrease misclassification of CRS subtypes by methodically evaluating imaging results. Help ENT physicians determine the best surgical strategy based on radiographic extent. To support evidence-based diagnostic procedures in South Asia, provide baseline regional data. By achieving these goals, the project hopes to close the current diagnostic gap, encourage early and accurate disease detection, and eventually improve patient outcomes and the use of healthcare resources. It immediately increases CRS diagnosis accuracy, which affects recurrence rates and treatment outcomes. By producing native data, it fills a significant void in South Asian medical literature. Early distinction between AFRS and non-fungal CRS minimizes needless medical costs, hospital stays, and problems. It improves physicians' and radiologists' comprehension of important CT imaging characteristics that are crucial for treating sinonasal disorders. The results can help improve early detection and management of AFRS through awareness campaigns and training initiatives. Essentially, This study combines regional applicability, diagnostic innovation, and clinical significance. In addition to advancing academic understanding, the use of CT imaging for radiological distinction has the potential to revolutionize normal clinical practice in the diagnosis and treatment of chronic rhinosinusitis in settings with limited resources.

AIM AND OBJECTIVES

- To compare the CT imaging features of Allergic Fungal Sinusitis (AFS) and Non-Fungal Chronic Rhinosinusitis (NFCRS) to identify key radiological differences.

Chapter 2

LITERATURE REVIEW

Yamauchi T, et al. (2017) had a study with the objective of determining the diagnostic accuracy of non-invasive chronic fungal rhinosinusitis using CBCT and comparing it with the MDCT method. CBCT (3D Accuitomo 170) and traditional multidetector CT (MDCT) (Aquilion 32) were used to perform preoperative CT evaluation of CBCT (13 patients) and traditional multidetector CT (38 patients) in non-invasive chronic fungal maxillary sinusitis at various medical institutions. The study compared the detection of intra sinus calcifications between the two imaging modalities. The results showed that MDCT had a significantly higher detection rate of intra sinus calcifications (84.2%) than CBCT (46.2%). The researchers concluded that CBCT was inferior to MDCT in identifying intra sinus calcifications in such patients. Although CBCT is frequently used for screening paranasal lesions, it was considered insufficient for the comprehensive evaluation of non-invasive chronic fungal maxillary sinusitis as a standalone imaging modality.[29]

Salamah, et al. (2020) carried out a retrospective study in the Otorhinolaryngology Department of the King Fahad Armed Forces Hospital in Jeddah, Saudi Arabia, with the objective of studying the clinical, pathological and imaging characteristics of AFS and establish the relationship between them and the course of the disease. Forty-six cases of AFS were diagnosed and it constituted 11.8 percent of the total cases of sinusitis. The majority of the patients (54.3) were women and the mean age of the patients was 33.57 years. Most patients (93.5%), had the symptoms of chronic rhinosinusitis, with smaller percentages with symptoms of chronic headache (30.4%), or hyposmia (4.3%). It is interesting to note that 78.3% were diagnosed five years or more years after the onset of the symptoms. CT imaging frequently revealed increased intra sinus attenuation (88.2%–95.3%), complete sinus opacification (74.4%–85.3%), sinus expansion (35.3%–51.2%), bony remodeling (20.6%–37.2%), and wall thinning (41.2%–58.1%). Some cases were also characterized by adjacent soft tissue involvement (11.8%–25.6%). Histopathological findings were included eosinophilic mucin (45.7%), eosinophilic infiltration (91.3%), fungal hyphae (93.5%), and Charcot-Leyden crystals (6.5%). Radiological and pathological alterations were more extensive in patients with delayed diagnoses especially

sinus expansion and wall thinning ($p < 0.05$). The experiment revealed that early cases and control of AFS is important to avoid further development of the disease [30].

Chen, et al. (2024) conducted a systematic review with the aim to identify imaging features that are most closely related to IFRS and sought to develop a diagnostic checklist that would help in early diagnosis. The search was based on the PRISMA 2020 guidelines and the databases such as PubMed, Embase, CENTRAL, and ScienceDirect were searched up to May 2023 to find the English-language studies describing the imaging features of IFRS. The total articles were 48 articles with six of them studying AIFRS and nine articles studying CIFRS. The most frequent were those reported on CT imaging of bony erosion and mucosal thickening, followed by thickening of nasal soft tissue, nasal cavity and sinus opacification and peri sinus soft tissue infiltration. Extra sinus spreading, particularly to the orbit and intracranial regions, was common on MRI and other areas of involvement include cavernous sinus, pterygopalatine fossa, infratemporal fossa, masticator space and facial soft tissues. The authors established that IFRS is associated with high morbidity and mortality and early detection of characteristic radiological features using a structured checklist can help in the achievement of timely diagnosis and treatment. They also emphasized that further research was needed to differentiate IFRS and other diseases with similar imaging appearances such as those caused by bacteria in the orbital cellulitis [31].

Kim J, et al. (2022) proposed a definition of allergic fungal rhinosinusitis (AFRS) as a specific type of chronic rhinosinusitis with nasal polyps (CRSwNP), which is characterized by the presence of eosinophil-rich mucus and type-1 hypersensitivity responses to fungal antigens in a person with a functioning immune system. Demographically, AFRS tended to appear in a younger population with the average age under 30 years and was geographically correlated with regions with high environmental humidity. Radiographic appearances of AFRS consisted of paranasal sinus opacification, non-uniform intra sinus densities and potential demineralization or bone proliferation or abrasion of sinus walls. About 30% of AFRS patients had extra sinus expansion into intracranial and orbital spaces, but without tissue invasion. AFRS patients were generally associated with nasal congestion, thick nasal drainage and loss of sense of smell, with severe cases being characterized by visual disturbances or facial deformity. In addition,

AFRS was regarded as a difficult CRSwNP subtype to treat because it presented as sticky eosinophilic mucin that was very advanced, contain fungal hyphae, and led to a high rate of nasal polyps recurrence, affecting up to an estimated 60% of patients a few months following treatment [32].

Khalid S, et al. (2022) are a cross-sectional observational study, which has been conducted to determine the accuracy of CT scan in the detection of fungi in the paranasal sinuses and has been undertaken in the Department of Radiology at Ziauddin University Hospital, Karachi, between April and September of 2014. This was done by including patients who had clinical suspicion of fungal sinusitis, without including patients who were previously diagnosed of this situation, or patients with recurring fungal infections. CT scan examinations of paranasal sinuses were carried out on all patients and the results documented. Smear analysis to culture fungi was used as the gold standard to evaluate the accuracy of the final diagnosis. In 120 patients, 59% were males. A CT scan revealed sensitivity of 96.19, specificity of 93.33, positive predictive value of 99.01 and negative predictive value of 77.77 and a diagnostic accuracy of 95.83. The Kappa statistics of missing showed that over 82 percent agreed. The researchers came up with the conclusion that CT scan was extremely useful in diagnosing and characterizing fungal infections of the paranasal sinuses and it was also useful in establishing the extent of the disease which was used in planning the correct surgical procedure[33].

Wang Y, et al. (2022) embarked on a study with the aim of increasing the rate of diagnosing a lesser-known condition known as allergic fungal rhinosinusitis (AFRS) by examining its clinical, radiological and histopathological features, because low detection rates of fungi are typically encountered. The patients that were used in this study were those who had CRS in the Department of Otolaryngology-Head and Neck. The First Affiliated Hospital of the University of Science and Technology of China (USTC) surgery in the period between January 2015 and December 2020. Retrospective analysis of patients who had AFRS or had the diagnosis or suspicion of having the disease based on radiological or intraoperative findings were analyzed. Clinical data and specific immunoglobulin E (IgE) testing were used to classify the patients into three categories: confirmed AFRS, suspected AFRS and FBS. Out of the 631 cases of non-invasive fungal sinusitis, 29 cases were diagnosed with AFRS, 69 cases suspected with AFRS, and 533

cases with FBS. In total, 98 confirmed or suspected AFRS cases were identified, with a mean age of 34.3 years. Multiple paranasal sinus involvement was noted in 79 cases, and bilateral sinus disease in 55. Bone erosion was noticed in 25 patients. No considerable contrasts were found between AFRS and suspected AFRS groups in terms of age, eosinophil and basophil counts, total serum IgE levels, Lund-Mackay CT scores, or comorbid allergic rhinitis, asthma, and hyposmia. However, these parameters differed significantly when comparing AFRS/suspected AFRS with FBS. The study concluded that AFRS is likely underdiagnosed due to fungal detection challenges, and diagnosis should rely on comprehensive clinical, radiological, laboratory, and histopathological evaluation. When clinical, radiological, and immunological features are strongly suggestive of AFRS, the diagnosis may still be considered even in the absence of direct fungal evidence, to avoid disease recurrence.[34]

