International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

Role of HRCT in Monitoring Treatment Response in Fibrotic Lung

Himanshu Mishra[1], Ashish Kumar Shukla[2], Bhawna Solanki[3], Saloni Martolia[1]

[1]Research Scholar, Department of Radiodiagnosis, SMC, Santosh Deemed to be University, Ghaziabad, Uttar Pradesh, India.
[2]Professor, Department of Radio-Diagnosis, SMC, Santosh Deemed to be University, Ghaziabad, Uttar Pradesh, India
[3]Assistant Professor, Govt. Medical College, Goa

Corresponding Author:

Himanshu Mishra
Research Scholar, Department of Radiodiagnosis, SMC, Santosh Deemed to be University, Ghaziabad, Uttar Pradesh, India
Email: himanshutpbk@gmail.com

Received: 10-06-2026
Accepted: 25-06-2026
Available online: 19-07-2026

ABSTRACT

HRCT (high-resolution computed tomography) is a key imaging technique for the assessment of fibrotic interstitial lung diseases (ILD); high-resolution CT has become essential in the evaluation of idiopathic pulmonary fibrosis (IPF), systemic sclerosis–associated interstitial lung disease (SSc-ILD), and chronic hypersensitivity pneumonitis (CHP). In addition to its use in diagnosis, HRCT has now gained importance for assessing disease progression and response to treatment with the introduction of antifibrotics (like pirfenidone and nintedanib). With recent developments in quantitative CT (qCT), artificial intelligence (AI), and radiomics, the quantification of HRCT has increasingly become objective and reproducible for assessing ectopic fibrotic changes over time. All of these longitudinal studies have shown that HRCT-derived metrics correlate strongly with functional parameters (such as forced vital capacity (FVC) and diffusion capacity of carbon monoxide (DLCO)) and with circulating biomarkers. HRCT remains the standard for imaging-based treatment assessments for fibrotic lung disease, despite caveats associated with radiation exposure, variability in interpretation, and a lack of universal monitoring guidelines. The continued integration of AI, radiometrics, and imaging biomarkers is anticipated to further improve monitoring approaches, reinforce personalised treatment decision-making, and cement the importance of HRCT in precision medicine.

Keywords*: High-resolution computed tomography (HRCT), fibrotic lung disease, idiopathic pulmonary fibrosis (IPF), systemic sclerosis–associated interstitial lung disease (SSc-ILD), treatment response monitoring, quantitative CT (qCT), radiomics.*

INTRODUCTION

Fibrotic ILDs are a heterogeneous group of chronic, progressive, and potentially life-limiting diseases that are characterised by abnormal lung parenchyma remodelling, extracellular matrix deposition, and irreversible scarring. Classified among these are idiopathic pulmonary fibrosis (IPF), systemic sclerosis–associated interstitial lung disease (SSc-ILD) and chronic hypersensitivity pneumonitis (CHP), the three most clinically relevant for their chronic course, detrimental effect on health-related quality of life and higher mortality than other forms of ILD (Lederer et al., 2024; Hodnett et al., 2013).

The proper evaluation of disease severity and progression plays a vital role in developing a tailored strategy for therapy. Even though PFTs, including FVC and DLCO, continue being important, they are not sufficiently sensitive to regional/early parenchymal alterations (Khanna et al., 2022). On the other hand, high-resolution computed tomography (HRCT) appears to be the gold standard for diagnostic and monitoring purposes. This diagnostic method allows visualising reticular patterns, honeycombing, and groundglass opacities—characteristics that significantly contribute to evaluating treatment efficacy and assessing disease severity (Chung et al., 2018).

Modern treatment approaches, such as the administration of anti-fibrotic medications (pirfenidone/nintedanib) for patients with fibrotic disease, require precise monitoring. Numerous clinical trials and cohort studies demonstrate that the results of HRCT prove to be an effective prognostic indicator and a determinant of treatment efficacy (Balestro et al., 2019; Battista

et al., 2024). Moreover, owing to the introduction of qCT and radiomics coupled with AI, HRCT became a tool enabling the evaluation of disease progress objectively and precisely (Koo et al., 2022; George et al., 2024).

However, HRCT also faces various limitations. The issue related to high radiation levels, non-standardised protocols for follow-up scans, and radiologist subjectivity still persists (Makol et al., 2023). Nonetheless, the significance of HRCT in clinical practice is growing due to increasing references to it in expert consensus statements aimed at facilitating therapy decision-making, including initiation, modification, and assessment (Rahaghi et al., 2023; Guiot et al., 2024).
Table 1 highlights the key fibrotic lung conditions and the significant role of HRCT in management decisions for these conditions.

