












SHORT REPORT

Effect of nintedanib in patients with systemic sclerosis-associated interstitial lung disease and risk factors for rapid progression

Dinesh Khanna ¹, Toby M Maher ^{2,3}, Elizabeth R Volkman ⁴, Yannick Allanore ⁵, Vanessa Smith ^{6,7,8}, Shervin Assasi ⁹, Michael Kreuter ^{10,11}, Anna-Maria Hoffmann-Vold ¹², Masataka Kuwana ¹³, Christian Stock ¹⁴, Margarida Alves¹⁵, Steven Sambevski¹⁵, Christopher P Denton ¹⁶

To cite: Khanna D, Maher TM, Volkman ER, *et al.* Effect of nintedanib in patients with systemic sclerosis-associated interstitial lung disease and risk factors for rapid progression. *RMD Open* 2023;**9**:e002859. doi:10.1136/rmdopen-2022-002859



Watch Video

rmdopen.bmj.com

► Additional supplemental material is published online only. To view, please visit the journal online (<http://dx.doi.org/10.1136/rmdopen-2022-002859>).

For 'Presented at statement' see end of article.

Received 11 November 2022
Accepted 2 February 2023



© Author(s) (or their employer(s)) 2023. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

For numbered affiliations see end of article.

Correspondence to
Dr Dinesh Khanna;
khannad@umich.edu

ABSTRACT

Objective To investigate the rate of decline in forced vital capacity (FVC), and the effect of nintedanib on the rate of decline in FVC, in subjects with systemic sclerosis-associated interstitial lung disease (SSc-ILD) who had risk factors for rapid decline in FVC.

Methods The SENSICIS trial enrolled subjects with SSc and fibrotic ILD of $\geq 10\%$ extent on high-resolution CT. The rate of decline in FVC over 52 weeks was analysed in all subjects and in those with early SSc (< 18 months since first non-Raynaud symptom), elevated inflammatory markers (C reactive protein ≥ 6 mg/L and/or platelets $\geq 330 \times 10^9/L$) or significant skin fibrosis (modified Rodnan skin score (mRSS) 15–40 or mRSS ≥ 18) at baseline.

Results In the placebo group, the rate of decline in FVC was numerically greater in subjects with < 18 months since first non-Raynaud symptom (-167.8 mL/year), elevated inflammatory markers (-100.7 mL/year), mRSS 15–40 (-121.7 mL/year) or mRSS ≥ 18 (-131.7 mL/year) than in all subjects (-93.3 mL/year). Nintedanib reduced the rate of FVC decline across subgroups, with a numerically greater effect in patients with these risk factors for rapid FVC decline.

Conclusion In the SENSICIS trial, subjects with SSc-ILD who had early SSc, elevated inflammatory markers or extensive skin fibrosis had a more rapid decline in FVC over 52 weeks than the overall trial population. Nintedanib had a numerically greater effect in patients with these risk factors for rapid ILD progression.

INTRODUCTION

Systemic sclerosis (SSc) is a complex and heterogeneous autoimmune disease characterised by progressive fibrosis of the skin and internal organs. Interstitial lung disease (ILD) is a common manifestation of SSc and the leading cause of death in patients with SSc.¹ A decline in forced vital capacity (FVC) in patients with SSc-ILD is associated with an

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Risk factors for more rapid progression of systemic sclerosis-associated interstitial lung disease (SSc-ILD) have been identified in several studies but need further validation.

WHAT THIS STUDY ADDS

⇒ In the placebo group of the SENSICIS trial in patients with fibrosing SSc-ILD, the rate of decline in forced vital capacity (FVC) over 52 weeks was greater in patients with early disease, elevated inflammatory markers or extensive skin fibrosis at baseline.
⇒ Nintedanib had a numerically greater effect on reducing the rate of FVC decline in patients with these risk factors.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ These results support the prompt initiation of nintedanib in patients with fibrosing SSc-ILD to target pulmonary fibrosis and preserve lung function.

increased risk of mortality.^{2–3} Although the course of SSc-ILD is variable,^{2–4} risk factors for decline in FVC have been identified. These include short SSc duration,⁵ male sex,⁶ elevated inflammatory markers⁷ and progression of skin fibrosis.⁸ Diffuse cutaneous SSc (dcSSc) has been identified as a risk factor for decline in FVC in some but not all studies.^{9–10}