Bahethi R, et al. (2024) conducted a systematic review in the aim of comparing the clinical symptoms and outcomes of CIFRS and GIFRS, two of the rarest types, which were mainly distinguished by the prevalence of non-caseating granulomas in GIFRS. A thorough search plan was developed to trace the research in Cochrane, EMBASE and PubMed databases since its inception up to January 2022. All the studies were filtered by two independent reviewers who included all the studies involving patients diagnosed with CIFRS or GIFRS and where necessary chi-square was used. A total of 51 studies were included that research involved 513 patients (389 with CIFRS and 124 with GIFRS). CIFRS was found to be more common among immunocompromised and diabetic patients ($p < 0.0001$; $p = 0.02$). CIFRS patients were more likely to have nasal discharge ($p = 0.0001$), nasal obstruction ($p = 0.03$), congestion ($p = 0.001$), and systemic symptoms of fever, facial pain ($p = 0.007$) and headache ($p = 0.004$) but none of the GIFRS patients had fever. *Aspergillus* species were found to be the most prevalent causes in both cohorts with a marginally greater prevalence in GIFRS ($p = 0.01$) and GIFRS cases exhibiting significantly more no identifiable organisms ($p = 0.0006$). Patients with CIFRS had a much higher mortality ($p = 0.0008$). The research determined that CIFRS exhibited more severe symptoms and worse prognoses, especially in immunocompromised individuals, and GIFRS had a more laid-back progression in immunocompetent patients. The importance of understanding these variations in clinical presentation and prognosis was

highlighted to make sound diagnosis and care [35].

The study by Çankal F, et al. (2021) examined the radiological evaluation of AFS, reporting that the number of cases reported in warm climates has drastically grown in recent years. Fungal sinusitis has been sub-categorized into five different subtypes over the past 20 years and it is imperative to distinguish between these types and determine the radiological features of each subtype to make a timely diagnosis and treatment. The purpose of the study was to ascertain even if a new radiologic finding, serrated turbinate appearance, could aid in distinguishing AFS and non-AFS rhinosinusitis. The sample consisted of 120 patients who had paranasal sinus CT in January-September 2019-2021. AFS was defined as a group of patients who had allergies and/or fungal culture and the rest constituted the non-AFS group. CT scans were evaluated in the way serrated turbinate appeared, nasal polyps, bone erosion, and hyper-density. The serrated turbinate appearance was much more prevalent among the AFS group ($p < 0.05$), but bone erosion, polyps, and hyper density were not considerably different among groups ($p > 0.05$). The results showed that the existence of the serrated turbinate appearance might be a helpful radiological indicator of AFS. The research also suggested the assessment of bone erosion as an independent variable and suggested adding bone density measurement to the clinical cases of sinus opacification [36].

Khullar T, et al. (2022) examined imaging features of acute invasive fungal rhinosinusitis during the COVID-19 pandemic and found a significant reemergence of this disease, especially by *Mucor* species, which were not previously very common. This was named COVID-associated mucormycosis (CAM), and was discovered to be a severe and frequently fatal complication in both patients with active COVID-19 infection and recovered patients within the past 4-6 weeks. The research examined different imaging characteristics that suggest early invasion in CAM and established a comprehensive checklist of quick and clinically pertinent reporting. Findings indicated that emphysematous or ulcerative mucosal alterations in the nasal cavity were early signs of imaging of CAM. Also, the presence of periantral soft tissue and soft tissue in the pterygopalatine fossa was also a valuable clue of extra sinus invasion. Multidirectional spread was observed to be aided by the disease involvement in the pterygopalatine fossa, and was deemed a very important location to consider. These features were commonly

observed even when there were no bony erosions, indicating the neurovascular diffuse of infection. Intra-orbital and intra-cranial extensions proved to be fairly frequent as well. The researchers found that the early and subtle CT imaging findings of CAM were crucial in timely diagnosis, prognosis, and the extent of disease in determining the surgical management of the disease [37].

Abesi F, et al. (2022) also discovered a case study of a 48-year-old female patient with diabetes who had recently been diagnosed with COVID-19 and presented to the Maxillofacial Radiology Center at Babol, Iran. With the patient having a specific health condition (diabetes) and a clinical and radiological picture, in particular, a clear bone destruction, the invasive form of fungal sinusitis was put in the first place in the list of the possible diagnoses, which is one of the typical post-COVID-19 conditions. The results of CBCT were important in determining the size of the lesion and the underlying bony involvement. The research indicated that CBCT imaging had proved to be very helpful in the process of identifying anatomical variations and sinus lesion, particularly bone destruction. Early diagnosis with CBCT enhanced prompt treatment which resulted in a rapid recovery in the patient.[38].

Alsalem S, et al. (2024) carried out a retrospective analysis to assess the diagnostic significance of MRI signal intensity in comparison to CT Hounsfield units (HU) inpatients with pathologically confirmed allergic fungal sinusitis (AFS). The research involved 111 patients who during the period between January 2012 and December 2022, both underwent CT imaging and an MRI assessment in King Saud Medical City in Riyadh, Saudi Arabia. The results of the MRI images (i.e., signal voids on T1-weighted and T2-weighted images (T2WI) and radiographic densities of the sinus opacities on the CT including the mean HU values were collected and analyzed. To establish the effectiveness of these radiographic features in the prediction of AFS and to determine the optimum cutoff values, receiver operating characteristic (ROC) curves were used. Patients were 31.9 ± 15.6 years old with the majority being females (66.7%). The predominant symptom was reported to be nasal obstruction in 65.8% of the patients. The research showed that there was moderate predictive performance between CT HU and MRI T2WI signal voids (area under the curve: 0.856, $P = 0.001$). An HU cutoff of 69.5 was determined, which had a sensitivity of 100% and a specificity of 44.7. ROC analysis for T1-weighted images

was not statistically significant (AUC: 0.566, $P = 0.287$). The authors came to the conclusion that a CT HU value of 69.5 had the potential to predict MRI T2WI signal voids, therefore aiding in the work-up and examination of AFS.[39].

El-Kholy NA, et al. (2021) conducted a longitudinal prospective study with the aim of outlining acute invasive fungal rhinosinusitis in patients with a history of recent COVID-19 infection whilst evaluating management strategies applied. The patients used in the study were 36 in number, with a mean age of 52.92 ± 11.30 years and diabetes mellitus as the most prevalent comorbidity (27.8%). Mycological analysis showed that the species of *Mucor* and *Aspergillus* were found in 77.8% and 30.6% of patients, respectively. The Sino-nasal region, orbit, cerebral structures and palate were found to be involved in 100, 80.6, 27.8 and 33.3 percent of the patients respectively. Facial pain (75%), facial numbness (66.7%), ophthalmoplegia, and visual loss (63.9%), were the most reported symptoms. A combination of surgical debridement and antifungal therapy (amphotericin B, voriconazole, or posaconazole) was used to treat patients, with two exceptions of PCR-positive COVID-19 patients who received antifungal therapy alone. The overall survival rate was 63.89% (23/36). This research came to the conclusion that clinical suspicion of acute invasive fungal sinusitis in patients who survived COVID-19 and early management with the antifungal therapy and surgery were critical to the better outcomes and the increased survival rate of the patients who survived COVID-19.[40]

Roland LT, et al. (2023) carried out a multi-institutional and multidisciplinary evidence-based review the aim of which was to assess diagnostic, prognostic and management interventions as applied to AIFS. Systematic searches were carried out in databases like PubMed, EMBASE, and Cochrane since its inception up to January 2022. Research papers that evaluate the management of orbital, non sinonasal. AIFS had its head and neck and intracranial manifestations, and an iterative review process was implemented on the basis of EBRR guidelines. The literature gave rise to levels of evidence and management recommendations to AIFS. The review explored 12 topics concerning AIFS such as signs and symptoms, laboratory and microbiology diagnostics, endoscopy, imaging, pathology, surgical interventions, medical therapy, management of extra sinus extension, reversal of immunosuppression, and outcomes and survival. The evidence level was different in the domains. The research findings did not show a precise diagnosis of AIFS was based on a

combination of history and physical examination, laboratory and histopathologic examination, and endoscopic examination. Multidisciplinary approach that involved the use of antifungal therapy, surgical resection (where feasible), and reversal of immunosuppression was optimal in management. To further clarify the role of every modality and create standardized diagnostic and treatment algorithms, the authors emphasized the need to conduct higher-quality prospective research. [41]