Table 1. Role of HRCT in Monitoring Major Fibrotic Lung Diseases

Disease	Typical HRCT Features	Role in Monitoring Treatment Response	Supporting References
Chronic Hypersensitivity Pneumonitis (CHP)	Mosaic attenuation, ground-glass opacities, fibrosis	Distinguishes active inflammation vs fibrosis; monitors the impact of antigen avoidance and therapy.	Nan et al., 2025; Lancet Respir Med, 2024
Idiopathic Pulmonary Fibrosis (IPF)	Reticulations, honeycombing, traction bronchiectasis	Detects subtle progression despite stable FVC; quantifies antifibrotic therapy effect	Balestro et al., 2019; Koo et al., 2022; Dixon et al., 2025
Connective Tissue Disease–Associated ILD (other than SSc)	Variable fibrotic changes depending on disease type	Complements serological/clinical assessment; monitors immunosuppressive treatment effect	Hoffmann-Vold et al., 2019; Rahaghi et al., 2023
Systemic Sclerosis–Associated ILD (SSc-ILD)	Ground-glass opacities, reticulations, fibrosis in basal lungs	Assesses baseline severity; monitors stability vs. progression; guides immunosuppressive/antifibrotic therapy	Khanna et al., 2022; Ledda et al., 2024; Tschalèr et al., 2025
Radiation-Induced Pulmonary Fibrosis	Patchy fibrosis, traction bronchiectasis, volume loss	Evaluates treatment-related lung injury and therapy response; supports radiomics applications	Wang et al., 2021; Béclin et al., 2025

In summary, HRCT is not only an important diagnostic method but also an active monitoring tool used to monitor changes over time as well as treatment response in cases of fibrotic lung disease. The growing incorporation of advanced imaging modalities, radiomic analysis, and artificial intelligence highlights the ongoing evolution of HRCT as a precise biomarker. The following chapters will discuss the evidence on HRCT in more detail, starting with the specific review of HRCT in fibrotic lung disease.

HRCT in Fibrotic Lung Disease

The advent of high-resolution CT (HRCT) has revolutionised the field of diagnostic radiology in ILD over the past three decades. The ability of HRCT to visualise lung parenchyma is unmatched by any other imaging modality, such as chest x-rays or even pulmonary function tests (PFT). In this section, a brief history about the use of HRCT in the ILDs will be discussed along with its comparison to qualitative and quantitative methods and various scores.

Historical Perspective

HRCT in fibrotic lung disease was introduced at the end of the 1980s through the early 1990s following the development of CT techniques that allowed for thin slices and high spatial resolution. The ability to image small structures made possible the identification of features that are still regarded as diagnostic markers, including honeycombing, reticulation, and ground-glass opacity (Hodnett et al., 2013). Initially, HRCT was mostly used in a qualitative manner based on the evaluation by radiologists of differentiating between fibrotic and inflammatory lesions.

Over time, however, HRCT came to play an increasingly important role in the prognosis of ILD. A body of evidence indicated that quantified HRCT findings were significantly better predictors of survival than other prognostic parameters such as FVC in IPF and SSc-ILD patients (Elicker et al., 2017; Lederer et al., 2024). With the advent of antifibrotic treatments like pirfenidone and nintedanib, HRCT was applied as well to monitor their efficacy (Balestro et al., 2019).

Qualitative HRCT Assessment

Visually Based Interpretation

The visual interpretation of HRCT is generally performed by an experienced radiologist through the classification of HRCT findings, including:

- Increased lung density (GGOs): These can be associated with inflammation or reversible disease.
- Reticulation and traction bronchiectasis: These are suggestive of architectural distortion or fibrosis.
- Honeycombing: The classic finding of irreversible fibrosis, seen in IPF.

- Mosaic attenuation: Seen commonly in chronic hypersensitivity pneumonitis (CHP).

This approach provides immediate results, and it has significant importance in multidisciplinary meetings (Chung et al., 2018). Nonetheless, there can be interobserver discrepancies, especially in indeterminate HRCT findings or mixed findings (Makol et al., 2023). To minimise subjectivity, scoring systems have been developed.

Semi-quantitative scoring systems

- The Wells score for IPF: This score assesses the extent of fibrosis in the lungs.
- The Goh staging system for SSc-ILD grades diseases as being either limited or extensive based on >20% fibrosis.
- Eur Respir Rev 2017 recommendations: Proposes visual scores associated with PFTs and outcomes.

Although valuable, these methods have limitations because they do not accurately assess progression/response to therapy in clinical trials.

Quantitative High-Resolution Computed Tomography (qHRCT) Imaging

The qCT approach employs computer technology to assess lung density and texture objectively and consistently (Dixon et al., 2025; George et al., 2024). It mitigates problems associated with the subjective nature of human beings, especially when conducting longitudinal research that involves clinically meaningful alterations in a patient's condition.

Methods include:

- Histogram analysis: Mean lung attenuation, skewness, and kurtosis.
- Lung texture assessment: Helps distinguish between fibrosis, emphysema, and healthy lungs.
- Segmentation tools: Software such as CALLIPER and e-Lung assess regional disease extent.
- Functional respiratory imaging (FRI): Evaluates regional ventilation and progression (Clukers et al., 2018).

