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ORIGINAL RESEARCH

HRCT Assessment of Interstitial Lung diseases and its Correlation with Spirometry Indices

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Abstract

Introduction: Interstitial lung diseases (ILDs) include disorders characterized by inflammation and fibrosis of the lung interstitium. These pathologies lead to restrictive lung function and impaired gas exchange. HRCT findings and spirometry indices are essential for a comprehensive evaluation of ILDs. The integration of HRCT and spirometry data empowers healthcare professionals to gain insights into the severity and progression of ILDs and have a better comprehension of the impact of interstitial changes on respiratory mechanics, prognosis, and treatment planning

Aim: To correlate radiological pattern and extent of involvement of ILD in HRCT with Spirometric indices and verify the radiological functional relationship.

Materials and Methods: The study was conducted at VPIMS, Lucknow and included a total of 50 patients. HRCT chest was done on 64 slices Siemens-Somatom go.Up CT scanner and Spirometry was performed using Masters medi-Spiro digital spirometry system. Lung parenchymal abnormalities were categorized and semiquantitative Warrick score was applied for grading severity.

Results: Correlations between severity scores and spirometry indices underscore the inverse relationship between disease severity and lung function.

Conclusion: This understanding of disease severity and extent facilitates personalized treatment strategies, leading to improved patient management and tailored interventions to mitigate symptoms and slow disease progression.

Introduction

Interstitial Lung Disease (ILD) is a heterogeneous group of pulmonary disorders that are classified together based on similar clinical, radiographic, physiological, or pathological features. Pathologically, interstitial lung diseases are characterized by varying degrees of fibrosis and inflammation of the lung parenchyma or interstitium.[1,2]

HRCT is widely recognized as a modality of choice for evaluating diffuse lung processes.[3] However, it has limitations due to its association

with radiation exposure. One key advantage of spirometry is that it is devoid of the risks associated with radiation exposure. Additionally, it assesses pulmonary function as compared to HRCT. [3,4]

The aim of this study was to correlate radiological pattern and extent of involvement of ILD in HRCT with Spirometric indices and verify radiological functional relationship.

Materials and Methods

This cross-sectional study was conducted in a tertiary care hospital for duration of 18-months. A total of 50 patients with clinical diagnosis of ILD were included in this study.

Methodology

The Scientific and Ethical Committee approval for conducting this study was obtained and informed consent for study was obtained from all participants. A detailed history was taken for all those patients who met the inclusion criteria (Patients more than 18-years with clinical suspicion of ILD and Patients with a provisional diagnosis of ILD either clinically or on previous HRCT chest), which included the patient's name, age, sex, registration number, complaints, risk factors, previous medical or surgical history, laboratory investigations and spirometric findings.

Technique

HRCT chest was done on 64 slices Siemens-Somatom go.Up CT scanner using standard protocol and it was examined by a radiologist with more than 20-years of experience in reading CT. Parenchymal abnormalities were then divided into five main and 10 other associated features and their distribution were noted. Extent and severity score (Table 1) were calculated using Warrick's Semi-quantitative scoring method.

Spirometry was performed using the Maesteros medi-Spiro digital spirometry system after explaining the procedure to the patient. A minimum of three acceptable spirograms were obtained from which the largest FVC and FEV1 were recorded. These spirometry indices and HRCT scores were later correlated.

Table 1: Warrick's Semi-quantitative scoring method.

