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High-Resolution Computed Tomography Findings in Interstitial Lung Disease and Their Correlation with Pulmonary Function Tests

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ABSTRACT
Background: *Interstitial lung disease (ILD) is a heterogeneous group of chronic pulmonary disorders characterised by inflammation and fibrosis of the lung parenchyma, leading to impaired gas exchange and restrictive ventilatory defects. High-resolution computed tomography (HRCT) provides a detailed morphological assessment, while pulmonary function tests (PFTs) quantify functional impairment. This study aimed to evaluate HRCT patterns in ILD patients and correlate them with PFT parameters.*
Methods: *A prospective observational study was conducted at RKDF Medical College & Hospital and Research Centre from December 2024 to December 2025. A total of 80 patients clinically suspected of ILD underwent HRCT and PFTs. HRCT patterns, including ground-glass opacities, reticulations, honeycombing, traction bronchiectasis, and mixed patterns, were analysed. PFT parameters recorded included forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), FEV1/FVC ratio, and diffusing capacity for carbon monoxide (DLCO). Correlations between HRCT findings and PFT results were assessed using Pearson's correlation coefficient.*
Results: *The mean age of patients was 53.2 ± 11.6 years, with 57.5% males. Reticulations were the most common HRCT finding (52.5%), followed by ground-glass opacities (37.5%), honeycombing (27.5%), and traction bronchiectasis (25%). Lower lobe involvement was observed in 62.5% of cases. PFTs revealed a restrictive pattern in most patients, with a mean FVC of 63 ± 14% and DLCO of 58 ± 12% of predicted. Fibrotic HRCT patterns (honeycombing, traction bronchiectasis, and mixed patterns) showed a strong negative correlation with FVC and DLCO ($r = -0.55$ to -0.70, $p < 0.001$), whereas ground-glass opacities exhibited a weaker correlation.*
Conclusion: *HRCT patterns in ILD correlate significantly with pulmonary function impairment. Fibrotic changes, especially honeycombing and traction bronchiectasis, are associated with severe functional compromise, while ground-glass opacities indicate milder disease. Combined HRCT and PFT assessment enhances disease staging, prognosis, and clinical management in ILD patients.*
Keywords: *Interstitial lung disease, High-resolution computed tomography, Pulmonary function test, Honeycombing, Reticulations, Ground-glass opacities*

I. INTRODUCTION

Interstitial lung disease (ILD) is a heterogeneous group of disorders characterised by varying degrees of inflammation and fibrosis of the lung parenchyma, leading to impaired gas exchange and restrictive ventilatory defects [1,2]. The clinical presentation of ILD is often non-specific, with symptoms such as exertional dyspnea, dry cough, and fatigue [3]. Early and accurate diagnosis is essential because disease progression can be variable, and timely management can improve outcomes [4].

High-Resolution Computed Tomography (HRCT) has emerged as the gold standard imaging modality for the evaluation of ILD. HRCT provides detailed visualisation of lung parenchymal architecture, allowing differentiation between inflammatory and fibrotic patterns, which is crucial for prognosis and treatment planning [5,6]. Common HRCT findings in ILD include ground-glass opacities, reticulations, honeycombing, and traction bronchiectasis, each correlating with different stages of disease activity and fibrosis [7,8].

Pulmonary function tests (PFTs), including Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV1), and Diffusing Capacity of the Lungs for Carbon Monoxide (DLCO), are routinely used to assess the functional impairment in ILD patients [9]. Restrictive ventilatory defects and reduced DLCO are hallmarks of ILD and often correlate with the extent of fibrotic changes observed on HRCT [10].

Despite advances in imaging and pulmonary function assessment, the correlation between HRCT patterns and PFT parameters remains critical for accurate disease staging and monitoring progression, as well as guiding therapeutic decisions [11]. Evaluating this correlation helps clinicians identify patients at risk of rapid progression and tailor interventions accordingly [12].

The present study aims to analyse HRCT findings in patients with ILD and correlate these with PFT parameters to determine the relationship between radiological severity and functional impairment in a cohort of patients attending RKDF Medical College & Hospital and Research Centre.

II. MATERIALS AND METHODS

Study Design and Setting

This was a prospective observational study conducted over a period of one year (December 2024 to December 2025) at RKDF Medical College & Hospital and Research Centre (RKDF MCH & RC), Bhopal. The study protocol was approved by the Institutional Ethics Committee (IEC), and written informed consent was obtained from all participants before enrolment. The study adhered to the principles of the Declaration of Helsinki.

Study Population

A total of 80 patients diagnosed or suspected of having interstitial lung disease (ILD) were enrolled in the study. Patients of both sexes aged ≥18 years, presenting to the pulmonology outpatient department or admitted in the hospital with clinical suspicion of ILD, were included.

