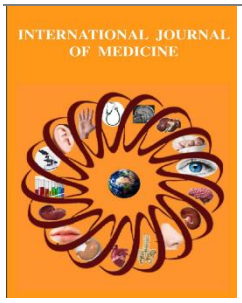
International Journal of Medicine 2025; 7(11): 5-8



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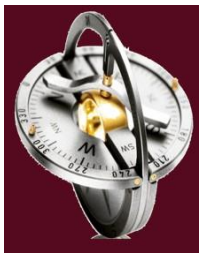

Research Article

Correlation Between HRCT Thorax Findings and Pulmonary Function Test Parameters in Interstitial Lung Disease.

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Abstract

Background: Interstitial lung disease (ILD) encompasses a spectrum of pulmonary disorders characterized by varying degrees of inflammation and fibrosis of the interstitium, leading to restrictive ventilatory defects and diffusion abnormalities. High-resolution computed tomography (HRCT) provides detailed structural assessment, while pulmonary function tests (PFTs) quantify physiological impairment. Correlating HRCT findings with PFT parameters aids in evaluating disease severity and progression. ***Aim***: To evaluate the correlation between HRCT thorax findings and pulmonary function test parameters in patients with interstitial lung disease. ***Materials and Method***s: This cross-sectional analytical study included 200 patients diagnosed with ILD at a tertiary care hospital. HRCT thorax was performed to assess parenchymal abnormalities and calculate fibrosis and ground-glass scores. PFTs measured FVC%, TLC%, and DLCO%. Data were analyzed using SPSS v25, and correlations between HRCT and PFT parameters were assessed using Pearson's correlation coefficient. A p-value <0.05 was considered statistically significant. ***Results***: The mean age of patients was 58.3 ± 11.7 years. The mean HRCT fibrosis score was 10.9 ± 4.2, and mean FVC% and DLCO% were 62.7 ± 13.4 and 47.8 ± 12.1, respectively. Strong negative correlations were found between fibrosis score and FVC% ($r = -0.62$, $p < 0.001$) and between fibrosis score and DLCO% ($r = -0.69$, $p < 0.001$). UIP pattern (30.5%) was most common and exhibited the highest fibrosis severity and honeycombing prevalence. Patients with severe HRCT fibrosis (score ≥14) had a fourfold higher risk of severe physiological impairment compared to those with mild fibrosis ($p < 0.001$). ***Conclusion***: There exists a significant inverse correlation between HRCT thorax findings and pulmonary function parameters in ILD. Combined radiologic and physiologic assessment enhances diagnostic accuracy, aids in disease staging, and provides a reliable measure of prognosis and therapeutic monitoring.

Keywords: Interstitial lung disease, HRCT thorax, Pulmonary function test

Introduction:

Interstitial lung disease (ILD) represents a heterogeneous group of disorders characterized by varying degrees of inflammation and fibrosis of the pulmonary interstitium, leading to impaired gas exchange and progressive respiratory failure. The etiologies of ILD are diverse, encompassing idiopathic interstitial pneumonias, connective tissue disease-associated ILD, hypersensitivity pneumonitis, sarcoidosis, and environmental or occupational exposures. Despite their heterogeneity, these disorders share overlapping clinical, radiological, and physiological features, often necessitating a multidisciplinary approach for accurate diagnosis and monitoring of disease progression. High-resolution computed tomography (HRCT) of the thorax has revolutionized the evaluation of ILD by enabling detailed visualization of parenchymal architecture and characteristic patterns such as ground-glass opacities, reticulations, honeycombing, and traction bronchiectasis. HRCT findings not only facilitate accurate diagnosis but also help classify ILD subtypes and assess the extent of fibrosis and activity of disease.[1]