Bracanovic, et al. (2021) carried out a prospective study to determine the diagnostic capability of computed tomography (CT) and CT image-based texture image analysis (TIA) to effectively diagnose AFRS. The main objectives of the study were to determine CT features that are closely related with AFRS and to evaluate the additional value of TIA as an extra diagnostic tool. Maxillary sinus uses CT images of 37 patients with chronic rhinosinusitis were rigorously examined. The assessment involved soft tissue homogeneity, the existence of high attenuation areas, soft tissue density and the thickness and density of the bony sinus wall. TIA parameters were measured of the uniformity, contrast, homogeneity and entropy of the sinus contents. The results showed that the soft tissue mass was much more heterogeneous in the AFRS-positive (F+) group, the high-attenuation areas were more prevalent, and tissue density was higher. Further, the sinuosity walls were thinner and had much higher density in the F + group. Of the TIA parameters, homogeneity was the only one which was significantly lower in the F+ group. The study concluded that the existence of fungal elements should be suspected when sinuses are filled with heterogeneous soft tissue of high CT density, although this may not be apparent on the surface. It was suggested as an extra radiological criterion in the diagnosis of AFRS the assessment of the sinus bony wall density. In spite of the fact that the TIA represented a quantitative approach to the assessment of subjective CT characteristics, its clinical application is only complementary. [24]

Goyal SS, et al. (2023) compiled a literature review to explore the progression from non-invasive fungal sinusitis to invasive fungal sinusitis, noting that while the exact prevalence of fungal sinusitis remains unclear, incidences of endemic mycoses have been increasing. In patients who are immunocompromised, fungi are capable of infiltrating the mucosa, leading to swift progression to critical health conditions within a matter of days, with reported mortality rates ranging from 58% to 80%. Due to the wide spectrum of severity,

management, and prognosis associated with different forms of fungal sinusitis, classification systems were developed to aid clinicians. Hora et al. initially classified fungal sinusitis into invasive and noninvasive types. Subsequently, noninvasive fungal sinusitis was further subdivided into saprophytic fungal infection, fungus ball, and allergic fungal rhinosinusitis (AFRS). Although transformation of noninvasive fungal sinusitis into invasive fungal sinusitis (IFS) remained rare, clinicians were advised to be aware of this potential complication, particularly in patients with fungal balls and AFRS.[42]

Chua AJ, et al. (2023) identified AFRS as a specific clinical entity within the wider spectrum of chronic rhinosinusitis with nasal polyps with type 2 inflammation. Nasal polyposis, thick eosinophilic mucin formation, and expansile alterations of the affected sinus canals were its defining characteristics. The Bent and Kuhn criteria were historically used for diagnosis, but new research revealed that some of the key criteria lacked specificity. This restriction was somewhat alleviated by meeting all five requirements, but doing so made the criteria onerous and emphasized the need for more precise diagnostic procedures. As our knowledge of the pathophysiology of AFRS has grown, it has become obvious that a lack of histatins had a role in the poor clearance of fungal spores, which in turn caused the fungus to breach the epithelial barrier and activate sinonasal epithelial cells. This in turn set off a chain reaction of type 2 inflammatory cytokines that were mediated by the innate and adaptive immune systems. Results indicated that type 2 inflammatory processes may have been overstimulated in response to a possible restricted type 3 immune response at the sinus mucosa. Surgery and topical corticosteroids were the main treatments for AFRS, with brief systemic corticosteroid courses administered with caution. Systemic antifungals and fungal-specific immunotherapy were used in resistant instances, and preliminary research suggested that biologics had potential. These understandings of the pathophysiology of AFRS made it possible to create innovative treatment approaches.[43]

Nakayama T, et al. (2023) admitted both AFRS and ABPM as a type of inflammatory disorder of the respiratory system caused by hypersensitivity to fungi. Similar features are seen in both disorders, such as viscid discharges and eosinophil infiltration in the airways caused by localized type 2 inflammation. Central bronchiectasis in the lower respiratory tract and bone erosion in the upper respiratory tract were caused by eosinophilic mucin-

induced compression of nearby anatomical structures. When compared to ABPM, AFRS was found to be significantly different, although it has similar pathogenic characteristics. In an epidemiological aspect, AFRS usually occurred at a younger age, was correlated with less complicated bronchial asthma and had lower total immunoglobulin E (IgE) levels in laboratory tests than ABPM. Moreover, although the pathogenesis of Sino bronchial allergic mycosis in the two diseases is alike, the difference between the diseases was emphasized by the rarity of the disease in both. The review highlighted the need for knowledge of ABPM for understanding the pathogenesis and management of AFRS, where this knowledge is less extensive.[44]

Silky S, et al. (2022) pointed out the increasing prevalence of fungal sinusitis globally in recent years, showing a drastic change in the system of classification. Fungal rhinosinusitis is classified into two main types: invasive and noninvasive. Each of these categories has 5 subgroups. The invasive group the acute invasive fungal sinusitis (AIFS), chronic invasive fungal sinusitis (CIFS), and chronic granulomatous invasive fungal sinusitis (CGIFS) constituted the invasive group, while fungal ball and allergic fungal rhinosinusitis (AFRS) comprised the non-invasive group. These five Specific radiologic and clinical characteristics were found in each of the subtypes. There were also different treatment strategies and prognoses for the subtypes which were based on the characteristic features of these subtypes. It was important to understand the different types of fungal sinusitis and knowledge of their particular radiologic features was essential for clinicians to apply appropriate diagnostic techniques to get confirmation. It was necessary to make relevant diagnosis and start any appropriate therapy to prevent any adverse effect. [45]

Yadav N, et al. (2023) outlined acute invasive fungal rhinosinusitis (AIFR) as a rare yet A fast spreading and potentially life-threatening disorder of the nose and paranasal sinuses. The study was limited to defining the imaging features of COVID-19 associated AIFR. The results from that research were retrospective observational study. The inclusion criteria included: (1) post-COVID-19 patients with fungal rhinosinusitis detected on potassium hydroxide smear or histopathology; (2) onset of symptoms such as facial pain, dental pain, facial swelling or discoloration, nasal bleeding, periorbital swelling, ptosis, redness of eyes, or vision loss within 4 weeks; and (3) magnetic

resonance imaging (MRI) or computed tomography (CT) performed within 5 days before surgery. Exclusion criteria were: (1) absence of sinusitis in patients who had no history of COVID-19 infection, and (2) absence of hyphae of fungi from pathological examination. Non-contrast CT and special sequences on the MRI were obtained first. The site of involvement (unilateral or bilateral), pattern of mucosal thickening (diffuse or localized), enhancement pattern (dyscorticulating or other), peri-antral invasion, orbital invasion, intracranial involvement, perineural spread, vascular involvement and bony changes were noted. A comparison of the imaging features of the CT and MRI was performed. A total of 60 patients underwent 90 imaging studies (CT and MRI) analysis. Ethmoid sinus was the most frequent site of involvement followed by maxillary sinus. The incidence of bilateral disease was higher. The MRIs showed thickening of the mucosa with T2 hypointense septations in 88.4%. Peri-antral involvement showed up in 84.6% of the MRI cases and orbital involvement showed up in 55.7% of the MRI cases. Intracranial involvement included meningitis, cerebritis, abscess, infarct, hemorrhage, cavernous sinus or perineural invasion. Vascular involvement was reported as pseudoaneurysm (n = 2), vascular narrowing (n = 3) and vascular occlusion (n = 3). MRI was determined to be more sensitive in identification of peri-antral invasion, deep infratemporal fossa, involvement of cavernous sinus, perineural invasion, optic nerve involvement, and vascular occlusion or narrowing, while CT was more useful in the identification of bony erosion. The study findings suggested the importance of early diagnosis of AIFR in post-COVID-19 patients to avoid morbidity and mortality related to the disease. Several findings which are not described often were mentioned, including optic nerve involvement, fungal abscess of the pituitary, perineural spread, fungal aneurysms and arteritis related posterior circulation infarcts. MRI was determined to be better than CT for both the early detection of the disease and for delineating the extent of the disease. Imaging was important in the early diagnosis of AIFR, and had a big impact upon the outcome of patient care.[46]

Raghvi A, et al. (2023) presented a case series, focusing on the clinical presentations related to allergic fungal rhinosinusitis. Fungal sinusitis can be broadly divided into two types: invasive and non-invasive. The invasive type was defined by hyphae being found in the mucosa, submucosa, bone or blood vessels of the paranasal sinuses, and comprised

acute invasive fungal sinusitis, acute fulminant fungal sinusitis, chronic invasive fungal sinusitis and chronic granulomatous fungal sinusitis. Fungal rhinosinusitis in its invasive form was relatively uncommon and mostly restricted to immunocompromised patients. The latter, the non-invasive type, lacked any fungal hyphae in the mucosa of the paranasal sinuses and included AFRS and fungus ball. The consent of the Institutional Human Ethical Committee was taken and a prospective case series study was conducted in 30 patients of the Department of ORL. The purpose of the study was to determine the different clinical features and treatment outcomes of patients diagnosed with allergic fungal sinusitis within one year. Patients who came with the symptoms of allergic fungal rhinosinusitis were also involved and also patients who came with the complaint of proptosis and diplopia were excluded so that AFRS and its potential complications could be eliminated. Chronic granulomatous nose and invasive fungal sinusitis patients were excluded. Assessment was done through in-depth case histories, clinical examination and radiological studies. Thirty patients who presented in the outpatient department with a complaint of sinusitis were analyzed after taking the necessary consent. The sample consisted there were 12 men and 18 women aged 22–70 years of which 9 were children and 4 were adults. Every patient complained of common incidences of allergic rhinosinusitis, nasal congestion, and facial heaviness. Twelve patients complained of impaired or loss of sense of smell. Four patients had reported with andrological and visual issues which resolved following endoscopic sinus surgery.