Severity score		**Extent score**	
Abnormality	Grading	Bronchopulmonary segments for each abnormality, scored by the number of segments involved	Grading
Ground-glass opacities Irregular pleural margin septal or subpleural lines Honeycombing Subpleural cyst	1 2 3 4 5	1 to 3 segments involved 4 to 9 segments involved >9 segments involved	1 2 3
Maximal severity score	15	Maximal extent score	15

Statistical Analysis

Data was entered in Microsoft Excel and analyzed using statistical software SPSS version 26 (SPSS Inc., Chicago, IL, USA). The statistical analysis in this study utilized descriptive statistics to summarize categorical data such as age distribution, gender, and chief complaints, with results presented as frequencies and percentages. Continuous variables, like age and severity scores, were expressed as mean ± standard deviation. To assess the relationship between spirometric indices (FVC, FEV1, FEV1/FVC) and HRCT findings, Spearman's correlation was applied, revealing significant negative correlations between disease severity and lung function ($p < 0.001$). Multiple linear regression was used to examine the association between HRCT features and spirometric indices, showing that septal lines, ground-glass opacities, and irregular pleural margins were positively correlated with better lung function, while emphysematous changes and mediastinal lymphadenopathy were linked to poorer outcomes. A *p-value* < 0.05 or 0.001 was regarded as significant.

Results

We included a total of 50 patients, more than 18-years of age with clinical profile of dyspnea and chronic cough and X-ray findings suspicious of ILD. The findings of the study are outlined in tables.

Table 3: Gender distribution of the enrolled patients.

GENDER	NUMBER	PERCENTAGE
Female	18	36.00%
Male	32	64.00%

Table 2: Age distribution of the enrolled patients.

AGE DISTRIBUTION	NUMBER	PERCENTAGE
24–30 yrs.	11	22.00%
31–40 yrs.	9	18.00%
41–50 yrs.	10	20.00%
51–60 yrs.	13	26.00%
61–70 yrs.	7	14.00%
MEAN±SD	49.76	±16.40

The age distribution of the study participants revealed a diverse range of ages, with the highest representation in the 51-60 years age group, comprising 26% (13 individuals) of the sample, followed by the 24-30 years group at 22% (11 individuals), the 41-50 years group at 20% (10 individuals), and the 31-40 years group at 18% (9 individuals). The least represented age group was the 61-70 years group, accounting for 14% (7 individuals) of the sample.

The mean age of the participants was 49.76 years. In the study majority were males 64% (n = 32). Male to female ratio was 1.8:1.

The chief complaints reported by the study participants highlight dyspnea as the most common symptom, affecting 30% (15 individuals). This was closely followed by dry cough, reported by 28% (14 individuals). Weakness and hemoptysis are each reported by 16% (8 individuals) of the participants, while 20% (10 individuals) experienced weakness. Chest pain and malaise were the least common complaints, affecting 16% (8 individuals) and 14% (7 individuals), respectively.

Table 5: Medical illness of the enrolled patients.

MEDICAL ILLNESS	NUMBER	PERCENTAGE
Diabetes	21	42.00%
Hypertensive	10	20.00%
Hypothyroidism	6	12.00%
Rheumatoid arthritis	7	14.00%

Table 6: Smoking history of the enrolled patients.

SMOKING HISTORY	NUMBER	PERCENTAGE
No	37	74.00%
Yes	13	26.00%

The distribution of medical illnesses among the study participants showed that diabetes was the most prevalent condition, followed by Hypertension, hypothyroidism, and Rheumatoid arthritis.

The smoking history of the study participants indicated that a majority had no history of smoking. In contrast, 26% (13 individuals) were current or former smokers.

Table 7: FVC severity of the enrolled patients.

FVC	NUMBER	PERCENTAGE
Mild	14	28.00%
Moderate	13	26.00%
Moderate Severe	6	12.00%
Severe	17	34.00%

Table 8: FEV1 severity of the enrolled patients.

FEV1	NUMBER	PERCENTAGE
Normal	5	10.00%
Mild	22	44.00%
Moderate	14	28.00%
Severe	9	18.00%

Table 9: FEV1/FVC severity of the enrolled patients.

	MEAN ± SD
FEV1/FVC	0.848 ± 0.05

Table 10: Spirometry pattern of the enrolled patients.

SPIROMETRY PATTERN	NUMBER	PERCENTAGE
Normal	14	28.00%
Restrictive	36	72.00%

Table 11: Severity score in the enrolled patients.