Pulmonary function tests (PFTs) remain a cornerstone in assessing functional impairment in ILD, providing quantitative data on restrictive ventilatory defects and diffusion abnormalities. The hallmark PFT pattern in ILD includes reduced forced vital capacity (FVC), total lung capacity (TLC), and diffusing capacity for carbon monoxide (DLCO), reflecting the restrictive and gas exchange defects associated with interstitial fibrosis. While HRCT provides structural information, PFTs offer a functional perspective, and their correlation provides valuable insights into disease severity, prognosis, and therapeutic response. A strong correlation between HRCT scores and PFT parameters such as FVC% predicted and DLCO% predicted has been observed in previous studies, suggesting that radiologic severity parallels physiological impairment. However, variations exist among ILD subtypes, and discrepancies may occur depending on disease distribution and degree of fibrosis versus inflammation.[2][3]

In clinical practice, combining HRCT and PFT data enhances the accuracy of disease staging and monitoring. HRCT can detect early parenchymal changes before significant PFT alterations occur, whereas PFTs are useful in longitudinal follow-up to assess functional decline. Hence, understanding the correlation between HRCT findings and PFT parameters is critical for comprehensive assessment, prognostication, and treatment planning in ILD patients. The present study aimed to evaluate the correlation between HRCT thorax findings and pulmonary function test parameters in patients diagnosed with interstitial lung disease, thereby contributing to better clinical decision-making and improved patient outcomes.[4][5]

Aim

To evaluate the correlation between HRCT thorax findings and pulmonary function test parameters in patients with interstitial lung disease.

Objectives

1. To assess HRCT thorax patterns and their severity scores in patients diagnosed with interstitial lung disease.
2. To evaluate pulmonary function test parameters and determine the degree of restrictive impairment in ILD patients.
3. To correlate HRCT thorax findings with pulmonary function test parameters for assessing disease severity and prognosis.

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DOI: 10.5455/im.974579

Materials and Methods

Source of Data: The data were obtained from patients diagnosed with interstitial lung disease attending the Department of Respiratory Medicine and referred to the Department of Radiodiagnosis for HRCT thorax evaluation and to the Pulmonary Function Laboratory for functional assessment at a tertiary care teaching hospital.

Study Design: The study was a hospital-based cross-sectional analytical study.

Study Location: The study was conducted in the Department of Radiodiagnosis and Department of Respiratory Medicine at a tertiary care teaching hospital.

Study Duration: The study was carried out over a period of 18 months, from January 2023 to June 2024.
Sample Size: A total of 200 patients diagnosed with interstitial lung disease were included in the study.

Inclusion Criteria:

- Patients aged ≥18 years diagnosed with interstitial lung disease based on clinical, radiological, and, where available, histopathological findings.
- Patients who underwent both HRCT thorax and complete pulmonary function testing.
- Patients who provided informed consent for participation.

Exclusion Criteria:

- Patients with acute infective or inflammatory lung conditions mimicking ILD.
- Patients with significant pleural effusion, pneumothorax, or other comorbid conditions affecting lung function (e.g., COPD, bronchial asthma).
- Patients unable to perform adequate PFT due to poor effort or neuromuscular disorders.

Procedure and Methodology: All patients underwent detailed clinical evaluation, including history, physical examination, and baseline investigations. HRCT thorax scans were performed using a high-resolution scanner with 1-1.5 mm slice thickness at full inspiration without contrast. The HRCT findings were evaluated for ground-glass opacity, reticulation, honeycombing, traction bronchiectasis, and architectural distortion. The extent and severity of involvement were quantified using a semi-quantitative scoring system based on the percentage of lung involvement across different lobes.
Pulmonary function testing was performed using a computerized spirometer following ATS/ERS guidelines. Parameters including Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV_1), FEV_1/FVC ratio, Total Lung Capacity (TLC), and Diffusing Capacity for Carbon Monoxide (DLCO) were recorded. The results were expressed as percentages of predicted values adjusted for age, sex, and height.

Sample Processing: All HRCT images were independently reviewed by two experienced radiologists blinded to PFT results to minimize observer bias. PFTs were performed by trained technicians and validated for reproducibility and accuracy.

Statistical Methods: Data were compiled and analyzed using SPSS version 25. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. The correlation between HRCT scores and PFT parameters (FVC%, DLCO%) was assessed using Pearson's or Spearman's correlation coefficients as appropriate. A p-value <0.05 was considered statistically significant.