Out of this group, 24 of the patients experienced allergic fungal mucin in their nasal secretions, 10 of them had a history of atopy and asthma and had high levels of IgE and 20 experienced greater eosinophil counts. Steroid, nasal spray and pre-op steroid were indicated given to all the patients who had extensive polyposis after which FESS was performed. Polypoidal mucosa and diseased tissue was removed during surgery, sinus blockages were debrided and fungal mucin or tissue samples were sent to be analyzed using histopathology, KOH. mount, and fungal culture. This research you can see that allergic patients with fungal rhinosinusitis have a wide spectrum of clinical presentations, diagnostic outcomes and therapeutic approaches, showed Datta. The authors stressed that, as AFRS is closely interconnected with, EMRS and chronic rhinosinusitis (CRS), The correct diagnosis and treatment of the conditions depends on thorough clinical,

radiological and immunological evaluation. [47].

Cameron BH, et al. (2023) Allergic fungal rhinosinusitis (AFRS) was defined as chronic rhinosinusitis (CRS) complicated by allergic fungal reaction with the presence of eosinophilic mucin which is the fungal hyphae trapped in mucus. The last decade has brought a better understanding of fungal inflammatory pathways and the key insights into the pathophysiological basis of chronic inflammatory respiratory diseases. In addition, new therapeutic biologic products were now available to help manage CRS. Fungi induced respiratory inflammation has been shown to be associated with fungal proteinase and toxin activity.

Patients with AFRS had local immunodeficiency in their nasal cavity and mouth by decreased expression of antimicrobial peptides, which leads to reduced antifungal activity, and increased expression of type 2 inflammatory response, which indicates imbalance among type 1, type 2, and type 3 immune profiles. The identification of these dysregulated molecular pathways had identified several new therapeutic targets. As a result, treatment of AFRS, which previously had been largely surgical and involved long-term oral corticosteroid use, was starting to include a new range of topical delivery technologies and biologic treatments for difficult-to-treat cases. A new understanding of the molecular mechanisms involved in AFRS has not only affected the therapeutic approach to AFRS, but also the possible changes in diagnostic procedures. To establish criteria and gain a deeper understanding of the impact of environmental factors on the disease, and to give an insight into the implications of the disease in the context of a better understanding of chronic rhinosinusitis-related inflammation. [48]

Dhanani R, et al. (2021) Conducted a study on the prevalence of Allergic Fungal Sinusitis (AFS) Among patients with nasal polyps, no significant differences were found between the Lund-Mackay scores of patients with and without an AFS. This is a cross sectional longitudinal study conducted in the tertiary care unit of a hospital in Karachi, Pakistan from December 2016 till November 2018. It involved patients with SNPs that had undergone any surgical procedure. The diagnosis of AFS was confirmed by histopathologic findings of allergic mucin with fungal hyphae and fungal culture. The Lund-Mackay the score for each patient was noted, and the two groups of patients – AFS and non-AFS – were subjected to statistical analysis. Out of 114 patients, 61 (53.5%) were

male, with a mean age of 37.3 ± 15.3 years. AFS was found in 27 patients (23.7%). A statistically significant there was an association between AFS and asthma ($p = 0.03$). The AFS group had a significantly higher mean score for Lund-Mackay ($p < 0.01$) than the non-AFS group. Eleven patients (9.6%) had recurrent disease. The study found that almost one-fourth AFS was found in 30% of the patients with nasal polyp and the radiological defects were more severe in these patients. [49]

Cha CH, et al. (2023) The data retrieved from the Chang Gung Research Database included patients with chronic rhinosinusitis who were treated with surgery from 2001 to 2019 who had microbiological cultures obtained during surgery. Patients were divided into two groups: fungal and non-fungal, according to the results of fungal culture and also the surgical pathology. Eight hundred ninety eight patients were diagnosed with fungal rhinosinusitis and 2,884 were diagnosed with nonfungal rhinosinusitis. The fungal group had a higher mean age (56.9 ± 13.1 years vs. 47.0 ± 14.9 years), a larger proportion of female patients (62.4% vs. 37.0%), more unilateral lesions (80.4% vs. 41.6%), and a lower incidence of revision surgery (3.6% vs. 6.0%; $p = 0.004$).

In addition, *Pseudomonas aeruginosa* was much more common among the fungal group (14.3% vs. 4.6; $p < 0.001$). The research determined that *Pseudomonas aeruginosa* was more commonly isolated in cases of fungal rhinosinusitis, especially in cases that necessitated revision surgery. These results indicate that the inclusion of specific antimicrobial measures against *Pseudomonas* could enhance the patient outcomes in fungal patients rhinosinusitis [50]

Jeon et al. (2021) developed a deep learning algorithm aiming to enhance the diagnosis of sinusitis utilizing Waters' and Caldwell radiographic views. This algorithm was trained and tested on 1,403 images, and it obtained remarkable AUCs of 0.71, 0.78 and 0.88, especially when compared to radiologists in the case of ethmoid and maxillary sinusitis. This paper highlights the possibilities of deep learning to complement radiography as a major method of assessment of sinusitis[51].

Chapter 3

METHODOLOGY

3.1. Research Design

This research was a comparative cross-sectional research design. The design was to compare the CT imaging characteristics of AFRS and CRS at one point in time to enable a disinterested analysis of the important radiological differences between the two groups.

3.2. Clinical Settings

The research was conducted in the District Headquarters (DHQ) Hospital, Kasur, in the CT Scan Center, where patients regularly received non-contrast CT scan services the paranasal sinuses. All imaging procedures were performed using the standard CT protocols of the institution.

3.3. Sample Size

The calculated sample size was using Cochran's formula for estimating proportions in cross-sectional studies:

$$n = \frac{Z^2 \times p \times (1 - p)}{d^2}$$

$$(p) = 7\% = 0.07$$

$$Z = 95\% (Z = 1.96)$$

$$d = 5\% = 0.05$$

$$n = \frac{(1.96)^2 \times (0.07) \times (1 - 0.07)}{(0.05)^2}$$

$$n = 100 \text{ patients}$$

3.4. Sampling Technique

A technique of non-probability purposive sampling was utilized. Patients were selected based on the predefined exclusion and inclusion criteria. Only those individuals who had undergone non contrast CT scans of paranasal sinuses at the study site during the specified study duration and met the diagnostic criteria for AFRS or Non-Fungal CRS were included.

3.5. Duration of Study

This study was completed over a tenure of four months, following the official approval of the research synopsis. During this period, patient records and CT scans were reviewed, selected, and analyzed.

3.6. Selection Criteria

3.6.1. Inclusion Criteria

- Patients who have been undergone through non-contrast CT scan of the paranasal sinuses.
- Patients examined with:
 - Allergic Fungal Rhinosinusitis (AFRS) based on clinical or radiological findings.
 - Non-Fungal Chronic Rhinosinusitis (CRS) based on clinical and radiological features.
- Patients willing to give informed consent for participation in the study (if applicable).

3.6.2. Exclusion Criteria

- Patients with fungal ball (mycetoma) or invasive fungal sinusitis.
- Patients with a history of facial fracture, surgery of sinus , or craniofacial anomalies.
- Patients with immunocompromised conditions, e.g., HIV/AIDS, chemotherapy, or long-term steroid use.
- CT scans with poor image quality or incomplete sinus visualization.
- Patients with co-existing sinonasal tumors or malignancies.

3.7. Ethical Consideration

This study was conducted in agreement with established ethical research standards and institutional protocols. Prior to the outset of data collection, ethical approval was obtained from the IRB / Ethical Review Committee of the concerned institution. All the participants were treated with a lot of privacy, dignity, and confidentiality during the research. In no section of the study were personal identifiers i.e. patient names, contact numbers, hospital registration numbers or any other information that can be traced given out. In order to ensure anonymity, the participants were given a specific study code and all data were processed with the help of the coded identifiers. Should patient interaction have been necessary, informed consent was written after clarifying, describing the purpose of the research, the methods, the possible advantages, the voluntary character of the participation. It was explained to the participants that they were free to opt out of the study at any point without adverse repercussions.

Where the data were retrospectively gathered, patient files and CT imaging archives were examined without patient interaction. No information was obtained or used otherwise than academically and research purposes. All documents, both hard and electronic, were stored safely and could be accessed only by the principal investigator and other members of the research team who had permission. There was no sharing of data with third parties. The study perused the ethical

guidelines provided in the announcement of Helsinki where all human subjects were protected, kept safe, and safeguarded study.