SEVERITY SCORE	NUMBER	PERCENTAGE
0-10	14	28.00%
11–15	36	72.00%
Mean±SD	10.88	± 3.51

Severe FVC impairment was the most common, affecting 34% (17 individuals) of the participants. Mild impairment was observed in 28% (14 individuals), while moderate impairment was seen in 26% (13 individuals). Moderate severe impairment was the least common, affecting 12% (6 individuals).

Normal FEV1 levels are observed in 10% (5 individuals) of the participants. Mild reduction in FEV1 is the most common, followed by moderate reduction.

The mean ratio of forced expiratory volume in one second to forced vital capacity (FEV1/FVC) among the study participants was 0.848, with a standard deviation of ±0.05.

The Spirometry pattern among the study participants revealed that the majority exhibited a restrictive pattern. This suggests reduced lung volumes and capacities, often associated with interstitial lung diseases and other restrictive lung conditions.

The severity scores for the study participants, based on HRCT assessment, indicate that the majority fall within the 11 to 15 range. The mean severity score is 10.88 with a standard deviation of 3.51.

Table 12: Extent score in the enrolled patients.

EXTENT SCORE	NUMBER	PERCENTAGE
0–5	5	10.00%
6–15	45	90.00%
Mean±SD	7.62	±1.73

The extent scores for the study participants, based on HRCT assessment, show that the vast majority had scores in the 6-15 range. The mean extent score is 7.62 with a standard deviation of 1.73, indicating that most participants had a moderate extent of lung involvement due to interstitial lung disease.

Table 13: HRCT findings in the enrolled patients.

HRCT FINDINGS	NUMBER	PERCENTAGE
Subpleural cyst	35	70.00%
Honeycombing	20	40.00%
Septal Line	50	100.00%
Irregular Pleural Margins	50	100.00%
Ground glass opacities	39	78.00%
Tractional bronchiectasis	29	58.00%
Nodules	7	14.00%
Traction bronchiolectasis	35	70.00%
Broncho vascular thickening	35	70.00%
Emphysematous Changes	9	18.00%
Mediastinal Lymphadenopathy	9	18.00%
Architectural Distortion	35	70.00%

Table 14: Association of the HRCT findings with Severity score in the enrolled patients

HRCT FINDINGS		SEVERITY SCORE		
		6–10	11–15	
	N	%	N	%
Subpleural cyst	0	0.00%	35	70.00%
Honeycombing	0	0.00%	20	40.00%
Septal Line	0	0.00%	50	100.00%
Irregular Pleural margins	0	0.00%	50	100.00%
Ground glass opacities	15	30.00%	29	58.00%
Tractional bronchiectasis	0	0.00%	29	58.00%
Nodules	0	0.00%	7	14.00%
Traction bronchiolectasis	0	0.00%	35	70.00%
Bronchovascular thickening	0	0.00%	35	70.00%
Emphysematous Changes	0	0.00%	9	18.00%
Mediastinal Lymphadenopathy	0	0.00%	9	18.00%
Architectural Distortion	0	0.00%	35	70.00%
p-VALUE $X = 111.7$ $p<0.001$*				

The most common findings were septal lines and irregular pleural margins, followed by ground glass opacities, subpleural cysts, traction bronchiolectasis, broncho-vascular thickening, and architectural distortion. Less common findings were nodules, emphysematous changes, and mediastinal lymphadenopathy.

Table 15: Association of the HRCT findings with Extent score in the enrolled patients.