Patients with diffuse SSc and risk factors for rapid progression of ILD are typically given immunosuppressants to address underlying inflammation. However, since inflammation and fibrosis can coexist early in the course of SSc-ILD, these patients may also benefit from antifibrotic therapy. Early treatment to stabilise lung function and improve outcomes

is an important aim of the management of SSc-ILD.¹¹ Recent studies have investigated the efficacy of particular therapies in patients with dcSSc and specific risk factors for progression of SSc-ILD, including early disease.^{12–14}

Nintedanib is an intracellular inhibitor of tyrosine kinases that has antifibrotic and anti-inflammatory effects that inhibit pathways involved in fibrosis.¹⁵ In the SENSICIS trial conducted in a broad population of subjects with SSc-ILD, nintedanib reduced the rate of decline in FVC (mL/year) over 52 weeks versus placebo by an average of 44%.¹⁶ In this post-hoc analysis, we investigated the rate of decline in FVC over 52 weeks, and the effect of nintedanib on the rate of decline in FVC, in subjects in the SENSICIS trial who had risk factors for rapid decline in FVC at baseline.

METHODS

The design of the SENSICIS trial (NCT02597933) has been described, and the protocol is publicly available.¹⁶ Briefly, subjects had SSc with their first non-Raynaud symptom in the prior ≤ 7 years, extent of fibrotic ILD on high-resolution CT $\geq 10\%$ (based on assessment of the whole lung), FVC $\geq 40\%$ predicted and diffusion capacity of the lung for carbon monoxide (DLco) 30%–89% predicted. Subjects taking prednisone ≤ 10 mg/day and/or stable therapy with mycophenolate or methotrexate for ≥ 6 months were allowed to participate. Subjects were randomised to receive nintedanib or placebo stratified by anti-topoisomerase I antibody (ATA) status. Subjects received trial medication until the last subject had reached week 52 but for ≤ 100 weeks.

The primary endpoint in the SENSICIS trial was the rate of decline in FVC (mL/year) assessed over 52 weeks. In these post-hoc analyses, we analysed the rate of decline in FVC (mL/year) over 52 weeks in subjects with early SSc (< 18 months since first non-Raynaud symptom), elevated inflammatory markers (C reactive protein ≥ 6 mg/L and/or platelets $\geq 330 \times 10^9$ /L) or significant skin fibrosis (assessed using two approaches: modified Rodnan skin score (mRSS) 15–40 or mRSS ≥ 18) at baseline. We also analysed this endpoint in subjects with one of these factors plus dcSSc. The statistical models were fitted analogously to the prespecified subgroup analyses of the endpoint.¹⁶ The rate of decline in FVC was based on a linear mixed-effects model for longitudinal data (with random intercepts and slopes on the patient level). It was based on all measurements taken over 52 weeks, including those from subjects who discontinued trial medication. Absolute changes from baseline in DLco % predicted at week 52 were analysed using a mixed model for repeated measures. Further, we descriptively assessed the prevalence of combinations of risk factors (intersecting sets) in the study sample.

RESULTS

The rate of decline in FVC was analysed in 575 subjects (287 treated with nintedanib, 288 with placebo). Of these

subjects, 79 (13.7%) had < 18 months since first non-Raynaud symptom, 210 (36.5%) had elevated inflammatory markers, 172 (29.9%) had mRSS 15–40 and 129 (22.4%) had mRSS ≥ 18 . The baseline characteristics of these subgroups are shown in [table 1](#). Of 299 subjects with dcSSc, 29 (9.7%) had < 18 months since first non-Raynaud symptom, 129 (43.1%) had elevated inflammatory markers, 162 (54.2%) had mRSS 15–40 and 129 (43.1%) had mRSS ≥ 18 .

In the placebo group, the rate of decline in FVC over 52 weeks was -93.3 mL/year. Compared with all subjects in the placebo group, the rate of decline in FVC was numerically greater in subjects with < 18 months since first non-Raynaud symptom (-167.8 mL/year), with elevated inflammatory markers (-100.7 mL/year), with mRSS 15–40 (-121.7 mL/year) and with mRSS ≥ 18 (-131.7 mL/year) ([figure 1A](#)). The rate of decline in FVC was also numerically greater in subjects with one of these factors plus dcSSc than in all subjects in the placebo group ([figure 1B](#)). The rate of decline in FVC was numerically lower in subjects treated with nintedanib than placebo across the subgroups in the overall population ([figure 1A](#)) and in subjects with dcSSc ([figure 1B](#)).

Analysis of intersecting sets of risk factors showed that combinations with dcSSc were frequent, while other (bivariate) combinations were less prevalent ([online supplemental figure 1](#)). The distribution of risk factor combinations was similar in both treatment groups ([online supplemental table 1](#)).