3.8. Data Collection Procedure

Data were collected from patients presenting to the CT Scan Center at DHQ Hospital, Kasur, with symptoms clinically suggestive of chronic rhinosinusitis. When a patient presented with complaints such as nasal discharge, nasal obstruction, facial pain or pressure, reduced sense of smell, or a history of allergy or asthma, their clinical history was reviewed and documented. Patients with symptoms persisting for more than 12 weeks were considered suspected cases of chronic rhinosinusitis.

Eligible patients underwent a non-contrast HRCT scan of PNS. All scans were performed in axial and coronal planes using thin section imaging (1–3 mm slices) to obtain high-quality anatomical detail.

After image acquisition, each CT scan was interpreted by an experienced radiologist. The following radiological parameters were systematically evaluated: Mucosal thickening, Hyperdense sinus contents suggestive of allergic mucin, Bony erosion or remodeling, Sinus expansion, Air-fluid levels, Laterality (unilateral or bilateral involvement), Specific sinus involvement (maxillary, ethmoid, frontal, sphenoid). Based on radiological features, combined with clinical presentation and available histopathological information, patients were categorized into: Allergic Fungal Rhinosinusitis (AFRS): if hyperdense contents, sinus expansion, bony changes, or a history of atopy/nasal polyps were present. Non-Fungal Chronic Rhinosinusitis (CRS): when only mucosal thickening was found without radiological signs of fungal infection. All the gathered data, such as demographic, clinical, imaging, and diagnostic classification, were documented in a structured data collection form. The data collected were later put into a digital database to be statistically analyzed.

3.9. Data Analysis

SPSS version 27 and Microsoft Excel 2021 were applied to analyze the data. The demographic traits and the CT imaging results were summarized and presented using descriptive statistics. Categorical variables were weighted with frequencies and percentages. Chi-square test was utilized to correlate the CT features between AFRS and Non-Fungal CRS. For variables with small expected frequencies, chi-square Test was used. A p value of less than 0.05 was considered statistically significant

Chapter 4

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. (see figure 4.1).

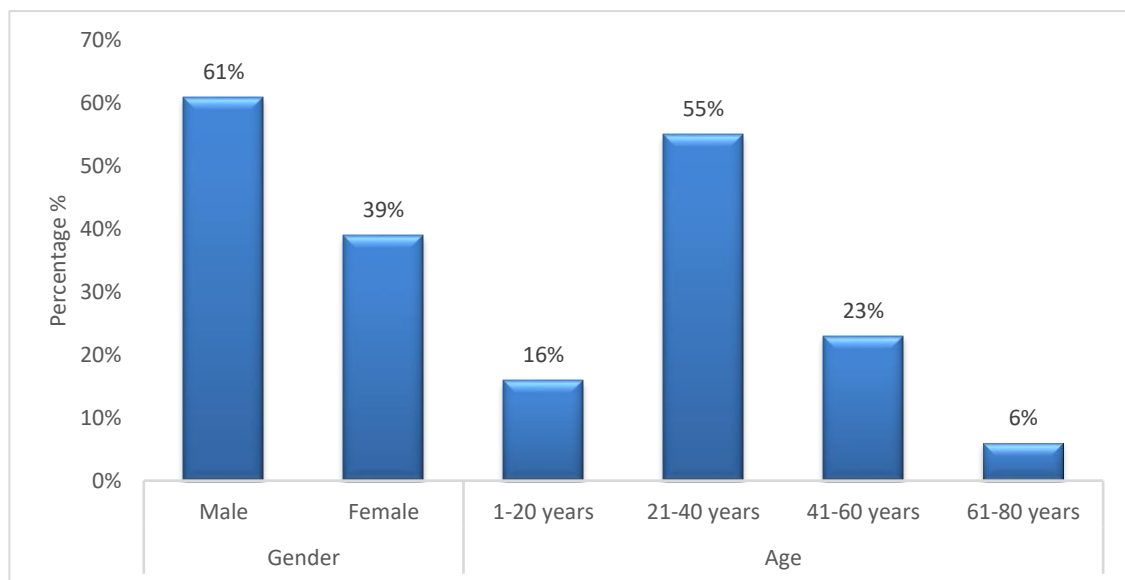


Figure 4.1. Illustrates the demographic distribution of the study participants based on gender and age groups.

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 (see Table 4.1 and Figure 4.2).

Table 4.1. Clinical Profile vs Final Diagnosis.

Clinical Profile vs Final Diagnosis Crosstab						
Variables			Final Diagnosis		Total	P Value
			AFRS	NFCRS		
Clinical Profile	History Allergy	No	9	75	84	<0.05
		Yes	6	10	16	
	Asthma	No	1	11	12	
		Yes	14	74	88	
	Nasal Obstruction	No	8	59	67	
		Yes	7	26	33	
	Nasal Discharge	No	11	54	65	
		Yes	4	31	35	
	Facial Pain	No	14	80	94	
		Yes	1	5	6	
	Loss of Smell	No	11	75	86	
		Yes	4	10	14	
	Sneezing	No	11	75	86	
	Itching	Yes	4	10	14	

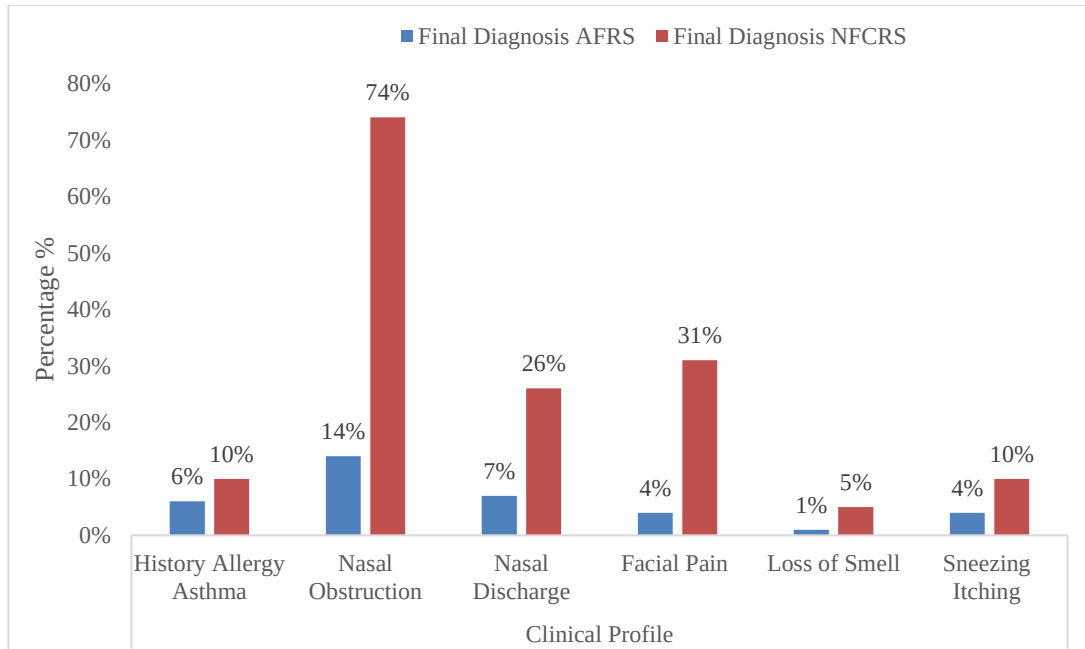
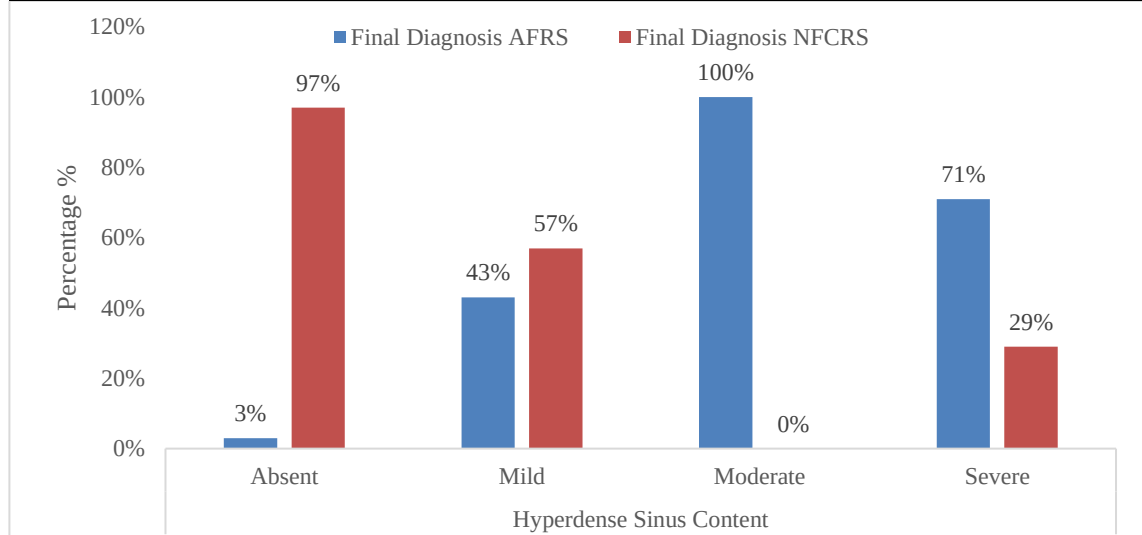


Figure 4.2. Comparison of clinical profile features between AFRS and NFCRS based on final diagnosis.