HRCT FINDINGS	EXTENT SCORE			
	0–5		6–15	
	N	%	N	%
Subpleural cyst	0	0.00%	35	70.00%
Honeycombing	0	0.00%	20	40.00%
Septal Line	0	0.00%	50	100.00%
Irregular Pleural margins	0	0.00%	50	100.00%
Ground glass opacities	10	20.00%	29	58.00%
Tractional bronchiectasis	0	0.00%	29	58.00%
Nodules	0	0.00%	7	14.00%
Traction bronchiolectasis	0	0.00%	35	70.00%
Broncho vascular thickening	0	0.00%	35	70.00%
Emphysematous Changes	0	0.00%	9	18.00%
Mediastinal Lymphadenopathy	0	0.00%	35	70.00%
p-VALUE $X = 80.55$ $p<0.001$*				

Individuals with a severity score of 11–15 and an extent score of 6–15 showed subpleural cysts, honeycombing, septal lines, irregular pleural margins, tractional bronchiectasis, nodules, traction bronchiolectasis, bronchovascular thickening, emphysematous changes, mediastinal lymphadenopathy, or architectural distortion on HRCT. Notably, no individuals with a severity score of 6-10 and an extent score of 0-5 exhibit these HRCT findings. It indicates a statistically significant association between higher severity scores and the presence of these HRCT findings and between the extent of the disease and the presence of these HRCT findings.

The strong negative correlations observed between severity score and FVC, as well as with FEV1, suggest that as the severity of the disease increases, there was a notable decrease in both FVC and FEV1, indicating impaired lung function. Similarly, the negative correlation between severity score and FEV1/FVC ratio implied that as disease severity rises, the ratio tends to decrease, suggesting airflow limitation relative to lung volume. Additionally, the extent score also demonstrated significant negative correlations with FVC, FEV1, and FEV1/FVC ratio, further highlighting the impact of disease extent on lung function.

Discussion

Interstitial lung disease (ILD), also known as diffuse parenchymal lung disease, encompasses a diverse group of over 150 unrelated disorders, each exhibiting unique clinical presentations, radiographic patterns, and pathological findings.[1,2]

Traditionally, HRCT employs multi-detector CT scanners with volumetric acquisition, capturing the entire chest with near-isotropic resolution through thin slice thickness (<1.5 mm) and high-frequency reconstruction algorithms.[3-5] Spirometry emerges as a powerful diagnostic tool for detecting, monitoring, and managing lung disorders. A notable advantage of spirometry is its radiation-free nature.[6,7]

The fundamental pathological abnormality observed in ILD patients' lungs is a reduction in distensibility, resulting in increased stiffness and resistance to inflation compared to healthy lungs.[9,10] This study aims to bridge this gap by investigating the relationship between HRCT findings and spirometric parameters in patients with interstitial lung diseases, aiming to enhance our understanding of ILD pathogenesis and optimize diagnostic and management strategies for these complex conditions.

Sociodemographic variables

In the present study, the age distribution of participants spanned a wide range, with the highest representation in the 51-60 years group (26%), followed by the 24–30 years group (22%), 41–50 years group (20%), and 31–40 years group (18%). The least represented age group was 61-70 years (14%). The mean age was 49.76 years, with a standard deviation of 16.40 years.

Gender distribution showed males at 64% and females at 36%. The most common complaint was dyspnea (30%), followed closely by dry cough (28%). Weakness was recorded in 20%, while hemoptysis and chest pain affected 16% each. Diabetes was the most prevalent medical condition (42%), followed by hypertension (20%), hypothyroidism (12%), and rheumatoid arthritis (14%). Regarding smoking history, 74% had no history, while 26% were current or former smokers.

Comparatively, Dhameliya M *et al.*[11] conducted a study with 100 participants suspected of having ILD who underwent HRCT. The average age of the patients was 49.1 ± 13.6 years, with a male majority of 58%. Significant proportions were housewives (40%), followed by farmers (10%). In terms of smoking status, 58% were non-smokers, and 32% were

Table 16: Correlation of the spirometry parameters with Severity and extent score in the enrolled patients.