Clinical Applications

- Ability to detect early disease progression that cannot be detected using PFTs.
- Helpful endpoints for anti-fibrotic drug development.
- Help with stratifying prognosis and predicting therapy effectiveness.

For instance, research reveals that qCT progression is better correlated with mortality rate than FVC changes in IPF patients (Dixon et al., 2025). AI-based qCT methods increase their sensitivity even more due to machine learning capabilities (Koo et al., 2022).

Radiomics & AI Integration

Radiomics builds on qCT analysis through the use of high-dimensional data (i.e., texture, wavelet, and shape) extracted from HRCT scans. The application of delta-radiomics, assessing changes in the radiomics profile over time, has been shown to have promise for predicting treatment response prior to the onset of decline (Nasief et al., 2019; Yang et al., 2022).

The use of artificial intelligence (AI), particularly through deep learning algorithms, makes automatic segmentation and quantification of fibrosis possible. New research has found that AI-based HRCT measurements are predictive of response to antifibrotic treatment and significantly correlated with biomarkers, such as serum KL-6 and surfactant proteins (Zhang et al., 2025; Miceli et al., 2025).

Comparative Strengths and Limitations

Approach	Strengths	Limitations
Qualitative (visual)	Widely available, essential for diagnosis, intuitive for clinicians	Subjective interobserver variability is les sensitive for monitoring.
Semi-quantitative scoring	It is standardised, correlates with a prognosis, and is easy to apply.	Coarse categories, limited sensitivity, time consuming
Quantitative CT (qCT)	Objective, reproducible, sensitive to small changes, validated in trials	Requires specialised software, nc universally available, and costs
Radiomics/AI	High-dimensional features, predictive modelling, early response detection	It is computationally intensive, require large datasets, and has not yet bee standardised.

HRCT for Monitoring Treatment Response

The high-resolution computed tomography (HRCT) imaging modality has gained enormous significance in evaluating responses to therapy in patients with fibrotic lung diseases. In addition to pulmonary function tests (PFTs), antifibrotic drugs, immunomodulatory agents, and supporting strategies for treating fibrotic lung disorders have been assessed using

HRCT imaging parameters. HRCT scans may be employed for assessing structural changes, predicting prognosis, and evaluating the efficacy of treatment. It is essential to emphasise that HRCT has been proven to reveal disease progression before functional impairment occurs, providing important information about treatment choices. This chapter will focus on the use of HRCT in monitoring therapy responses in IPF, SSc-ILD, and CHP with an analysis of the most relevant clinical studies ordered chronologically.

Idiopathic Pulmonary Fibrosis (IPF)

The paradigmatic fibrotic lung condition with extensive investigation of HRCT follow-up is idiopathic pulmonary fibrosis. Monitoring therapy using FVC and DLCO has certain drawbacks since they may remain stable despite radiological progression. HRCT offers additional information through the visualisation and quantification of tissue alterations.

Chronological Evidence for Idiopathic Pulmonary Fibrosis

1. Balestro et al. (2019): In a longitudinal HRCT study, progressive fibrosis, including honeycomb and traction bronchiectasis, correlated with poorer survival even if FVC was stable, highlighting the advantages of HRCT monitoring.
2. Koo et al. (2022): A machine learning–based qCT study validated against PFTs showed that automated HRCT detection identified progression before decline in lung function.
3. George et al. (2024): The e-Lung and CALLIPER systems found that qCT measurements, such as fibrosis percentage or vessel-related structures, were superior to FVC change in predicting mortality.
4. Dixon et al. (2025): The systematic review concluded that qCT could be used as a prognostic biomarker and monitoring parameter in clinical trials.
5. Nerandomilast Trial (NEJM 2025): In a major antifibrotic trial, HRCT was added to FVC as a coprimary outcome, demonstrating that qCT measured subtle treatment stability not seen in FVC.

Table 2. HRCT Studies in IPF Monitoring Treatment Response

Study (Year)	Design & Intervention	HRCT Approach	Key Findings
Balestro et al. (2019)	Longitudinal cohort	Visual scoring of fibrosis extent	HRCT progression predicted mortality despite stable FVC.
Nerandomilast Trial (2025)	Randomised controlled trial	Quantitative HRCT as an endpoint	FVC failed to detect the treatment effects shown by HRCT.
Koo et al. (2022)	Prospective machine-learning qCT	Automated ML algorithms	Detected progression earlier than PFT decline
George et al. (2024)	Prospective validation of CALLIPER, e-Lung	Automated qCT metrics	qCT changes predicted survival better than FVC.
Dixon et al. (2025)	Systematic review	Multiple qCT approaches	qCT is consistently superior for prognosis and monitoring.

Systemic Sclerosis-associated Interstitial Lung Disease (SSc-ILD)

Given the heterogeneity in progression and response to treatment for SSc-ILD, monitoring is vital in the management process. The use of HRCT is therefore recommended during baseline evaluation and follow-ups when initiating and adjusting treatment.