DISCUSSION

The SENSICIS trial included a broad population of subjects with fibrosing SSc-ILD, including those with early SSc, elevated inflammatory markers and extensive skin fibrosis, which are considered risk factors for the progression of SSc-ILD. Our analyses of data from the placebo group show that these factors, particularly early SSc (< 18 months since first non-Raynaud symptom), were associated with a greater rate of decline in FVC over 52 weeks. The effect of nintedanib on reducing the rate of decline in FVC was numerically greater in patients with risk factors for rapid SSc-ILD progression than in the overall trial population.

Patients with early dcSSc and elevated acute phase reactants appear to benefit from treatment with the interleukin-6 inhibitor tocilizumab.¹⁷ The current analyses suggest that patients with early SSc who have lung fibrosis may also benefit from nintedanib. Inflammation and fibrosis are early events in the pathogenesis of SSc-ILD and often coexist. Nintedanib inhibits key fibrotic and inflammatory pathways leading to pulmonary fibrosis, including the release of profibrotic mediators, the proliferation and migration of fibroblasts, and the deposition of extracellular matrix.¹⁵ Our data suggest that nintedanib slows the progression of pulmonary fibrosis in patients with SSc-ILD irrespective of risk factors for progression. These findings are supported by previous analyses showing that nintedanib slows FVC decline in

Table 1 Baseline characteristics in subjects with risk factors for rapid decline in FVC in the SENSICIS trial

	<18 months since onset of first non-Raynaud symptom		Elevated inflammatory markers*		mRSS 15–40		mRSS ≥18	
	Nintedanib (n=40)	Placebo (n=39)	Nintedanib (n=104)	Placebo (n=106)	Nintedanib (n=96)	Placebo (n=76)	Nintedanib (n=69)	Placebo (n=60)
Age (years)	56.3 (11.3)	52.6 (14.5)	53.0 (12.6)	53.6 (12.5)	52.5 (12.1)	49.5 (13.5)	52.2 (12.3)	48.6 (13.7)
Female	29 (72.5)	25 (64.1)	81 (77.9)	75 (70.8)	72 (75.0)	61 (80.3)	52 (75.4)	49 (81.7)
Years since onset of first non-Raynaud symptom	1.0 (0.4)	0.9 (0.4)	3.3 (1.5)	3.4 (1.7)	3.7 (1.7)	4.1 (1.9)	3.8 (1.7)	4.0 (1.8)
Diffuse cutaneous SSC	16 (40.0)	13 (33.3)	65 (62.5)	64 (60.4)	91 (94.8)	71 (93.4)	69 (100.0)	60 (100.0)
ANA positive	31 (77.5)	31 (79.5)	83 (79.8)	83 (78.3)	72 (75.0)	62 (81.6)	53 (76.8)	49 (81.7)
ATA positive	19 (47.5)	22 (56.4)	69 (66.3)	64 (60.4)	68 (70.8)	48 (63.2)	51 (73.9)	36 (60.0)
ARA positive	3 (7.5)	5 (12.8)	7 (6.7)	9 (8.5)	7 (7.3)	8 (10.5)	7 (10.1)	8 (13.3)
ACA positive	4 (10.0)	7 (17.9)	6 (5.8)	10 (9.4)	4 (4.2)	4 (5.3)	3 (4.3)	4 (6.7)
Extent of fibrotic ILD on HRCT (%)†	33.9 (20.8)	33.1 (20.3)	36.4 (21.9)	37.0 (21.6)	37.5 (23.1)	39.3 (20.9)	36.4 (22.1)	41.3 (22.5)
Presence of honeycombing on HRCT	4 (10.0)	11 (28.2)	17 (16.3)	22 (20.8)	13 (13.5)	10 (13.2)	9 (13.0)	5 (8.3)
Presence of reticulation on HRCT	33 (82.5)	38 (97.4)	95 (91.3)	98 (92.5)	88 (91.7)	70 (92.1)	64 (92.8)	52 (86.7)
Presence of ground-glass opacities on HRCT	32 (80.0)	38 (97.4)	89 (85.6)	92 (86.8)	85 (88.5)	62 (81.6)	60 (87.0)	50 (83.3)
FVC (mL)	2601 (925)	2595 (942)	2405 (757)	2483 (878)	2410 (713)	2402 (817)	2354 (697)	2419 (865)
FVC % predicted	75.1 (17.8)	71.6 (16.5)	70.0 (15.2)	70.4 (16.0)	68.7 (16.9)	69.6 (16.2)	67.4 (14.3)	69.3 (16.1)
DLco % predicted‡	57.0 (15.7)	54.9 (15.7)	49.8 (14.5)	49.3 (14.5)	51.7 (17.3)	53.8 (15.1)	51.5 (16.6)	51.6 (14.7)
SpO ₂ (%)	97.4 (1.9)	97.0 (3.9)	97.3 (2.0)	97.3 (2.5)	97.3 (2.1)	97.2 (3.3)	97.2 (2.2)	97.0 (3.1)
mRSS	10.6 (10.4)	10.4 (9.2)	12.9 (9.8)	12.7 (9.6)	21.7 (5.9)	21.1 (4.8)	24.5 (6.2)	24.7 (6.6)
Immunosuppressants§	34 (85.0)	27 (69.2)	96 (92.3)	96 (90.6)	91 (94.8)	65 (85.5)	67 (97.1)	52 (86.7)
Most commonly used immunosuppressants¶								
Mycophenolate mofetil	14 (35.0)	7 (17.9)	50 (48.1)	58 (54.7)	50 (52.1)	39 (51.3)	40 (58.0)	31 (51.7)
Acetylsalicylic acid	7 (17.5)	6 (15.4)	19 (18.3)	31 (29.2)	17 (17.7)	22 (28.9)	13 (18.8)	16 (26.7)
Prednisone	7 (17.5)	3 (7.7)	24 (23.1)	17 (16.0)	23 (24.0)	9 (11.8)	19 (27.5)	9 (15.0)
Prednisolone	6 (15.0)	8 (20.5)	15 (14.4)	19 (17.9)	14 (14.6)	9 (11.8)	11 (15.9)	7 (11.7)
Methotrexate	4 (10.0)	2 (5.1)	7 (6.7)	5 (4.7)	11 (11.5)	2 (2.6)	8 (11.6)	3 (5.0)
Corticosteroids§	21 (52.5)	17 (43.6)	61 (58.7)	59 (55.7)	58 (60.4)	28 (36.8)	43 (62.3)	25 (41.7)