Correlation Analysis			Severity score	Extend score
Spearman's rho	FVC	Correlation Coefficient	-.653	-.565
		Sig. (2-tailed)	<0.001*	<0.001*
	FEVI	Correlation Coefficient	-.353	-.465
		Sig. (2-tailed)	.006	.003
	FEVI1/FVC	Correlation Coefficient	-0.345	-0.238
		Sig. (2-tailed)	.002*	.016*

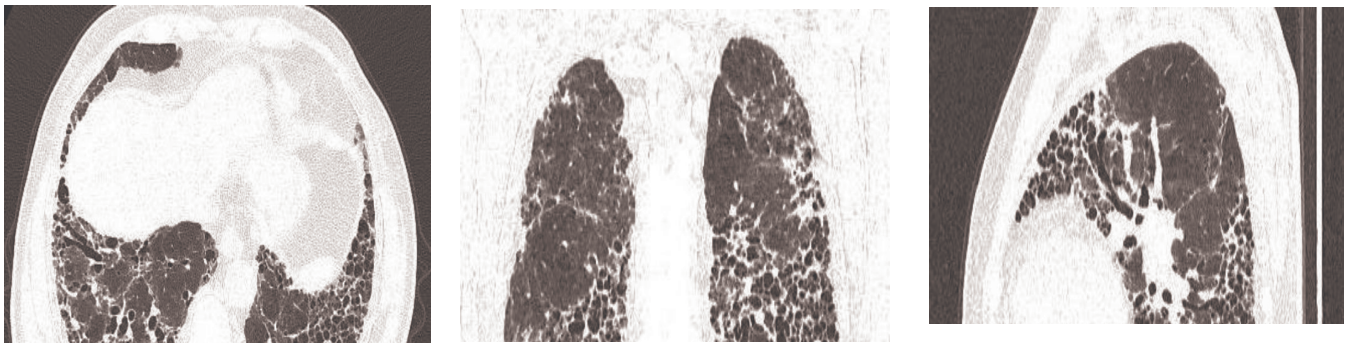

Figure 1: Axial, coronal, and sagittal reformatted images of HRCT chest in a 63-year-old male show bilateral extensive fibrosis with honeycombing, septal thickening, subpleural cysts, and traction bronchiectasis having basal and mid predominance. Findings are suggestive of Interstitial lung disease (Definite Usual interstitial pneumonia) with HRCT Severity Score: 14/15 and Extent Score: 9/15 (Warrick Semiquantitative Scoring Method)

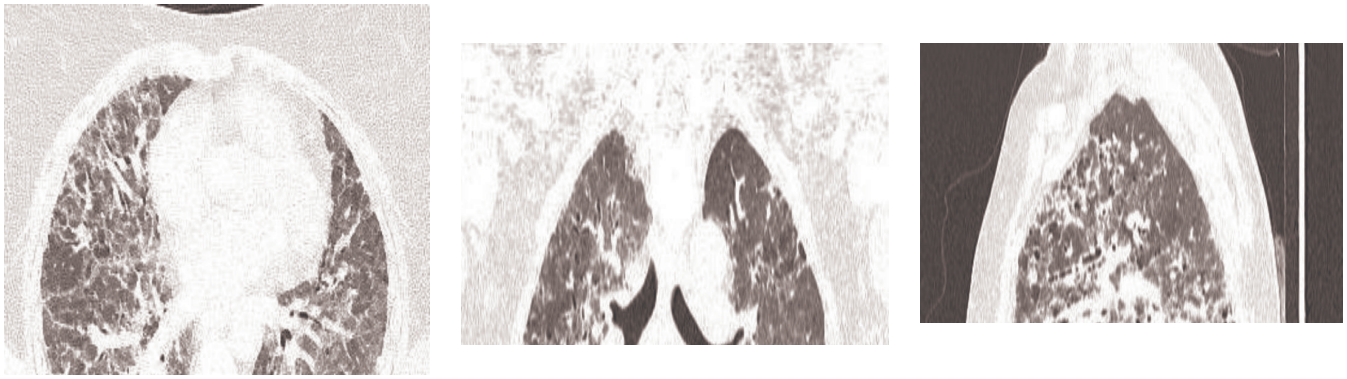

Figure 2: Axial, coronal, and sagittal reformatted images of HRCT chest in a 33-year-old female patient with Rheumatoid arthritis show extensive ground glass opacities in both lungs with associated interlobular septal thickening, traction bronchiectasis and interspersed multiple cystic changes. Findings are suggestive of Interstitial lung disease... possibility of non-specific interstitial pneumonia with HRCT Severity Score: 8/15 and Extent Score: 9/15 (Warrick Semiquantitative Scoring Method)