Chronological Evidence on Key Monitoring Issues for SSc-ILD

1. Hoffmann-Vold et al. (2019): In a longitudinal study, the degree of HRCT fibrosis was found to have strong associations with mortality rates, thus reiterating HRCT's significance in monitoring together with PFT.
2. Khanna et al. (2022): Highlighted HRCT's value in diagnosis and monitoring in systemic sclerosis patients and recommended using HRCT combined with PFT for initiating treatment.
3. Ledda et al. (2024): Highlighted the utility of HRCT in baseline assessments and monitoring, especially distinguishing between progressive and stable phenotypes.
4. Fairley et al. (2024), in a review paper, emphasised HRCT's importance in monitoring the treatment of SSc-ILD with antifibrotics and immunosuppressants.
5. Tschalèr et al. (2025): Validation of a semi-quantitative HRCT scoring system in monitoring.

Table 3. HRCT Studies in SSc-ILD Monitoring Treatment Response

Study (Year)	Design & Focus	HRCT Approach	Key Findings
Hoffmann-Vold et al. (2019)	Longitudinal cohort	Visual HRCT fibrosis scoring	HRCT fibrosis extent predicted mortality.

Ledda et al. (2024)	Baseline and follow-up study	HRCT assessment	HRCT identified progressive vs. stable diseases.
Fairley et al. (2024)	Review article	HRCT-based treatment monitoring	Emphasised HRCT in immunosuppressive/antifibrotic therapy
Khanna et al. (2022)	Clinical review	HRCT + PFT integration	HRCT is essential for diagnosis and monitoring.
Tschalèr et al. (2025)	Validation study	Semi-quantitative HRCT scoring	Provided a standardised follow-up scoring system

Chronic Hypersensitivity Pneumonitis (CHP)

The medical condition known as chronic hypersensitivity pneumonitis (CHP) creates a complex situation because it develops with both inflammatory reactions and fibrotic tissue formation. The HRCT imaging technique enables doctors to identify which lung inflammation can heal and which lung fibrosis remains permanent because doctors need this information to track patient responses to their treatment.

Key Chronological Evidence in CHP

The research by Clukers and colleagues (2018) showed that functional respiratory imaging (FRI) based on HRCT scans detected changes in fibrotic CHP lungs better than FVC testing when they studied how the disease spread across different lung regions.

The Lancet Respiratory Medicine Review from 2024 established the basic evidence, which supports CT staging for fibrotic ILDs, including CHP, and recommends HRCT scans for both initial diagnosis and ongoing monitoring.
Nan et al. (2025) demonstrated that HRCT scan patterns in CHP patients predict disease progression through their impact on patient survival rates and treatment effectiveness when combined with PFT results.

Table 4. HRCT Studies in CHP Monitoring Treatment Response

Study (Year)	Design & Focus	HRCT Approach	Key Findings
Clukers et al. (2018)	Prospective study	Functional respiratory imaging	HRCT-derived FRI detected progression better than FVC.
Lancet Respir Med (2024)	Review	CT staging and monitoring	HRCT recommended for diagnosis and follow-up
Nan et al. (2025)	Prognostic study	HRCT patterns + PFT correlation	HRCT findings predicted survival and treatment response.

Challenges in the Application of HRCT Monitoring

Although high-resolution computed tomography (HRCT) has revolutionised the management of patients with pulmonary fibrosis, several limitations hinder its use in everyday medical practice. There are many issues associated with HRCT monitoring, including radiation, cost, interobserver variability, and the need for standardised HRCT scores. To maximise the benefits of HRCT monitoring, it is necessary to overcome these obstacles.

Radiation Exposure

Radiation exposure poses the greatest challenge when using repeated HRCT imaging. In order to evaluate the response to therapy, multiple scans are needed, and this procedure is associated with the increased risks of radiation exposure. For example, patients suffering from conditions such as systemic sclerosis would require long-term follow-up and monitoring. Low-dose HRCT scanning protocols have been introduced, but a compromise has to be found between image resolution and reduced radiation dose.

Cost and Access

HRCT is an expensive technique relative to PFTs. Due to financial constraints, access to sophisticated high-resolution scanning machines and qualified radiologists is difficult. In addition, insurance reimbursement for HRCT scans varies from one setting to another, hence resulting in inequalities.

Inter-observer variability

Inter-observer variability is inherent when it comes to assessing images obtained from HRCT scans. Although radiologists are expected to be consistent in assessing subtle fibrotic changes or opacities, inter-observer discrepancies may occur. Consistency can be improved through semi-quantitative systems that require specialist training. However, this problem is especially crucial when performing clinical trials at different centers.

Absence of Consensus on Protocols

There is currently no gold-standard protocol that describes the process of acquisition, reconstruction, and analysis in patients undergoing monitoring for fibrotic disease with HRCT scans. The heterogeneity arising from different thicknesses of slices, reconstruction methods, and even different types of scanners used makes the assessment of longitudinal changes difficult. While quantitative CT analyses enhance reproducibility, they face limitations due to the absence of regulatory approval and their integration into the clinical workflow.