Data are n (%) or mean (SD). Not all subjects provided data for all variables.

*C reactive protein ≥6 mg/L and/or platelets ≥330×10⁹/L.

†Assessed in whole lung to nearest 5% by central review. Pure (non-fibrotic) ground-glass opacity was not included.

‡Corrected for haemoglobin.

§Customised drug grouping.

¶Taken by >10% of patients in the nintedanib and/or placebo group in any subgroup.

ACA, anti-centromere antibody; ANA, anti-nuclear antibody; ARA, anti-RNA polymerase III antibody; ATA, anti-topoisomerase I antibody; DLco, diffusing capacity of the lung for carbon monoxide; FVC, forced vital capacity; HRCT, high-resolution CT; ILD, interstitial lung disease; mRSS, modified Rodnan skin score; SpO₂, oxygen saturation; SSC, systemic sclerosis.

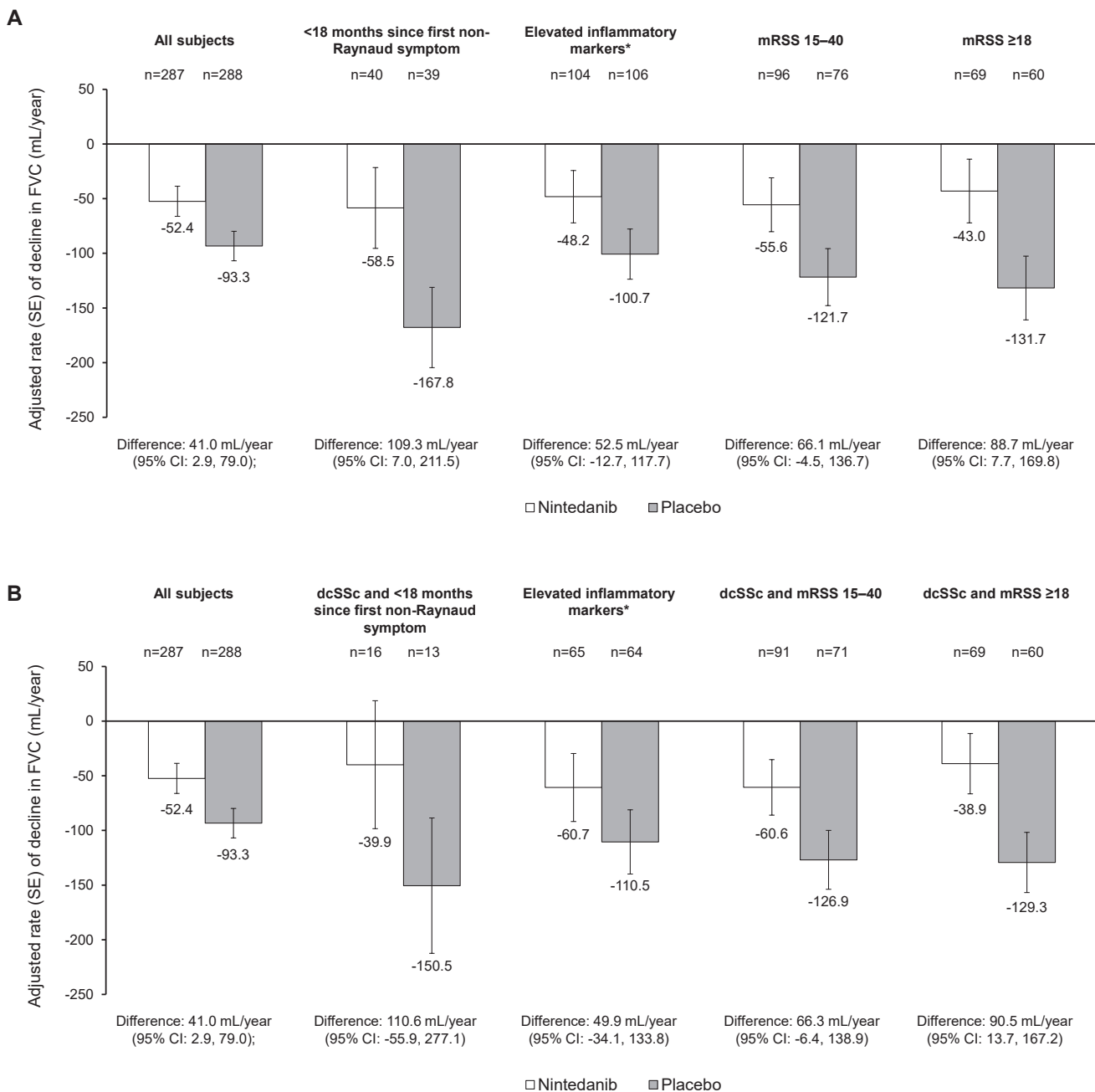


Figure 1 Rate of decline in FVC (mL/year) over 52 weeks (A) in all subjects and in subjects with risk factors for rapid decline in FVC at baseline and (B) in all subjects and in subjects with dcSSc and risk factors for rapid decline in FVC at baseline in the SENSICIS trial. *C reactive protein ≥ 6 mg/L and/or platelets $\geq 330 \times 10^9$ /L. dcSSc, diffuse cutaneous systemic sclerosis; FVC, forced vital capacity; mRSS, modified Rodnan skin score.

subjects with SSc-ILD across subgroups based on ATA status, the severity of lung function impairment or the presence of respiratory symptoms at baseline.^{18 19} Previous analyses of data from the SENSICIS trial have shown that nintedanib reduced the rate of decline in FVC both in subjects who were and were not taking mycophenolate at baseline,²⁰ suggesting that targeting fibrosis with nintedanib slows the progression of SSc-ILD even in patients receiving immunomodulatory