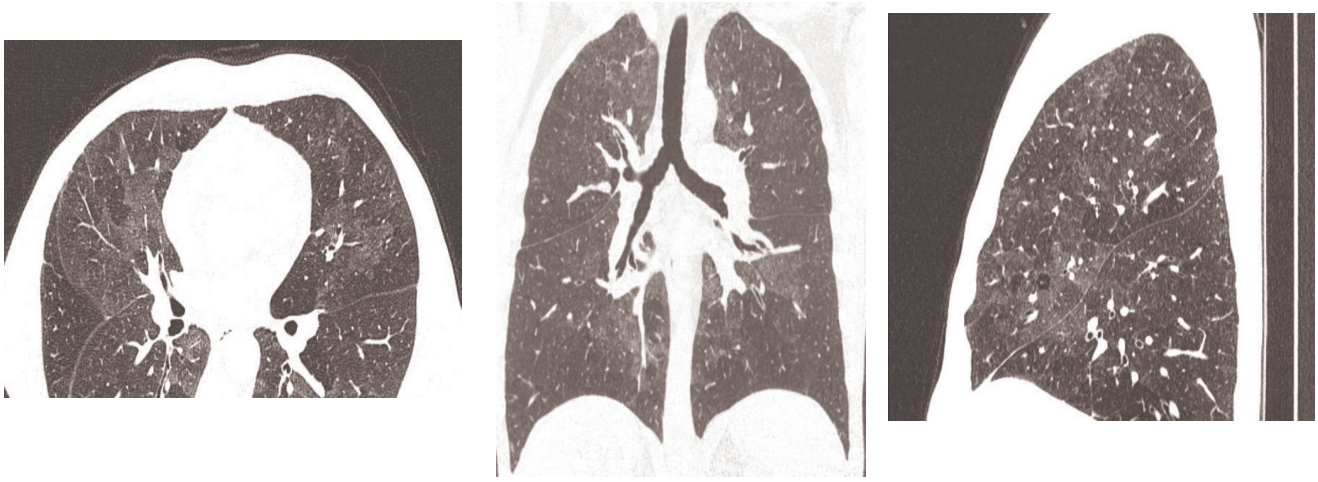

Figure 3: Axial, coronal, and sagittal reformatted images of HRCT chest in a 55-year-old male smoker show bilateral ground-glass opacities, mild centrilobular emphysema in upper lobes with mild air trapping predominantly at the lung bases. History of smoking and findings are suggestive of respiratory bronchiolitis associated interstitial lung disease with HRCT Severity Score: 6/15 and Extent Score: 5/15 (Warrick Semiquantitative Scoring Method)

smokers. Exertional dyspnea was the most frequent symptom, observed in 93% of cases, followed by dry cough in 45%.

In the present study, the severe FVC impairment was the most common, affecting 34% of the participants. Mild impairment was observed in 28%, while moderate impairment was seen in 26%. Moderate severe impairment was the least common, affecting 12%. Normal FEV1 levels were observed in 10% of the participants. Mild reduction in FEV1 was the most common, affecting 44%, followed by moderate reduction at 28%. A Severe reduction in FEV1 was observed in 18% of the participants. The mean ratio of forced expiratory volume in one second to forced vital capacity (FEV1/FVC) among the study participants was 0.848 ± 0.05. Comparatively, Mathur M *et al.*[12] found that 36.67% of their patients had severely low FVC, 16.67% had moderately low FVC, and 23.33% had mildly low FVC. Additionally, 33.33% had normal FEV1, 21.67% had moderately affected FEV1, and only 1.67% had very severely affected FEV1. Another study reported mean values of FVC as 63.97 ± 20.73%, FEV1 as 61.93 ± 16.97%, and FEV1/FVC ratio as 79.32 ± 6.17%.