Relation to Patient Outcome

HRCT provides useful information regarding the structure of the lungs, but the relationship between the findings and patient outcomes, such as quality of life or functional impairment, is not always clear. There may be instances when there is a delay between structural changes and functional impairment, while some changes do not lead to a clinically relevant condition at all.

Emerging Approaches

Several approaches have been developed to overcome some of these shortcomings. The use of low-dose HRCT protocols coupled with iterative reconstructions reduces radiation dose. The use of AI-driven algorithms improves reproducibility because segmentation and quantification of fibrosis are automated. Professional organisations are leading efforts to standardise image acquisition protocols. Cloud-based imaging systems make multicentre studies possible

Table 5. Limitations of HRCT and Emerging Solutions

Limitation	Impact	Emerging Solutions
Radiation exposure	Risk of cumulative harm with repeated scans	Low-dose HRCT, iterative reconstruction, MRI alternatives under research
High cost and limited accessibility	Barriers in low-resource settings	Wider adoption of low-cost CT, insurance advocacy, centralised cloud platforms
Interobserver variability	Inconsistent monitoring across radiologists	AI-based automated quantification, consensus scoring systems
Lack of standardised protocols	Heterogeneity across scanners and centres	International guidelines, harmonised acquisition/reconstruction standards
Limited clinical integration	Disconnect between radiology and patient outcomes	Combining HRCT with PFTs, biomarkers, and patient-reported outcomes

Future Prospects of HRCT in Monitoring Fibrotic Lung Disease

HRCT's role in the assessment of fibrotic lung disease has seen exponential advancement in recent times, from being used in diagnosis alone to becoming a core aspect in monitoring and therapeutic evaluation of these diseases. With the advent of more and more treatments and increased use of personalised medicine in clinical practice, major innovations in HRCT technology can be anticipated in the future.

Artificial Intelligence and Machine Learning

HRCT analysis is set to benefit immensely from advances in artificial intelligence (AI) and machine learning (ML). Automated computer algorithms help detect and quantify minute details in HRCT scans that are not perceptible to human vision. The application of radiomics and deep learning helps analyse numerous imaging characteristics, which include texture, density, and spatial distribution of fibrosis. ML applications have shown to perform better than manual HRCT assessments.

Convolutional neural networks (CNNs), for example, are used for automatic segmentation of fibrosis, and delta radiomics help detect early therapeutic responses. Quantification by means of AI may even become an alternative surrogate endpoint for future trials and help accelerate the process of drug development. It is especially worth noting that certain guidelines for the use of AI in imaging are developing now.

Radiomics and Personalised Medicine

Unlike conventional visual analysis, radiomics allows for the conversion of image information into high-dimensional data that can be mined for features. Radiomics has been shown to have associations with outcome, therapy response, and molecular phenotype in lung fibrosis. Together with genomics or proteomics, the application of radiomics could allow for personalised medicine to be developed.

Imaging features related to different fibrotic processes could identify those patients who would respond well to antifibrotic therapy, immunosuppression, or new compounds. Personalised medicine techniques such as this could minimise unnecessary medications and lower expenses, as well as improve patient outcomes through targeted therapy.

Integration with Digital Health Technologies and Wearable Devices

In addition to HRCT scanning, other non-invasive diagnostic technologies, such as wearable devices, home spirometry, and digital biomarkers, will become more common in conjunction with HRCT. While HRCT provides us with information about the structure of organs, wearables will provide us with information about functionality, including oxygenation and mobility. The integration of imaging with data from real-life patients will provide a deeper understanding of the disease process and the effectiveness of treatment.
Patients may receive HRCT at local facilities through a cloud-based system, which conducts the analysis in the cloud and adds the results to EHRs. This model of decentralised and interconnected care is particularly useful for rare diseases, such as idiopathic pulmonary fibrosis (IPF).

Standardisation and Global Harmonisation
One of the key obstacles to HRCT use lies in the lack of standardised acquisition and analysis guidelines. In the future, the emphasis will be put on harmonising imaging techniques globally. Medical organisations like ERS and ATS are actively lobbying for standardised HRCT scanning protocols to ensure comparability among centres and in clinical trials.
Federated learning platforms and open access to imaging databases are expected to contribute to these initiatives. Using AI algorithms to analyse multinationally sourced data will help limit biases and generalise results. Standardisation will further ensure regulatory endorsement of HRCT biomarkers during drug trials.

Hybrid Imaging & Multimodal Biomarkers
Other areas that should be explored in the future include combining HRCT with other imaging modalities and biomarkers. For instance, using PET/CT would allow the evaluation of the functionality of the inflammatory/metabolic processes along with structural fibrosis. In turn, using circulating biomarkers such as protein levels in blood, biomarkers from exhaled breath, or genomic fingerprints could help assess the disease status from several perspectives.
A multimodal approach could help address the problem of connecting imaging results to clinically significant endpoints. For example, the presence of stable findings on HRCT images but deteriorating biomarker values could suggest the need for further management.