therapy to address the inflammatory component of the disease. More data are needed on the risk:benefit of earlier combination therapy for SSc-ILD versus sequential therapy, but these results suggest that there may be a benefit of introducing nintedanib early in the course of fibrosing SSc-ILD.

Strengths of these analyses include the standardised collection of FVC data over 52 weeks in the setting of a randomised controlled trial. Limitations include that

the SENSICIS trial was not designed to assess the impact of risk factors on decline in FVC and patients were not randomised by these factors; thus, there were differences in the characteristics of the subgroups at baseline and the derived estimates are subject to substantial uncertainty. In particular, there was an unequal distribution of mycophenolate use across the subgroups based on risk factors. This hampered the comparability of FVC decline, and consequently estimates of treatment effects, across the subgroups based on risk factors. Interpretation of groups of small size should be approached with caution. This analysis was driven by hypotheses about risk factors for rapid progression and did not involve screening of an array of patient-level variables that might be influential. Assessing interaction effects between the explored risk factors would be of interest; however, apart from bivariate interactions with the diffuse cutaneous subtype of SSc, robust modelling of longitudinal data was precluded by sample size limitations.

In conclusion, subjects with SSc-ILD in the SENSICIS trial who had early SSc, elevated inflammatory markers or extensive skin fibrosis had a more rapid decline in FVC over 52 weeks than the overall trial population. Nintedanib reduced the rate of decline in FVC across the subgroups based on risk factors for rapid FVC decline. These results support the prompt initiation of nintedanib in patients with fibrosing SSc-ILD to preserve lung function and improve patient outcomes.