In the present study, the spirometry pattern among the study participants revealed that 72% exhibited a restrictive pattern, indicating reduced lung volumes and capacities often associated with interstitial lung diseases. In contrast, 28% had a normal spirometry pattern. Regarding HRCT assessment, the majority (72%) had severity scores falling within the 11–15 range, with the remaining 28% scoring between 010. The mean severity score was 10.88 ± 3.51. Extent scores showed that 90% of participants had scores in the 6-15 range, with only 10% falling within the 0– 5 range. The mean extent score was 7.62 ± 1.73, indicating a moderate extent of lung involvement due to interstitial lung disease in most participants. Comparing these findings to previous studies, Phansalkar D *et al.*[13] reported mean severity and extent scores of 8.63 ± 3.1 and 7.2 ± 2.9, respectively, aligning closely with this study results. However, Mathur M et al.[12] observed a different distribution, with most severity scores falling within the 6-10 range and the majority of extent scores in the 11-15 range. Notably, a previous study reported a total HRCT score of 22, indicating a higher overall severity compared to this study.

In the present study, HRCT findings consistently revealed the presence of septal lines and irregular pleural margins in all participants. Ground-glass opacities were prevalent in 78% of cases, while subpleural cysts, traction bronchiolectasis, bronchovascular thickening, and architectural distortion each impacted 70% of individuals. Tractional bronchiectasis was evident in 58% of cases, whereas honeycombing was observed in 40%. Less frequently encountered findings included nodules in 14% of cases, alongside emphysematous changes and mediastinal lymphadenopathy, each noted in 18% of cases. Similarly, Dhameliya et al.[11] found that septal thickening was prevalent in 71% of cases, honeycombing in 42%, and ground-glass opacity in 27%. Likewise, Mathur M *et al.*[12] observed that the most common HRCT finding was septal or subpleural lines, seen in 86.67% of cases. Ground-glass opacities, irregular pleural margins, and honeycombing were also frequently noted.

While examining the relationship between HRCT findings and severity score as well as extent score, we recorded a significant association between elevated severity scores and HRCT findings ($p<0.001$). Additionally, the association between extent score and HRCT findings was highly significant ($p<0.0001$). The analysis of HRCT findings revealed a consistent pattern: they were more prevalent in patients with more severe impairment of FVC, indicating an association between structural abnormalities and declining lung function in interstitial lung diseases. Similarly, structural abnormalities were more common in patients with severe FEV1 impairment, indicating a progressive decline in lung function corresponding to the severity of these abnormalities. This pattern underscores the importance of HRCT imaging in assessing disease severity and guiding treatment decisions for individuals with interstitial lung diseases.

Furthermore, the study observed strong inverse correlations between disease severity score and both, indicating that as the disease progressed, there was a notable decline in both FVC and FEV1, suggesting compromised lung function. Likewise, the negative correlation between severity score and FEV1/FVC ratio (-0.345, $p = 0.002$) suggested that as the

severity of the illness increased, the ratio tended to decrease, indicating airflow limitation relative to lung volume. Furthermore, the extent score also showed significant negative correlations with lung function parameters. Extent scores correlated strongly with decreased FVC (–0.565, p < 0.001) and FEV1 (–0.465, p = 0.003), indicating impaired lung function with greater disease extent. Additionally, the negative correlation with FEV1/FVC ratio (–0.238, *p* = 0.016) underscored the impact of disease extent on airflow limitation relative to lung volume. Similarly, Mathur M *et al.*[12] found significant inverse correlations between HRCT severity score and both FVC (*r* = –0.578, *p* < 0.0001) and FEV1 (*r* = –0.271, *p* < 0.0001). They also observed negative correlations between HRCT extent score and FVC (*r* = –0.506, *p* < 0.0001), as well as between FEV1 and extent score (r= -0.163, *p* < 0.0001).