Inclusion Criteria

- Adults aged 18 years and above.
- Patients with clinical symptoms suggestive of ILD, such as chronic cough, exertional dyspnea, or fine inspiratory crackles on auscultation.
- Patients willing to undergo high-resolution computed tomography (HRCT) and pulmonary function tests (PFTs).

Exclusion Criteria

- Patients with acute respiratory infections or exacerbations of ILD at the time of evaluation.
- Patients with other significant pulmonary diseases such as tuberculosis, chronic obstructive pulmonary disease (COPD), or asthma.
- Pregnant or lactating women.
- Patients unwilling or unable to provide informed consent.

Data Collection

Demographic details, clinical history, and relevant laboratory investigations were recorded. Each patient underwent:

1. **High-Resolution Computed Tomography (HRCT) of the Chest**
    - HRCT scans were performed using a 64-slice multidetector CT scanner.
    - Scans were obtained at full inspiration in the supine position, with thin-section (1–2 mm) axial images at 10–20 mm intervals.
    - Images were reconstructed using high-spatial-frequency algorithms and evaluated in lung window settings.
    - HRCT findings were classified according to the current international guidelines for ILD, noting features such as ground-glass opacities, reticulations, honeycombing, traction bronchiectasis, and distribution patterns.
    - Two experienced radiologists independently reviewed the scans, and discrepancies were resolved by consensus.
    -
2. **Pulmonary Function Tests (PFTs)**
    - PFTs were performed using a standard computerised spirometer following American Thoracic Society (ATS) guidelines.
    - Parameters recorded included Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV1), FEV1/FVC ratio, and Diffusing Capacity of the Lungs for Carbon Monoxide (DLCO).
    - PFT results were expressed as absolute values and percentages of predicted normal values.

Statistical Analysis

- Data were entered and analysed using SPSS software (version 28.0).
- Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequencies and percentages.
- Correlation between HRCT findings and PFT parameters was assessed using Pearson or Spearman correlation coefficients as appropriate.
- A p-value <0.05 was considered statistically significant.

III. RESULTS AND OBSERVATIONS

Table; 1. Demographic and Clinical Characteristics

Parameter	n (%) / Mean ± SD
Total patients	80 (100%)
Age (years)	53.2 ± 11.6
Sex	
– Male	46 (57.5%)
– Female	34 (42.5%)
Symptom duration (months)	16.8 ± 7.5
Common presenting symptoms	
– Exertional dyspnea	70 (87.5%)
– Chronic non-productive cough	62 (77.5%)
– Fine inspiratory crackles	56 (70%)
– Clubbing	18 (22.5%)

ILD predominantly affects middle-aged adults, with a slight male predominance. Dyspnea was the most common symptom, and fine crackles were present in the majority of patients.

Table; 2. HRCT Findings

HRCT Pattern	n (%)	Distribution
Ground-glass opacities	30 (37.5%)	Bilateral lower lobes 20, diffuse 10
Reticulations	42 (52.5%)	Bilateral lower lobes predominant
Honeycombing	22 (27.5%)	Lower lobes 18, diffuse 4
Traction bronchiectasis	20 (25%)	Lower lobes 16, diffuse 4
Mixed pattern (GGO + reticulations)	16 (20%)	Lower lobes 12, diffuse 4

Lower lobe predominance is typical in ILD. Honeycombing and traction bronchiectasis represent advanced fibrosis, while ground-glass opacities reflect active inflammation.

Table; 3. Pulmonary Function Test (PFT) Results

Parameter	Mean ± SD	% Predicted
FVC (L)	2.25 ± 0.75	63 ± 14
FEV1 (L)	1.85 ± 0.65	64 ± 13
FEV1/FVC (%)	82 ± 5	—
DLCO (mL/min/mmHg)	13.8 ± 4.8	58 ± 12

Most patients showed a restrictive ventilatory defect (FVC <80% predicted) with reduced DLCO, consistent with ILD patterns.

Table; 4. Correlation of HRCT Patterns with Pulmonary Function

HRCT Pattern	Mean FVC (% predicted)	Mean DLCO (% predicted)	Patients with Restrictive Pattern (FVC <80%) n (%)
Ground-glass opacities	70 ± 12	64 ± 10	18 (60%)
Reticulations	61 ± 11	56 ± 9	32 (76%)
Honeycombing	48 ± 9	42 ± 8	20 (91%)
Traction bronchiectasis	50 ± 10	44 ± 9	18 (90%)
Mixed pattern	52 ± 11	46 ± 10	14 (87.5%)

Fibrotic changes such as honeycombing, traction bronchiectasis, and mixed patterns are associated with significantly reduced FVC and DLCO. Ground-glass opacities correlate with milder functional impairment.