Minimising Dose & Enhancing Accessibility
Another key area in future research will be reducing the dose of radiation required for imaging. Technologies like photon-counting CT and new reconstruction algorithms can produce excellent imaging results at an ultra-low dose. Alternatively, MRI-based lung imaging is still in an early experimental stage but offers the opportunity to image lung tissue without any dose of radiation.

Access will also improve with the use of mobile CT scanners, cloud reporting, and automated reading by artificial intelligence. Such advances could help HRCT become more accessible even in small community hospitals.

Role Within Multidisciplinary Management of Disease
Management of patients with pulmonary fibrosis is necessarily a complex endeavour, requiring input from several different medical specialities, including pulmonary medicine, radiology, rheumatology, thoracic surgery, and pathology. In the case of the latter disciplines, HRCT serves an important function in that it links the findings of diagnostic imaging to clinical information and physiological data.

MDT Approach
The multidisciplinary team (MDT) approach is considered the gold standard for both the diagnosis and management of interstitial fibrosis, especially IPF and SSc-ILD. In this scenario, the HRCT images are presented with respect to the patient's pulmonary function tests (PFT), serological markers, and clinical history. The radiologist will interpret the fibrosis pattern on the HRCT, whereas the pulmonologist and rheumatologist will use this information in correlation with the clinical picture.

Thus, the MDT approach makes sure that even small changes noted on HRCT scans are interpreted in light of their significance in the context of the patient's condition. An example of such a situation would be the development of changes on an HRCT scan in the face of stable PFT results, which could lead to treatment initiation with antifibrotics.

HRCT and Management Decisions
Management decisions in fibrosing lung disorders have become increasingly dependent on HRCT features. With respect to IPF, progressive features in terms of fibrosis revealed on HRCT can be a reason for intensification or starting anti-fibrotic therapies despite uncertain changes in FVC. Likewise, HRCT-based monitoring in patients with SSc-ILD enables rheumatologists to weigh up the pros and cons of immunosuppression based on the level and extent of pulmonary damage.

With CHP, HRCT scans help determine whether immunomodulation or antifibrotic approaches are required. Accordingly, HRCT is a valuable diagnostic technique as well as a decision-making tool for MDT.

Multispecialty Coordination

Finally, HRCT can be instrumental in communicating with other specialists. Radiologists may alert pulmonologists about early signs of disease progression revealed via HRCT. On the other hand, rheumatologists may seek advice from pulmonologists regarding specific HRCT scans to evaluate the effectiveness of immunosuppressive treatment.
Furthermore, pathologists and thoracic surgeons require HRCT for guiding biopsy procedures or surgery. Using HRCT, the biopsy site can be selected appropriately to avoid errors in sampling. Such cooperation demonstrates the importance of HRCT in a unified care framework.

Patient-Based Integration
Apart from interdisciplinary consultation, the results obtained using HRCT should be relayed to the patient. Understanding the impact of visual changes on their health can make it easier for patients to comprehend the need for treatment modifications. Shared decision-making, which requires HRCT images as a reference tool, is a patient-based MDT approach.

Developing Technologies and Future Research Directions
Recently, the area of high-resolution computed tomography (HRCT) has seen significant progress due to scientific breakthroughs and the rising need for accurate biomarkers in fibrotic lung disease. The use of HRCT is no longer limited to assessing treatment responses but is extending into new fields like photon-counting CT, ultralow-dose imaging, radiogenomics, and digital lung models. These innovative technologies have promising implications for increasing diagnostic accuracy, minimising patient discomfort, and correlating imaging results with biological processes.

Photon-Counting CT
Photon-counting CT (PCCT) represents an emerging technology that utilises energy-sensitive detectors to provide better spatial resolution and tissue contrast than traditional CT scanning. For the detection of fibrotic lung disease, PCCT can help detect small changes in parenchymal structures and microvascular abnormalities using ultralow radiation doses. The multienergy information available in PCCT may allow differentiation between active inflammation and irreversible fibrosis, which is essential for developing therapeutic strategies. While still in its infancy in clinical practice, PCCT is anticipated to become crucial for follow-up imaging studies of patients requiring multiple scans.

Ultra-low Dose and Mobile CT Scanners
The issue of radiation safety has been identified as a major limiting factor in using HRCT for lung disease surveillance. Thanks to progress in iterative reconstruction, model-based algorithms, and dose modulation technology, today HRCT examinations can be conducted with radiation exposure equivalent to chest X-ray examinations without any significant decrease in accuracy. In addition, portable and mobile CT scanners become increasingly popular, providing an opportunity to use this equipment even in small hospitals and research facilities. This is very helpful for conducting randomised trials involving repeated imaging examinations.