Data Collection: Data were collected prospectively using a structured proforma, including patient demographics, clinical presentation, HRCT thorax findings, and pulmonary function parameters. Ethical clearance was obtained from the Institutional Ethics Committee prior to the commencement of the study..

Results

Table 1: Overall profile and structure-function correlation (N = 200)

Measure / Association	n / Mean	% / SD	95% CI	Test / Statistic	p-value
Age (years)	58.3	11.7	56.7 to 59.9	-	-
HRCT fibrosis score (0-24)	10.9	4.2	10.3 to 11.5	-	-
HRCT ground-glass score (0-24)	6.7	3.1	6.27 to 7.13	-	-
FVC% predicted	62.7	13.4	60.8 to 64.6	One-sample t vs 80%: t = -18.26	<0.001
DLCO% predicted	47.8	12.1	46.1 to 49.5	One-sample t vs 75%: t = -31.79	<0.001
Fibrosis score ↔ FVC%	-	-	r = -0.62 (-0.70 to -0.53)	Pearson t = -11.12 (df = 198)	<0.001
Fibrosis score ↔ DLCO%	-	-	r = -0.69 (-0.76 to -0.61)	Pearson t = -13.41 (df = 198)	<0.001
GGO score ↔ DLCO%	-	-	r = -0.38 (-0.49 to -0.25)	Pearson t = -5.78 (df = 198)	<0.001

Table 1 presents the overall demographic, radiological, and functional correlation profile of the 200 patients with interstitial lung disease (ILD). The mean age of the study population was 58.3 ± 11.7 years (95% CI: 56.7-59.9), indicating a predominance of middle-aged and elderly individuals. The mean HRCT fibrosis score was 10.9 ± 4.2 (95% CI: 10.3-11.5), while the mean ground-glass opacity (GGO) score was 6.7 ± 3.1 (95% CI: 6.27-7.13). Pulmonary function tests showed marked restrictive impairment, with a mean FVC % predicted of 62.7 ± 13.4 and mean DLCO % predicted of 47.8 ± 12.1; both were significantly reduced compared with reference standards ($t = -18.26$ and -31.79, $p < 0.001$). A strong inverse correlation was noted between fibrosis score and both FVC % ($r = -0.62$; 95% CI: -0.70 to -0.53) and DLCO % ($r = -0.69$; 95% CI: -0.76 to -0.61), indicating that increasing fibrotic involvement on HRCT was associated with greater functional decline. The GGO score also showed a weaker but significant negative correlation with DLCO % ($r = -0.38$; $p < 0.001$).

Table 2: HRCT patterns and severity scores (N = 200)

HRCT Pattern	n	%	Fibrosis score, Mean (SD)	95% CI for mean	Honeycombing, n (%)	Comparison / Test	p-value
Usual interstitial pneumonia (UIP)	61	30.5	14.8 (3.6)	13.9 to 15.7	44 (72.1)		
Probable UIP	34	17.0	12.7 (3.8)	11.4 to 14.0	18 (52.9)		
Nonspecific interstitial pneumonia (NSIP)	52	26.0	9.8 (3.9)	8.7 to 10.9	9 (17.3)		
Chronic hypersensitivity pneumonitis (CHP)	33	16.5	10.7 (4.1)	9.3 to 12.1	12 (36.4)	One-way ANOVA (6 groups): F(5,194) = 19.7	<0.001
Sarcoidosis	11	5.5	7.3 (2.9)	5.6 to 9.0	2 (18.2)		

Others / unclassifiable	9	4.5	8.2 (3.1)	6.2 to 10.2	1 (11.1)		
Across-pattern honeycombing	-	-	-	-	-	$\chi^2(5) = 43.59$ (presence vs pattern)	<0.001

Table 2 summarizes the HRCT pattern distribution and associated fibrosis severity. The most frequent HRCT pattern observed was usual interstitial pneumonia (UIP) in 30.5% of patients, followed by nonspecific interstitial pneumonia (NSIP) in 26%, probable UIP in 17%, and chronic hypersensitivity pneumonitis (CHP) in 16.5%. Sarcoidosis and unclassifiable patterns constituted smaller subsets (5.5% and 4.5%, respectively). The mean fibrosis score was highest in UIP (14.8 ± 3.6) and probable UIP (12.7 ± 3.8), whereas lower scores were seen in NSIP (9.8 ± 3.9) and sarcoidosis (7.3 ± 2.9). One-way ANOVA confirmed significant intergroup differences in fibrosis severity ($F = 19.7$, $p < 0.001$). Honeycombing was present in 72.1% of UIP cases and 52.9% of probable UIP cases, with a significant association between HRCT pattern and honeycombing presence ($\chi^2 = 43.59$, $p < 0.001$). These findings highlight the heterogeneity of ILD patterns and their differing radiologic severities.