Table; 5. Statistical Correlation (HRCT Features vs PFTs)

HRCT Feature	FVC (% predicted) r	DLCO (% predicted) r	p-value
Ground-glass opacities	-0.28	-0.25	0.03
Reticulations	-0.46	-0.42	0.001
Honeycombing	-0.68	-0.70	<0.001
Traction bronchiectasis	-0.55	-0.58	<0.001
Mixed pattern	-0.62	-0.60	<0.001

There is a strong negative correlation between fibrotic HRCT features and pulmonary function, particularly DLCO. Ground-glass opacities show a mild correlation, indicating less functional impairment.

IV. DISCUSSION

Interstitial lung disease (ILD) encompasses a spectrum of chronic pulmonary disorders characterised by progressive inflammation and fibrosis of the lung parenchyma [1,2]. Early identification and accurate assessment of disease severity are critical for guiding management and predicting outcomes [3]. In this study, we analyzed HRCT patterns in ILD patients and correlated these with pulmonary function test (PFT) parameters to evaluate the relationship between radiological severity and functional impairment.

Demographics and Clinical Features

In our cohort of 80 patients, the mean age was 53.2 ± 11.6 years, with a slight male predominance (57.5%). These findings are consistent with previous studies, which report that ILD commonly affects middle-aged adults, with a male-to-female ratio of approximately 1.3:1 [4,5]. Exertional dyspnea was the most frequent symptom (87.5%), followed by chronic dry cough (77.5%) and fine inspiratory crackles on auscultation (70%), similar to patterns observed in idiopathic pulmonary fibrosis and other fibrotic ILDs [6,7].

HRCT Patterns

HRCT is the most sensitive imaging modality for assessing the type and extent of parenchymal involvement in ILD [8]. In our study, reticulations were the most common finding (52.5%), followed by ground-glass opacities (37.5%), honeycombing (27.5%), and traction bronchiectasis (25%). Lower lobe predominance was observed in 62.5% of patients, consistent with the typical distribution of idiopathic pulmonary fibrosis and other fibrotic ILDs [9,10]. Mixed patterns (ground-glass opacities with reticulations) were observed in 20% of patients, representing a combination of inflammatory and fibrotic changes [11]. These findings are in line with previous literature, highlighting HRCT as a crucial tool for staging ILD and distinguishing between early and advanced disease [12,13].

Pulmonary Function Tests

Pulmonary function testing revealed a restrictive ventilatory pattern in most patients, with mean FVC 63 ± 14% of predicted and mean DLCO 58 ± 12% of predicted. The restrictive pattern with reduced diffusion capacity is typical of ILD, reflecting impaired lung compliance and alveolar-capillary membrane dysfunction [14,15]. Patients with honeycombing and mixed fibrotic patterns demonstrated the most significant reductions in FVC and DLCO, consistent with the progression from inflammation to irreversible fibrosis [16]. Ground-glass opacities, indicative of active inflammation, were associated with milder functional impairment, supporting the concept that HRCT findings can predict disease severity [17].

Correlation Between HRCT and PFTs

Our study demonstrated a strong negative correlation between fibrotic HRCT patterns (honeycombing, traction bronchiectasis, and mixed patterns) and PFT parameters (FVC and DLCO). Specifically, honeycombing showed the highest negative correlation with FVC ($r = -0.68$) and DLCO ($r = -0.70$), highlighting its association with advanced fibrosis and severe functional compromise. Ground-glass opacities exhibited a weaker correlation, suggesting that inflammatory changes alone have less impact on lung function [18,19]. These results are consistent with previous studies showing that HRCT patterns can serve as surrogate markers for pulmonary impairment and can guide both prognosis and therapeutic decisions [20,21].

Clinical Implications

The findings of this study reinforce the complementary roles of HRCT and PFTs in ILD evaluation. HRCT allows detailed morphological assessment, while PFTs quantify functional impairment. Correlating these modalities helps clinicians identify patients with early disease who may benefit from anti-inflammatory therapy and those with advanced fibrosis requiring closer monitoring or consideration for lung transplantation [22].

Limitations

This study has certain limitations. First, the sample size was relatively small, limiting generalizability. Second, histopathological confirmation was not available for all patients, so some diagnoses were based on clinical and radiological criteria. Third, the study was conducted at a single centre, which may introduce referral bias. Future multicenter studies with larger cohorts and long-term follow-up are warranted to validate these findings.

V. CONCLUSION

In conclusion, HRCT is a valuable tool for identifying patterns of lung involvement in ILD, and its findings correlate strongly with functional impairment measured by PFTs. Fibrotic changes, especially honeycombing and traction bronchiectasis, are associated with more severe restrictive defects and reduced gas transfer, whereas ground-glass opacities indicate milder disease. The combined assessment of HRCT and PFTs enhances disease staging, prognostication, and clinical decision-making in patients with ILD.

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