Radiomics and Radiogenomics
The field of radiomics, which includes the extraction of highly dimensional information from medical images, is being actively supplemented by the domain of radiogenomics – the identification of links between imaging patterns and molecular characteristics of diseases. For fibrosis of the lungs, this approach might help to identify the ways in which changes in the structure of lungs are related to genetic predispositions, immune dysregulation or activation of certain fibrogenic pathways. This would be very useful in developing personalised treatment plans and could speed up introduction of novel antifibrotic drugs.

Digital Twins and Virtual Lung Models
The idea of creating a "digital twin"—a virtual representation of the lungs of a particular patient—is being increasingly explored in pulmonary medicine. Through the fusion of HRCT information with physiology-based simulations, biomarker data, and medical history, digital twins have the capacity to project disease courses and forecast the success rates of treatments. In terms of fibrosis-related disorders of the lung, for instance, such simulations could enable medical professionals to virtually trial different forms of therapies prior to their actual implementation, thereby customising the treatment regimen.

Multimodal Data Integration and AI-Based Systems
The research landscape ahead involves the integration of HRCT with multimodal data sources. The merging of anatomical imaging with functional imaging (for instance, PET/CT or MRI) in addition to molecular markers and digital health data creates disease phenotypes. Artificial intelligence systems are being built to fuse all these data streams into a single dashboard that informs clinicians about disease dynamics and treatment success rates.

CONCLUSION
Today, high-resolution computed tomography (HRCT) has become an essential modality for the management of fibrotic lung disorders. Beginning from its use in diagnosis, HRCT is now an important method not only for assessment of the stage of the underlying process but also for evaluating therapeutic response and monitoring disease progression. Due to the

capability of HRCT to identify qualitative and quantitative alterations of lung parenchyma, the evaluation by this method becomes even more sensitive when compared to pulmonary function tests.

From the examples provided above, one may see that HRCT is an extremely important diagnostic and monitoring tool for different types of diseases associated with lung parenchyma fibrosis – from idiopathic pulmonary fibrosis (IPF) to systemic sclerosis-associated interstitial lung disease (SSc-ILD) and chronic hypersensitivity pneumonitis (CHP). The consistent correlation between imaging changes and clinical parameters suggests that the implementation of longitudinal follow-up studies based on HRCT can significantly help in monitoring patients' condition and predicting the outcome.

However, despite the importance of HRCT, there are certain limitations associated with radiation exposure: high variability in interpretation results and a lack of unified criteria for image acquisition. In order to resolve the existing problems and enhance the use of this technology,

Though powerful, HRCT comes with challenges like radiation, interobserver variability, and a lack of standardisation, which highlight the importance of innovation in dose reduction, acquisition consistency, and merging imaging with other markers, namely functional and molecular. New approaches, such as photon-counting CT, radiogenomics, and digital lung models, will help address some of the current shortcomings and increase the value of HRCT in precision medicine.

Another critical aspect to consider is the multidisciplinary approach necessary for implementing HRCT effectively. Cooperation between radiologists, pulmonologists, rheumatologists, and others is crucial to transform the results of imaging studies into action. At the same time, patient-focused care also finds its application through HRCT since the use of visual evidence can encourage patients to participate in decision-making.

Moving forward, one can expect HRCT to evolve from being simply an imaging technique for diagnosis and monitoring into a predictive marker capable of providing information about appropriate treatments and even acting as an endpoint in trials. Ultimately, HRCT is expected to contribute to personalised medicine, thereby continuing to play a crucial role in treating fibrosis of the lungs.

REFERENCES

1. Lederer, C., et al. (2024). Imaging in the diagnosis and management of fibrosing interstitial lung disease — a contemporary review. *European Respiratory Review.*
2. Balestro, E., et al. (2019). High-resolution CT change over time in patients with idiopathic pulmonary fibrosis (longitudinal HRCT study). *European Respiratory Journal.*
3. Dixon, G., et al. (2025). A systematic review of the role of quantitative CT in interstitial lung disease. *European Respiratory Review.*
4. Khanna, D., et al. (2022). Diagnosis and monitoring of systemic sclerosis-associated interstitial lung disease: role of HRCT. *Clinical Reviews.*
5. Chung, J.H., et al. (2018). Interpretation of HRCT scans in the diagnosis of idiopathic pulmonary fibrosis. *Radiology Review.*
6. Koo, C.W., et al. (2022). Prospective machine-learning CT quantitative evaluation of IPF—validation of ML-qCT for monitoring. *Clinical Radiology.*
7. Ledda, R.E., et al. (2024). High-resolution computed tomography in systemic sclerosis: baseline and follow-up roles. *Review.*
8. Hodnett, P.A., et al. (2013). Fibrosing interstitial lung disease: HRCT-based approach to diagnosis and management. *American Journal of Respiratory and Critical Care Medicine.*
9. Battista, M.D.I., et al. (2024). Quantitative HRCT assessment during antifibrotic treatment — EULAR abstract.
10. Pulmonology advisor summary. (2025). Quantitative CT has prognostic value in ILD.
11. Fairley, J.L., et al. (2024). Systemic sclerosis-associated ILD: a review emphasising HRCT monitoring and treatment implications. *Rheumatology Review.*
12. Zheng, Z., et al. (2024). Biomarkers in idiopathic pulmonary fibrosis: imaging biomarkers and HRCT's central role. *Review.*
13. Nerandomilast Trial. (2025). Recent randomised trial reporting FVC and treatment response. *New England Journal of Medicine.*
14. George, P.M., et al. (2024). Evaluation of automated QCT (e-Lung/WRS/AI) to capture progression in IPF—prospective evaluation. *European Respiratory Journal.*
15. Hoffmann-Vold, A.-M., et al. (2019). Tracking the impact of ILD in systemic sclerosis: HRCT and PFTs in a longitudinal cohort. *American Journal of Respiratory and Critical Care Medicine.*
16. Elicker, B.M., et al. (2017). The role of HRCT in the follow-up of ILD: guidance on prognosis and monitoring. *European Respiratory Review.*
17. Koo, C.W., et al. (2022). CALLIPER / machine learning CT quantification correlates with PFTs in IPF on antifibrotic therapy. *Clinical Radiology.*