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 (see Table 4.2 & Figure 4.3).

Table 4.2. 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 4.3.** 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. (see Table 4.3 & Figure 4.4).

Table 4.3. 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	

Heterogeneous Opacification	Final Diagnosis AFRS (%)	Final Diagnosis NFCRS (%)
Absent	0%	100%
Mild	6%	94%
Moderate	12%	88%
Severe	64%	36%

Figure 4.4. 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 (see Table 4.4 & Figure 4.5).

Table 4.4. 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	

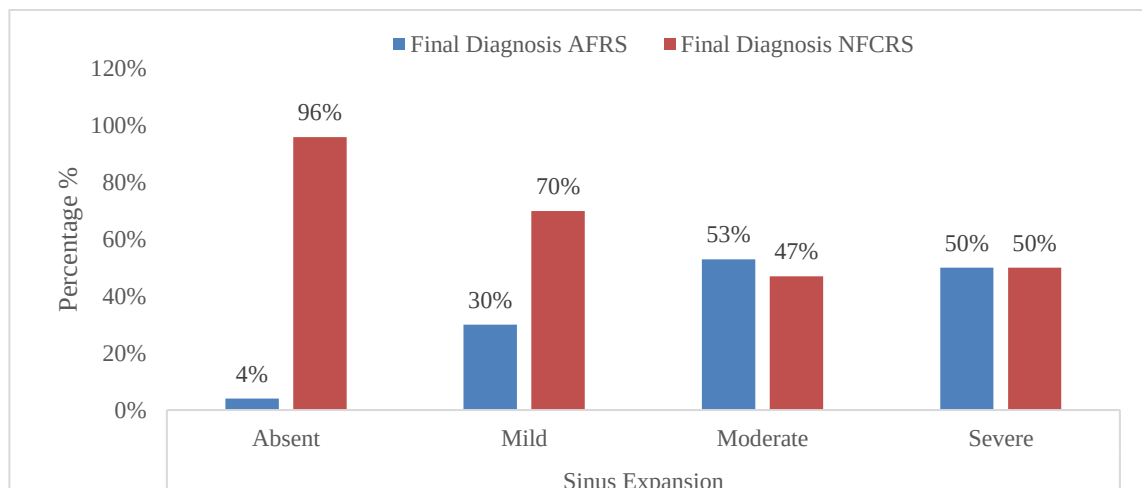


Figure 4.5. Distribution of Sinus Expansion (absent to severe) in relation to final diagnosis.

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. (see Table 4.5 & Figure 4.6).

Table 4.5. 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	

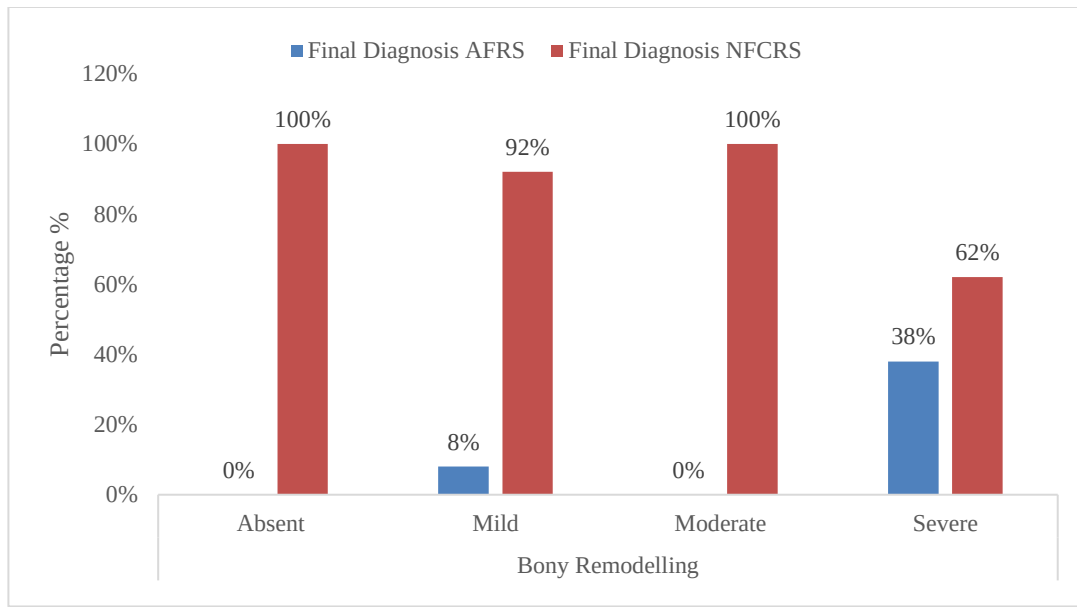


Figure 4.6. Distribution of Bony Remodeling vs final diagnosis.

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. (see Table 4.6 & Figure 4.7).

Table 4.6. 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	

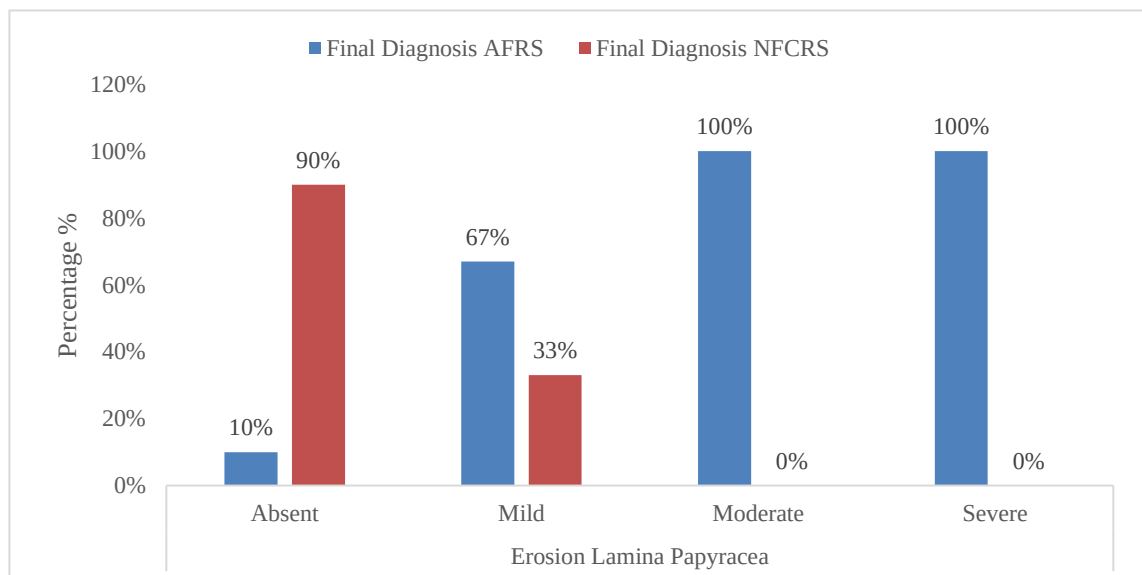


Figure 4.7. Distribution of Erosion Lamina Papyracea vs final diagnosis.

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. (see Table 4.7 and Figure 4.8).

Table 4.7. 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	

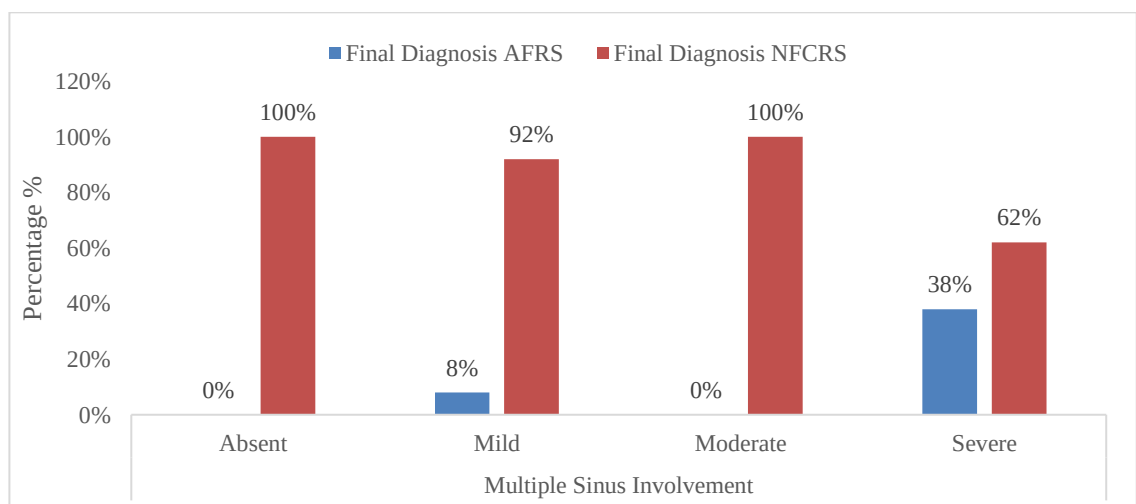


Figure 4.8. Distribution of Multiple Sinus Involvement vs final diagnosis.