The study unearthed a significant association between severity and extent scores with HRCT findings, emphasizing the relevance of structural abnormalities in assessing disease severity and guiding treatment decisions. Moreover, the analysis uncovered strong negative correlations between disease severity and spirometric indices, indicating a progressive decline in lung function with advancing disease severity and extent.

Conclusion

By correlating HRCT findings with spirometry indices, clinicians can enhance diagnostic accuracy, enabling precise differentiation between ILD subtypes and other respiratory conditions. This understanding of disease severity and extent facilitates personalized treatment strategies, leading to improved patient management and tailored interventions to mitigate symptoms and slow disease progression. Moreover, the data generated from this study can fuel advancements in ILD research, guiding the development of novel diagnostic tools and therapies, while also informing healthcare policies to optimize resource allocation and enhance patient outcomes on a broader scale.

References

1. American Thoracic Society. European Respiratory Society: American Thoracic Society/European Respiratory Society international multidisciplinary consensus classification of the idiopathic interstitial pneumonias. Am J Respir Crit Care Med. 2002; 165: 277-304.
2. Coultas DB, Zumwalt RE, Black WC, Sobonya RE. The epidemiology of interstitial lung diseases. American journal of respiratory and critical care medicine. 1994 Oct; 150(4):967-72.
3. Gulati M. Diagnostic assessment of patients with interstitial lung disease. Prim Care Respir J. 2011; 20(2):120-27.
4. Grenier PH, Valeyre D, Cluzel P, Brauner MW, Lenoir S, Chastang C. Chronic diffuse interstitial lung disease: diagnostic value of chest radiography and highresolution CT. Radiology. 1991 Apr; 179(1):123-32.
5. Almeida RF, Watte G, Marchiori E, Altmayer S, Pacini GS, Barros MC, Paza Junior A, Runin AS, Salem MC, Hochhegger B. High resolution computed tomography patterns in interstitial lung disease (ILD): prevalence and prognosis. Jornal Brasileiro de Pneumologia. 2020 Mar 9;46.
6. Sneider MB, Kershaw CD. The importance of imaging in the assessment of interstitial lung diseases. Journal of thoracic imaging. 2023 Nov 1; 38:S2-6.
7. Boros PW, Franczuk M, Wesolowski S. Value of Spirometry in Detecting Volume Restriction in Interstitial Lung Disease PatientsSpirometry in Interstitial Lung Diseases. Respiration. 2004 Aug 1;71(4):374-9.
8. Raghu G, Nyberg F, Morgan G. The epidemiology of interstitial lung disease and its association with lung cancer. British Journal of Cancer. 2004 Aug; 91 (2):S3-10.
9. Suki B, Stamenovic D, Hubmayr R. Lung parenchymal mechanics. Comprehensive Physiology. 2011 Jul; 1(3):1317.
10. Kalchiem-Dekel O, Galvin JR, Burke AP, Atamas SP, Todd NW. Interstitial lung disease and pulmonary fibrosis: a practical approach for general medicine physicians with focus on the medical history. Journal of clinical medicine. 2018 Nov 24; 7(12):476.
11. Dhameliya M, Patel KM, Borisagar GB. A spectrum of pulmonary function test in interstitial lung diseases. National Journal of Physiology, Pharmacy and Pharmacology. 2022; 12 (4): 531-6.
12. Mathur M, Gupta S, Bhalla R, Mathur A. High Resolution Computed Tomography Assessment of Interstitial Lung Diseases and its Correlation with Spirometry Indices. J Clin Diag Res. 2017 Nov 1;11 (11):7-12.