Author affiliations

- ¹Division of Rheumatology, Scleroderma Program, University of Michigan, Ann Arbor, Michigan, USA
- ²Keck School of Medicine, University of Southern California, Los Angeles, California, USA
- ³National Heart and Lung Institute, Imperial College London, London, UK
- ⁴Division of Rheumatology, University of California, David Geffen School of Medicine, Los Angeles, California, USA
- ⁵Department of Rheumatology A, Descartes University, APHP, Cochin Hospital, Paris, France
- ⁶Department of Rheumatology, Ghent University Hospital, Ghent, Belgium
- ⁷Unit for Molecular Immunology and Inflammation, VIB Inflammation Research Center (IRC), Ghent, Belgium
- ⁸Department of Internal Medicine, Ghent University, Ghent, Belgium
- ⁹Division of Rheumatology, University of Texas McGovern Medical School, Houston, Texas, USA
- ¹⁰Center for Interstitial and Rare Lung Diseases, Pneumology and Respiratory Care Medicine, Thoraxklinik, University of Heidelberg and German Center for Lung Research, Heidelberg, Germany
- ¹¹Department of Pneumology, RKH Clinic Ludwigsburg, Ludwigsburg, Germany
- ¹²Inflammatory and Fibrotic Rheumatic Disease Research Area, Oslo University Hospital, Oslo, Norway
- ¹³Department of Allergy and Rheumatology, Nippon Medical School Graduate School of Medicine, Tokyo, Japan
- ¹⁴Global Biostatistics and Data Sciences, Boehringer Ingelheim Pharma GmbH & Co. KG, Ingelheim am Rhein, Germany
- ¹⁵TA Inflammation Med, Boehringer Ingelheim International GmbH, Ingelheim am Rhein, Germany
- ¹⁶University College London Division of Medicine, Centre for Rheumatology and Connective Tissue Diseases, London, UK

Presented at

Some of the data in this report were presented at the American College of Rheumatology Convergence 2021 conference and published in abstract form: Khanna D, Maher T, Volkman E, *et al*. Effect of nintedanib in patients with systemic

sclerosis-associated interstitial lung disease and risk factors for rapid decline in forced vital capacity: further analyses of the SENSICIS trial [abstract]. *Arthritis Rheumatol* 2021;73 (suppl 10). Available at: <https://acrabstracts.org/abstract/effect-of-nintedanib-in-patients-with-systemic-sclerosis-associated-interstitial-lung-disease-and-risk-factors-for-rapid-decline-in-forced-vital-capacity-further-analyses-of-the-sensicis-trial/>

Acknowledgements We thank the patients who participated in the SENSICIS trial. The authors did not receive payment for development of this manuscript. Elizabeth Ng and Wendy Morris of FleishmanHillard, London, UK, provided writing assistance, which was contracted and funded by Boehringer Ingelheim (BI). BI was given the opportunity to review the manuscript for medical and scientific accuracy as well as intellectual property considerations.

Contributors DK, TMM, YA, VS, SA, MKreuter, A-MH-V, MKuwana and CPD were involved in the acquisition of data. CS was involved in data analysis. All authors were involved in the interpretation of the data and in drafting the article or revising it for critically important content. All authors approved the final version of the manuscript.

Funding The SENSICIS trial was funded by Boehringer Ingelheim International GmbH.