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. (see Table 4.8 and Figure 4.9).

Table 4.8. 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	

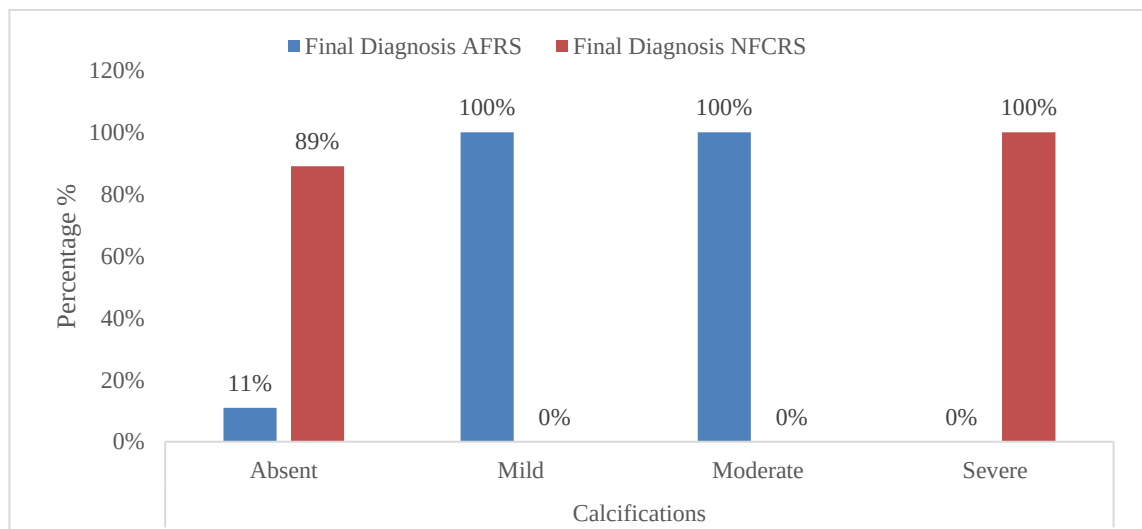


Figure 4.9. Distribution of Calcifications vs final diagnosis.

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. (see Table 4.9 and Figure 4.10).

Table 4.9. 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	

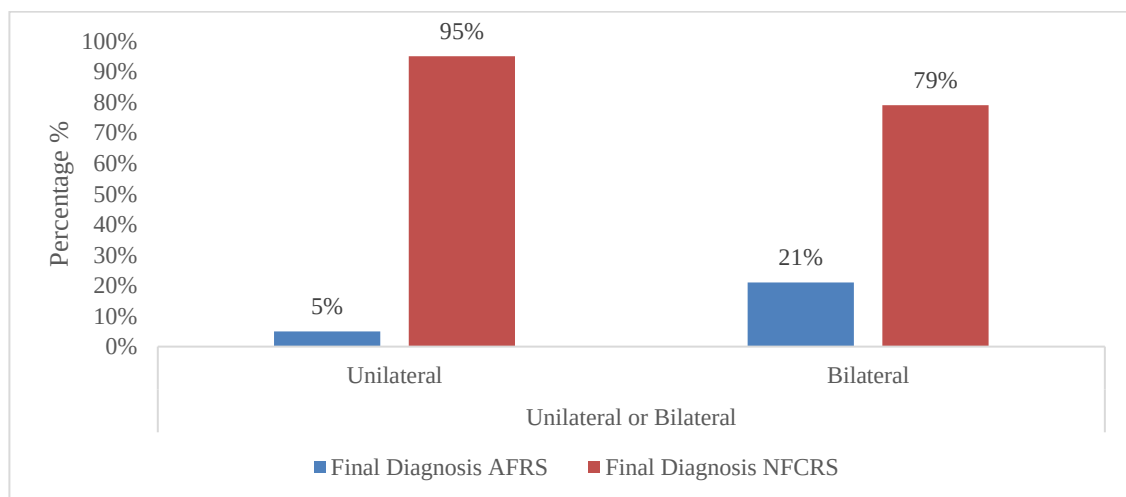


Figure 4.10. Distribution of unilateral and bilateral sinus involvement vs final diagnosis.

Chapter 5

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). The main aim was to determine some of the most important radiological distinctions that can help in the correct differentiation of these two entities, because early diagnosis is an essential factor in the right management. The use of CT imaging as the modality of choice in assessment of chronic rhinosinusitis is because it is good in demonstrating sinus anatomy, extension of the disease, and bony alterations.

A total of 100 patients were considered in the present research at the CT Scan Center of District Headquarters (DHQ) Hospital, Kasur. The gender of the predominancy in this study is well in line with the past literature that states that males have higher prevalence of chronic rhinosinusitis. Most of the patients were in the age group of 21-40, indicating that AFRS and NFCRS mainly impact young to middle-aged adults, which is also backed up by previous research in such a population.

Especially in the case of NFCRS patient's clinical symptom evaluation showed that nasal blockage was the utmost frequent submitting complaint. Other symptoms like nasal discharge and facial pain were also more common in NFCRS, but history of allergy was equally common. or asthma revealed a comparatively greater correlation with AFRS. This confirms the etiological of medical condition in the pathogenesis of AFRS and the significance of integrating clinical history with radiological evidence to make accurate diagnoses.

Hyperdense sinus content was one of the most important radiological results of this study. Moderate hyperdense sinus content was only observed among AFRS patients and severe hyper density was also more prevalent in AFRS than in NFCRS. Conversely, lack of hyperdense material was mainly identified in the cases of NFCRS. The results are consistent with the existing literature, which refers to hyperdense sinus contents as a characteristic feature of AFRS since allergic mucin is mixed with fungal factors. Thus, hyperdense sinus on CT is a powerful indicator in favor of AFRS as compared to NFCRS. Heterogeneous opacification was also found to establish a bright line of differences

between the two diagnostic groups. NFCRS was more often associated with mild to moderate heterogeneous opacification, but severe heterogeneous opacification was more often related to AFRS. Also, no heterogeneous opacification was only seen in NFCRS cases. Smoothly growing heterogeneity observed in AFRS can be explained by thick secretions of allergic mucus, fungus debris and inflammatory secretions, which is why this characteristic can be used as a useful radiological sign. Another parameter that was important in this study was the sinus expansion. Absence of sinus expansion was strongly linked to NFCRS, and moderate to severe expansion was more likely to be linked with AFRS. This observation is in line with the pathophysiology of AFRS in which the chronic pressure due to the accumulated allergic mucin causes to expansion and remodeling of sinus. Even though severe sinus expansion was uncommon, its existence is another indication of AFRS.

There was also a significant difference in bony remodeling patterns between the two groups. Lacking to moderate bony remodeling was mainly observed in NFCRS patients but severe bony remodeling was more common with AFRS. This observation supports prior experiments that document widespread bony alterations in AFRS as a result of chronically inflammatory mechanisms and pressure forces and not actual bone destructive effects in invasive disease.

Analysis of lamina papyracea erosion showed that it was closely correlated with AFRS. Mild erosion was prevalent in AFRS, whereas all instances of moderate and severe erosion were only found in AFRS. The lack of lamina papyracea erosion was observed mostly in NFCRS. These observations indicate the aggressive but non-invasive characteristic of AFRS in which bone is eroded as a result of pressure and remodeling instead of fungal invasion. Several sinus involvements illustrated a definite tendency towards greater disease among AFRS patients. Although the absence to moderate involvement was mostly related to NFCRS, severe multiple sinus involvement displayed a greater percentage of AFRS cases. This helps in the idea that AFRS normally happens to be a diffuse disease, where numerous sinuses are hit at once, whereas NFCRS frequently occurs with restricted or localized involvement.

Another notable differentiating feature was discovered to be calcifications in this study. Only AFRS patients had mild and moderate calcifications whereas NFCRS was mostly

linked with absence of calcifications. Severe calcifications, although rare, were more commonly seen in NFCRS. These results indicate that the internal presence of the calcifications in the sinus contents, especially mild- to moderate-degree ones, is conducive to a diagnosis of AFRS.