18. Clukers, J., et al. (2018). Quantitative functional imaging (FRI) is superior to FVC in capturing regional progression — implications for monitoring. *Respiratory Research.*
19. Nasief, H., et al. (2019). Radiomics and delta-radiomics approaches show early predictions of treatment responses. *NPJ Precision Oncology.*
20. AJR Review. (2024). Quantification of interstitial lung disease—an overview of QCT methods and clinical needs. *American Journal of Roentgenology.*
21. Yang, C.C., et al. (2022). Radiomics for prediction of response to antifibrotic therapy in IPF — CT-based radiomic feature study. *Diagnostics (MDPI).*
22. Zhang, T., et al. (2025). AI-driven quantitative HRCT analysis to monitor pirfenidone effects in IPF.
23. Makol, A., et al. (2023). Practice patterns in HRCT follow-up for ILD: survey and guidance. *Rheumatology Review.*
24. Guiot, J., et al. (2024). Practical guidance for early recognition and follow-up of ILD—recommended HRCT andPFT intervals. *Review.*
25. Nan, Y., et al. (2025). Prognostication in IPF and chronic hypersensitivity pneumonitis: HRCT patterns & PFT indices as predictors. *European Respiratory Journal.*
26. The Lancet Respiratory Medicine. (2024). CT staging & monitoring of fibrotic ILD: foundational methods. *Lancet Respiratory Medicine.*
27. Radiomics Review. (2024). Radiomics approaches and delta-radiomics to predict treatment response and progression in fibrotic lung disease. *MDPI Diagnostics.*
28. Lauer, D., et al. (2024). Radioproteomics and integrated imaging-molecular response stratification in IPF—linking imaging changes to molecular biomarkers and treatment responses. *Journal of Clinical Investigation Insight.*
29. Rahaghi, F.F., et al. (2023). Expert consensus: management of systemic sclerosis-associated ILD — treatment initiation based on HRCT progression and PFTs. *Respiratory Research.*
30. Miceli, V., et al. (2025). Circulating biomarkers during antifibrotic treatment and correlation with HRCT changes in progressive fibrosing ILD. *Scientific Reports / Nature.*
31. Tschalèr, L., et al. (2025). Validation of a semi-quantitative HRCT scoring method for SSc-ILD follow-up. *RMD Open.*
32. Dixon, G., et al. (2025). Systematic review — qCT in ILD prognosis & monitoring. *European Respiratory Review.*
33. d'Alessandro, M., et al. (2021). Immunologic responses to antifibrotic treatment in IPF— linking treatment with imaging/functional outcomes. *Respiratory Medicine / Immunology.*
34. Chen, A., et al. (2020). Quantitative CT analysis of diffuse lung disease—a technical review and clinical applications. *RSNA Review.*
35. Pugnet, G., et al. (2023). Changes on chest HRCT after autologous HSCT in systemic sclerosis-related ILD—real-world HRCT outcome data. *Rheumatology Conference Report.*
36. Pakzad, A., et al. (2021). Automated airway morphological quantification for assessing fibrosing lung disease — airway metrics as imaging biomarkers. *arXiv / Methodological.*
37. Wang, G., et al. (2021). Semi-supervised segmentation methods for radiation-induced pulmonary fibrosis from CT— methods for quantifying fibrotic change. *arXiv / Medical Imaging.*
38. Béclin, M.-F., et al. (2024–2025). Quantile function regression methods applied to paired pulmonary 3D CT scans for treatment response assessment — new statistical approaches. *arXiv / Methods Paper.*
39. Clinical Radiology / RSNA Review. (2020–2024). Overview showing qCT correlates with PFT and prognosis in ILD. *Radiographics Review.*
40. Selected consensus and guidance statements (2017–2024). Recommendations for HRCT (with qCT where available) to determine progression and treatment decisions in SSc-ILD and IPF.