Competing interests DK reports grants from Bristol Myers Squibb, Horizon Therapeutics and Pfizer; consulting fees from AbbVie, BI, Bristol Myers Squibb, CSL Behring, Genentech, Horizon Therapeutics, Janssen, Prometheus, Talaris and Thery; fees for presentations from AbbVie, BI, CSL Behring, Genentech, Horizon Therapeutics and Janssen; has a leadership or fiduciary role with Eicos; has received royalties or licences for the University of California Los Angeles Scleroderma Clinical Trials Consortium (SCTC) Gastrointestinal Tract instrument 2.0; and owns stock in Eicos. TMM reports consulting fees from AstraZeneca, Bayer, Blade Therapeutics, BI, Bristol Myers Squibb, Galapagos, Galecto, GlaxoSmithKline, IQVIA, Pliant, Respivant Sciences, Roche/Genentech, Theravance Biopharma and Veracyte; and fees for presentations from BI and Roche/Genentech. ERV reports grants from BI, Forbuis, Kadmon and Horizon; and fees from BI for serving on advisory boards and for presentations. YA reports consulting fees from BI and Sanofi; fees for presentations from AbbVie, BI and Janssen; and has participated on Data Safety Monitoring Boards or advisory boards for BI, Chemomab, Curzion, Medsenic, Menarini, Prometheus and Sanofi. VS reports grants paid to her institution from the Belgian Fund for Scientific Research in Rheumatic Diseases, Research Foundation Flanders, BI and Janssen-Cilag; consulting fees and fees for presentations paid to herself and to her institution from BI; consulting fees paid to her institution from Janssen-Cilag; fees for presentations paid to her institution from Janssen-Cilag and UCB; support for travel paid to her institution by BI; and holds unpaid roles with the ACR and EULAR study groups on microcirculation, ERN-ReCONNECT and the SCTC working group on capillaroscopy. SA reports grants paid to his institution from BI, Janssen and Momenta; consulting fees from AbbVie, AstraZeneca, BI, Corbus, CSL Behring and Novartis; and fees for presentations from Integrity Continuing Education. MKreuter reports grants, consulting fees and fees for presentations from BI and Roche; and holds leadership or fiduciary roles with Deutsche gesellschaft für Pneumologie, the European Respiratory Society and the German Respiratory Society. A-MH-V reports grants from BI; consulting fees from Arxx Therapeutics, Bayer, BI, Janssen, Lilly, Medscape, Merck Sharp & Dohme and Roche; fees for presentations from Arxx Therapeutics, Bayer, BI, Janssen, Lilly, Medscape, Merck Sharp & Dohme and Roche; support for travel from Actelion, BI, Medscape and Roche; and holds leadership or fiduciary roles with EUSTAR, the Nordic PH vision group and the Norwegian SSc study group. MKuwana reports grants paid to his institution from BI, MBL and Ono Pharmaceutical; consulting fees from BI, Chugai, Corbus and Mochida; fees for presentations from AbbVie, Asahi Kasei, Astellas, Bayer, BI, Chugai, Eisai, Janssen, Mitsubishi Tanabe and Ono Pharmaceutical; and has received royalties or licences from MBL. CS, MA and SS are employees of BI. CPD reports grants from Arxx Therapeutics, CSL Behring, GlaxoSmithKline, Inventiva and Servier; consulting fees from AbbVie, Acceleron, Bayer, BI, Corbus, CSL Behring, GlaxoSmithKline, Horizon Therapeutics, Inventiva, Roche and Sanofi; and fees for presentations from BI, Corbus and Janssen.

Patient consent for publication Not required.

Ethics approval The SENSICIS trial was carried out in compliance with the protocol, the principles of the Declaration of Helsinki and the Harmonised Tripartite Guideline for Good Clinical Practice of the International Conference on Harmonisation. The trial was approved by an independent ethics committee or institutional review board at every site. The participating sites are listed in Distler *et al.*¹⁶ All patients provided written informed consent before trial entry.

Provenance and peer review Not commissioned; externally peer reviewed.

To ensure independent interpretation of clinical study results and enable authors to fulfill their role and obligations under the ICMJE criteria, Boehringer Ingelheim grants all external authors access to relevant clinical study data. In adherence with

the Boehringer Ingelheim Policy on Transparency and Publication of Clinical Study Data, scientific and medical researchers can request access to clinical study data after publication of the primary manuscript in a peer-reviewed journal, regulatory activities are complete and other criteria are met. Researchers should use <https://vivli.org/> to request access to study data and visit <https://www.mystudywindow.com/msw/datasharing> for further information.

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

ORCID iDs

Dinesh Khanna <http://orcid.org/0000-0003-1412-4453>
 Toby M Maher <http://orcid.org/0000-0001-7192-9149>
 Elizabeth R Volkman <http://orcid.org/0000-0003-3750-6569>
 Yannick Allanore <http://orcid.org/0000-0002-6149-0002>
 Vanessa Smith <http://orcid.org/0000-0001-6271-7945>
 Shervin Assassi <http://orcid.org/0000-0002-8059-9978>
 Michael Kreuter <http://orcid.org/0000-0003-4402-2159>
 Anna-Maria Hoffmann-Vold <http://orcid.org/0000-0001-6467-7422>
 Masataka Kuwana <http://orcid.org/0000-0001-8352-6136>
 Christian Stock <http://orcid.org/0000-0002-3493-3234>
 Christopher P Denton <http://orcid.org/0000-0003-3975-8938>