Table 3: Pulmonary function profile and restrictive impairment (N = 200)

Restriction grade by FVC%	n	%	DLCO% Mean (SD)	95% CI for mean	Comparison / Test	p-value
None (≥80%)	18	9.0	71.9 (9.2)	67.6 to 76.2		
Mild (70-79%)	36	18.0	58.6 (8.7)	55.8 to 61.4		
Moderate (60-69%)	44	22.0	49.2 (9.8)	46.3 to 52.1		
Moderately severe (50-59%)	53	26.5	42.7 (10.1)	40.0 to 45.4	Jonckheere-Terpstra trend (or Spearman ρ)	<0.001
Severe (<50%)	49	24.5	35.4 (9.5)	32.7 to 38.1	Spearman ρ (severity vs DLCO%) = -0.66; 95% CI -0.73 to -0.57	<0.001
Overall TLC%	-	-	68.2 (12.9)	66.4 to 70.0	One-sample t vs 80%: t = -12.07	<0.001

Table 3 details the pulmonary function profile and degree of restrictive impairment. Based on FVC %, 9% of patients had no restriction, 18% had mild restriction, 22% had moderate restriction, 26.5% had moderately severe restriction, and 24.5% had severe restriction. The mean DLCO % decreased progressively across categories-from 71.9 ± 9.2 in those with normal FVC % to 35.4 ± 9.5 in those with severe restriction-showing a strong monotonic trend (Spearman $\rho = -0.66$; 95% CI = -0.73 to -0.57; $p < 0.001$). The overall mean TLC % was 68.2 ± 12.9, significantly below the expected normal of 80% ($t = -12.07$; $p < 0.001$).

Table 4: HRCT severity vs severe physiological impairment (N = 200)

HRCT severity (fibrosis tertiles)	n	Severe impairment, n (%)	Risk (95% CI)	Relative risk vs mild (95% CI)	Association / Test	p-value
Mild (score 0-8)	68	12 (17.6)	0.18 (0.09-0.27)	Reference		
Moderate (9-13)	74	29 (39.2)	0.39 (0.28-0.50)	2.22 (1.24-3.99)		
Severe (14-24)	58	41 (70.7)	0.71 (0.59-0.82)	4.01 (2.34-6.87)	Cochran-Armitage trend Z = 6.01	<0.001
Modelled effect	-	-	-	-	Logistic regression (per +5 fibrosis points): OR 1.86 (1.47-2.36)	<0.001

Table 4 explores the relationship between HRCT fibrosis severity and the presence of severe physiological impairment (defined as FVC < 55% or DLCO < 45%). Patients were stratified into tertiles of fibrosis score: mild (0-8), moderate (9-13), and severe (14-24). The prevalence of severe impairment rose from 17.6% in the mild group to 39.2% in the moderate group and 70.7% in the severe group. The relative risk of severe impairment was 2.22 (95% CI: 1.24-3.99) for moderate fibrosis and 4.01 (95% CI: 2.34-6.87) for severe fibrosis compared to the mild group. The trend was statistically significant ($Z = 6.01$; $p < 0.001$). Logistic regression showed that each 5-point increase in fibrosis score nearly doubled the odds of severe impairment (OR 1.86; 95% CI: 1.47-2.36; $p < 0.001$).