The radiological difference between AFRS and NFCRS was also confirmed by laterality analysis. The unilateral sinus disease was mainly found in the patients of NFCRS, bilateral sinus was more likely to be found in the patients of AFRS. In AFRS, it demonstrates the bilateral disease that it is an inflammatory condition with the propensity to engage more than one sinus use and thus laterality becomes a significant issue in the CT examination. Generally, the results of this research are mainly corresponding to the previously published literature and support the diagnostic usefulness of CT imaging in differentiating AFRS and NFCRS. The identification of particular imaging features including hyperdense sinus content, extreme heterogeneous opacification, sinus expansion, bony remodeling, lamina papyracea erosion, calcifications, multiple sinus involvement and bilateral disease could have a great impact on diagnostic confidence.

Clinically, radiological distinction between AFRS and NFCRS is necessary because there are significant differences in treatment. The AFRS usually necessitates surgical intervention in conjunction with corticosteroid therapy, but NFCRS can possibly be treated by means of medical management. Timely and correct diagnosis can consequently lessen recurrence of diseases, complications and better health results of a patient.

This study has some limitations to its strengths. The research was done in one tertiary care facility and with a fairly small sample, which can impact the generalizability of the findings. Also, radiological data did not correlate with histopathological or immunological data. It is also recommended that future research should be conducted on larger, multi-center populations and that it should be correlated with the laboratory findings in order to support these findings.

Summarizing, this paper has emphasized the critical role of CT imaging in the differentiation between AFRS and NFCRS. Certain CT characteristics like hyperdense sinus content, severe heterogeneous opacification, sinus expansion, bony remodeling, lamina papyracea erosion, calcifications, multiple sinus involvement, and bilateral disease are favorable to a diagnosis of AFRS. Close examination of these imaging features can

help radiologists and clinicians attain correct diagnosis and best patient treatment.

In the current research, computed tomography (CT) imaging features of patients with Allergic Fungal Rhinosinusitis (AFRS) and Non-Fungal Chronic Rhinosinusitis (NFCRS) were analyzed and compared to help recognize these two conditions using radiology, which is their accurate diagnosis. CT is the most popular imaging modality to use in chronic rhinosinusitis because it is a superb imaging modality to show the sinus anatomy, extent of disease, and bony alterations, as was previously published in the literature [52]. Hyperdense sinus content was found to be one of the most prominent distinguishing features of CT in the present study. Hyper sinuous contents were moderate to severe and were mostly observed in AFRS and absence of hyper density was mostly found in NFCRS. These results are in line with the report of Aribandi et al., which cited hyperattenuating sinus contents as an imaging characteristic of AFRS owing to the thick allergic mucin that harbors fungal components [2].

The present study indicated that other radiological appearances like severe heterogeneous opacification, sinus expansion, bony remodeling, lamina papyracea erosion, calcifications, multiple sinus involvement, and bilateral disease were more commonly related to AFRS. Similar tendencies have been outlined by Fokkens et al. in the European news Paper on Nasal Polyps and Rhinosinusitis (EPOS) that highlights that AFRS usually involves widespread, bilateral disease and pressure-induced bony alterations, in contrast to NFCRS. which is generally localized and not so violent [52].

In general, the results of the current research demonstrate high compliance with the literature on the topic, as well as the importance of CT imaging in the differentiation of AFRS and NFCRS to support the pivotal role of CT imaging. The identification of such typical imaging patterns may contribute to a considerable increase in the diagnostic confidence and the provision of the correct clinical management.

CONCLUSIONS

This paper finds that CT imaging is crucial in distinguishing between AFRS and NFCRS. Certain CT appearances: hyperdense sinusosity, extreme heterogeneous opacification, sinus expansion, bony remodeling, erosion of the lamina papyracea, intraluminal calcifications, several sinusosity.

AFRS was identified to be more strongly linked with involvement, and bilateral disease. Conversely, NFCRS was generally described as a lack or mild types of these radiological features, as well as unilateral or localized sinus participation.

The findings of the present paper underline the fact that a thorough assessment of the CT imaging characteristics would greatly promote the diagnostic quality and help clinicians to diagnose AFRS in the earliest possible stage. There is a clinical relevance in accurate distinction between AFRS and NFCRS because management options vary significantly. Therefore, CT

scan is an important diagnostic method that should be regarded in the assessment and treatment of chronic rhinosinusitis.

Limitation

The author of this study performed the research in one tertiary care hospital, which can be a constraint to the external validity of the study results. The sample size was quite small ($n = 100$), and it can decrease the statistical power of the study.

It was a cross-sectional/retrospective study design thus it was not possible to determine disease progression and long-term outcomes.

The diagnosis was made mostly on the basis of CT image results without any correlation of the investigation results of the histopathological, microbiological, or immunological studies. Inter-observer variation in CT interpretation was not assessed, which could affect diagnostic consistency.

Recommendations

Routine use of CT imaging should be considered as one of the most important diagnostic methods to distinguish AFRS and NFCRS.

Radiologists are to be attentive to certain CT characteristics including hyperdense sinus contents, calcifications, sinus expansion, bony remodeling, and lamina papyracea erosion. Subsequent research ought to involve larger sample sizes and multi-centers to enhance

reliability and generalizability of results.

More precise diagnosis is advised by correlating the CT results with the histopathology, fungal cultures, and immunological tests.

A system of standardized CT reporting should be devised and put in place to improve the accuracy of diagnosis and decrease inter-observer variability.

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APPENDICES

Performa for the Analysis of Computed Tomography Imaging Features in Diagnosis of Allergic Fungal Rhinosinusitis Versus Non- Fungal Chronic Rhinosinusitis

Consent Confirmation

☐ Informed consent taken from patient before data collection.

Patient Demographics

Age:

Gender:

Clinical Profile section:

Symptom	Present (1=Yes,0=No)
History of allergy/asthma	
Nasal obstruction	
Nasal discharge	
Facial pain/pressure	
Loss of smell	
Sneezing / Itching	

CT Imaging Features (Radiological Checklist):

Radiologic Feature	Absent	Mild	Moderate	severe
	0	1	2	3
Hyperdense sinus content (central)				
Heterogeneous opacification				
Sinus expansion				
Bony remodelling				
Erosion of lamina papyracea				
Involvement of multiple sinuses (pan-sinusitis)				
Calcifications within sinuses				
Orbital extension				
Unilateral/Bilateral disease				

Final Diagnosis by Radiologist | ☐ AFRS | ☐ Non-Fungal CR

ENGLISH CONSENT FORM

The study you are about to participate is a randomized control trial survey titled as;

“Analysis of Computed Tomography Imaging Features in
Diagnosis of Allergic Fungal Rhinosinusitis Versus Non-
Fungal Chronic Rhinosinusitis”

The study has no potential harm to participants. All data collected from you will be coded in order to protect your identity, and should not be disclosed to anyone. Following the study there will be no way to connect your name with your data. Your answers to the questions will not affect the quality of education given to you. Any additional information about the study results will be provided to you at its conclusion, upon your request.

You are free to withdraw from the study at any time. You agree to participate, indicating that you have read and understood the nature of the study, and that all your inquiries concerning the activities have been answered to your satisfaction.

NAME _____

SIGNATURE _____

DATE _____

URDU CONSENT FORM

میں _____ تصدیق کرتا/ کرتی ہوں کہ محترمہ (YOUR NAME IN URDU) نے اپنی
اس تحقیق

“YOU TITLE ”

زیر نگرانی (YOUR SUPERVISOR NAME) کے متعلق بتا دیا ہے۔ مجھے اس تحقیق کی
نوعیت، مقاصد، احداث، توقعات، فوائد اور خطرات کے متعلق ، ساری معلومات فراہم کر دی گئی ہیں
اس تحقیق کے دوران ساری معلومات صیغہ راز میں رہیں گی اور مریض کا نام اور دیگر معلومات
صرف تحقیق کے لیے استعمال ہوں گی۔ مجھے یہ بھی بتا دیا گیا ہے کہ میں اس تحقیق سے متعلق ہر
قسم کے سوال پوچھنے کا مجاز ہوں اور یہ تحقیق صرف ایک شخص ک مفاد میں نہیں ہے بلکہ
بحسبیت مجموعی انسانیت کا مفاد اس سے وابستہ ہے۔ تمام تفصیلات جاننے کے بعد یس تحقیق میں
شامل ہونے یا نہ ہونے پر کسی کا قائل نہیں ہوں۔ اس تحقیق سے کسی بھی وقت علیحدہ ہونے پر مجھ
پر کوئی پابندی نہیں ہو گی۔ میں بذاتِ خود بقائمی حوش و حواس
اور رضا مندی سے اس تحقیقاتی عمل میں شامل ہوتی/ ہوتا ہوں۔

دستخط محقق _____

دستخط شرکت کار _____

تاریخ _____

DEMOGRAPHICS FORM & QUESTIONNAIRE
PERMISSION LETTER

ETHICS COMMITTEE LETTER

PLAGIARISM SI CERTIFICATE

PLAGIARISM REPORT