REFERENCES

- Elhai M, Meune C, Boubaya M, *et al*. Mapping and predicting mortality from systemic sclerosis. *Ann Rheum Dis* 2017;76:1897–905.
- Hoffmann-Vold A-M, Fretheim H, Halse A-K, *et al*. Tracking impact of interstitial lung disease in systemic sclerosis in a complete nationwide cohort. *Am J Respir Crit Care Med* 2019;200:1258–66.
- Volkman ER, Tashkin DP, Sim M, *et al*. Short-term progression of interstitial lung disease in systemic sclerosis predicts long-term survival in two independent clinical trial cohorts. *Ann Rheum Dis* 2019;78:122–30.
- Hoffmann-Vold A-M, Allanore Y, Alves M, *et al*. Progressive interstitial lung disease in patients with systemic sclerosis-associated interstitial lung disease in the EUSTAR database. *Ann Rheum Dis* 2021;80:219–27.
- Steen VD, Conte C, Owens GR, *et al*. Severe restrictive lung disease in systemic sclerosis. *Arthritis Rheum* 1994;37:1283–9.
- Volkman E, Li N, Roth M, *et al*. Sex differences in severity and progression of interstitial lung disease in systemic sclerosis: what we have learned from clinical trials. *Arthritis Rheumatol* 2020;72.
- Ross L, Stevens W, Rabusa C, *et al*. The role of inflammatory markers in assessment of disease activity in systemic sclerosis. *Clin Exp Rheumatol* 2018;36:S126–34.
- Wu W, Jordan S, Graf N, *et al*. Progressive skin fibrosis is associated with a decline in lung function and worse survival in patients with diffuse cutaneous systemic sclerosis in the European scleroderma trials and research (EUSTAR) cohort. *Ann Rheum Dis* 2019;78:648–56.
- Assassi S, Sharif R, Lasky RE, *et al*. Predictors of interstitial lung disease in early systemic sclerosis: a prospective longitudinal study of the GENISOS cohort. *Arthritis Res Ther* 2010;12:R166.
- Frantz C, Huscher D, Avouac J, *et al*. Outcomes of limited cutaneous systemic sclerosis patients: results on more than 12,000 patients from the EUSTAR database. *Autoimmun Rev* 2020;19:102452.
- Hoffmann-Vold A-M, Maher TM, Philpot EE, *et al*. The identification and management of interstitial lung disease in systemic sclerosis: evidence-based European consensus statements. *Lancet Rheumatol* 2020;2:e71–83.
- Khanna D, Spino C, Johnson S, *et al*. Abatacept in early diffuse cutaneous systemic sclerosis: results of a phase II investigator-initiated, multicenter, double-blind, randomized, placebo-controlled trial. *Arthritis Rheumatol* 2020;72:125–36.
- Khanna D, Lin CJF, Furst DE, *et al*. Tocilizumab in systemic sclerosis: a randomised, double-blind, placebo-controlled, phase 3 trial. *Lancet Respir Med* 2020;8:963–74.
- Spiera R, Kuwana M, Khanna D, *et al*. OP0171 phase 3 trial of lenabasum, a CB2 agonist, for the treatment of diffuse cutaneous systemic sclerosis (dcSSc) [abstract]. *Ann Rheum Dis* 2021;80:102–3.
- Wollin L, Distler JHW, Redente EF, *et al*. Potential of nintedanib in treatment of progressive fibrosing interstitial lung diseases. *Eur Respir J* 2019;54:1900161.
- Distler O, Highland KB, Gahlemann M, *et al*. Nintedanib for systemic sclerosis-associated interstitial lung disease. *N Engl J Med* 2019;380:2518–28.
- Roofeh D, Lin CJF, Goldin J, *et al*. Tocilizumab prevents progression of early systemic sclerosis-associated interstitial lung disease. *Arthritis Rheumatol* 2021;73:1301–10.
- Kuwana M, Allanore Y, Denton CP, *et al*. Nintedanib in patients with systemic sclerosis-associated interstitial lung disease: subgroup analyses by autoantibody status and modified rodnan skin thickness score. *Arthritis Rheumatol* 2022;74:518–26.
- Volkman ER, Kreuter M, Hoffmann-Vold AM, *et al*. Dyspnoea and cough in patients with systemic sclerosis-associated interstitial lung disease in the SENSICIS trial. *Rheumatology (Oxford)* 2022;61:4397–408.
- Highland KB, Distler O, Kuwana M, *et al*. Efficacy and safety of nintedanib in patients with systemic sclerosis-associated interstitial lung disease treated with mycophenolate: a subgroup analysis of the SENSICIS trial. *Lancet Respir Med* 2021;9:96–106.