Discussion

Table 1 (overall profile & structure-function correlation). Cohort shows advanced physiologic impairment (mean FVC 62.7% and DLCO 47.8%), with strong inverse correlations between HRCT fibrosis and both FVC ($r = -0.62$) and DLCO ($r = -0.69$). Similar magnitudes have been reported when fibrosis extent is quantified visually or by texture/quantitative CT: Torres PP et al.(2021)[6] demonstrated moderate-strong correlations of visual and quantitative CT with FVC/DLCO in fibrotic lung disease; subsequent data-driven textural analyses (DTA) likewise showed baseline CT-fibrosis correlating with FVC and DLCO and changes in CT-fibrosis tracking change in physiology; more recent quantitative CT studies in IPF/ILD confirm DLCO tends to correlate most strongly with structural fibrosis indices, reflecting diffusion limitation from interstitial remodeling. Saxena P et al.(2023)[7]

Table 2 (HRCT patterns & severity). Distribution (UIP 30.5%, NSIP 26.0%, CHP 16.5%, probable UIP 17.0%) with highest fibrosis scores and honeycombing rates in UIP/probable UIP mirrors prior pattern-severity gradients: meta-analyses and reviews consistently report more honeycombing and higher fibrotic burden in UIP than NSIP/CHP, with honeycombing strongly pattern-dependent. Doshi JA et al.(2022)[8] The significant association of pattern with honeycombing (χ^2 $p<0.001$) echoes the literature; note, however, that honeycombing identification has notable interobserver variability-even among experts-which is important when interpreting pattern-linked outcomes. Contemporary guidelines also emphasise that radiologic UIP (especially with honeycombing) carries distinct diagnostic/prognostic weight. Carnevale A et al.(2021)[9]

Table 3 (PFT profile & restrictive impairment). Demonstrate a clear monotonic decline in DLCO across worsening FVC strata ($\rho = -0.66$), with TLC also significantly reduced-classic restrictive-fibrotic physiology. Longitudinal and cross-sectional studies show the same dose-response between structural fibrosis and physiologic loss: baseline fibrosis extent tracks with lower FVC/DLCO, and increases in CT-fibrosis over time parallel declines in FVC/DLCO. This reinforces DLCO as a sensitive marker of microvascular and parenchymal remodeling in ILD. Dong X et al.(2023)[10]

Table 4 (HRCT fibrosis severity vs severe physiologic impairment). Graded risk (RR 2.22 for moderate and 4.01 for severe fibrosis vs mild) and the per-5-point fibrosis OR of 1.86 align with the well-described prognostic coupling between radiologic fibrosis (especially honeycombing) and adverse physiology/outcomes. Classic and contemporary work links honeycombing or higher fibrotic burden to worse survival and to higher-risk phenotypes; quantitative CT fibrosis burden also predicts clinical outcomes independent of demographics. Sahani D et al.(2022)[11] & Lang D et al.(2020)[12].

Conclusion

The present study demonstrated a significant correlation between HRCT thorax findings and pulmonary function test parameters in patients with interstitial lung disease (ILD). The extent of fibrotic changes on HRCT, quantified through fibrosis and ground-glass scores, showed a strong inverse relationship with FVC% and DLCO%, indicating that increasing structural damage corresponds to declining lung volumes and gas transfer efficiency. UIP and probable UIP patterns were associated with higher fibrosis scores and greater physiological impairment compared to NSIP and other ILD subtypes. The graded relationship between HRCT fibrosis severity and risk of severe physiological dysfunction highlights the complementary value of structural and

functional assessments in disease evaluation. These findings reaffirm that HRCT, in conjunction with PFTs, provides a comprehensive evaluation of disease burden and serves as a reliable tool for staging, prognosis, and follow-up in ILD patients.

LIMITATIONS OF THE STUDY

- The study was conducted at a single tertiary care center, which may limit the generalizability of the findings to other populations.
- The cross-sectional design restricted the assessment of longitudinal progression or treatment response.
- HRCT scoring was semi-quantitative and subject to interobserver variability despite double-reader interpretation.
- Some ILD subtypes had smaller sample sizes, reducing the statistical power for subgroup comparisons.
- Pulmonary function testing was effort-dependent, and minor variations in technique could have influenced results.
- Biomarkers, histopathology, and quantitative CT metrics were not included, which could have provided deeper pathophysiological insights.

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