EXTENDED REPORT

Sarilumab for the treatment of ankylosing spondylitis: results of a Phase II, randomised, double-blind, placebo-controlled study (ALIGN)

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ABSTRACT

Objectives The ALIGN study (NCT01061723) evaluated the efficacy and safety of sarilumab, the first fully human monoclonal antibody against interleukin-6 receptor-α (IL-6Rα), in patients with ankylosing spondylitis (AS).

Methods Patients with active AS despite conventional treatment were randomised to placebo, or one of five subcutaneous dose regimens of sarilumab (100, 150 or 200 mg every other week, or 100 or 150 mg every week), for 12 weeks. The primary efficacy end point was the percentage of patients achieving the Axial SpondyloArthritis international Society (ASAS) 20 response criteria at week 12. Secondary endpoints included ASAS40 response, ASAS partial remission, AS Disease Activity Score, high-sensitivity C-reactive protein (hs-CRP) value, and safety.

Results Baseline demographic and disease characteristics of the 301 patients enrolled were similar across treatment groups. At week 12, there was no statistically significant difference in ASAS20 response rate between placebo (ASAS20 = 24.0%) and any sarilumab dose group. A significantly greater reduction in hs-CRP value was achieved with the higher sarilumab doses versus placebo. No other statistically significant differences were evident for secondary efficacy endpoints.

The most common treatment-emergent adverse events reported for sarilumab included infections (non-serious), neutropenia, and increase in alanine aminotransferase. No cases of tuberculosis, opportunistic, or fungal infections, or bowel perforations were reported. Seven patients experienced a treatment-emergent serious adverse event (all in sarilumab treatment groups). No deaths occurred.

Conclusions The ALIGN study shows that IL-6Rα blockade with sarilumab was not an effective treatment for AS. Sarilumab was generally well tolerated with a manageable safety profile.

INTRODUCTION

Ankylosing spondylitis (AS) is a chronic inflammatory disease that typically develops in the third decade of life,1–3 affecting men about twice as frequently as women.4 A close relationship exists between the prevalence of the HLA-B27 gene and the development of AS, with 80–95% of patients with AS being HLA-B27 positive.4 Traditional therapies, such as non-steroidal anti-inflammatory drugs (NSAIDs), have limited efficacy in many patients. Although biologic agents have significantly improved outcomes, 30–40% of patients experience substantial disease activity despite anti-tumour necrosis factor (TNF-α) therapy.5–7 For some patients, the initial response to anti-TNF-α agents diminishes over time and they are switched to another anti-TNF agent.8 However, if TNF-blockade fails to control AS disease activity, no other treatment options are currently available. Because high levels of TNF-α and interleukin (IL)-6 have been found in biopsy specimens from sacroiliac joints of patients with AS, these cytokines were thought to at least partially mediate the inflammation in AS.9–12 Circulating levels of IL-6 also correlate with spinal inflammation,13 and the clinical and radiological efficacy of TNF-blockade in AS is associated with significant reduction of IL-6 and C-reactive protein (CRP) levels.14 Thus, blockade of IL-6 is an appealing potential therapeutic option.

Tocilizumab (TCZ) is a humanised monoclonal antibody against IL-6 receptor-α (IL-6Rα), and is approved for the treatment of rheumatoid arthritis (RA).15 When the current study was designed and initiated, case reports suggested benefit with TCZ in AS patients who had been refractory to two or more anti-TNF agents.16–19 After the study had been completed, negative results of a placebo-controlled trial of tocilizumab in patients with active AS were reported.20 No anti-IL-6 agent is currently approved for the treatment of AS.

Sarilumab, the first fully human monoclonal antibody directed against IL-6Rα, is currently in development for RA. The phase II ALIGN study reported here evaluated the efficacy and safety of five subcutaneously (SC) administered sarilumab dose regimens versus placebo in anti-TNF-naïve patients with active AS despite treatment with NSAIDs.

METHODS

Study design

ALIGN was a randomised, multicentre, double-blind, parallel-group, placebo-controlled study conducted in 68 study centres in Europe, Canada and the USA (NCT01061723). The study duration was 22 weeks, including 4 weeks of screening, 12 weeks of treatment and 6 weeks of post-treatment follow-up. Patients were randomised with balanced allocation to receive either SC placebo or sarilumab...
Patients
Consecutively enrolled patients were randomised using a central randomisation scheme generated by an Interactive Voice Response System. All data were collected during scheduled clinic and home visits. Patients included in the study were men and women between the ages of 18 and 75 years, had active AS for at least 3 months, and Bath AS Disease Activity Index (BASDAI) ≥ 4 at screening and baseline, without complete fusion of the spine, and did not respond adequately to, or were intolerant of, ≥ 2 NSAIDs (each taken for ≥ 2 weeks). Patients treated with oral prednisone or equivalent corticosteroids (≤ 10 mg/day) must have been taking a stable dose for ≥ 2 weeks prior to baseline. Patients treated with the disease-modifying anti-rheumatic drugs hydroxychloroquine (≤ 400 mg/day), sulfasalazine (≤ 3 g/day) or methotrexate (MTX) (≤ 25 mg/week) must have been on a stable dose ≥ 12 weeks prior to baseline.

Patients were excluded from the study if they had a past history of non-response to any anti-TNF-α agent or non-response to any other biological treatment for AS, had received treatment with a disease modifying anti-rheumatic drug (DMARD) (except those allowed in the inclusion criteria) or any biological agent within 3 months prior to screening, had received oral prednisone or equivalent corticosteroids >10 mg/day within 6 weeks prior to screening, intramuscular or intra-articular corticosteroids within 4 weeks of screening, or had previously been treated with cyclosporine or azathioprine.

Study objectives and efficacy endpoints
The primary study objectives were to evaluate sarilumab efficacy during the 12-week treatment period according to the Axial SpondyloArthritis international Society (ASAS)20 22 outcome measure in patients with AS, and to define the best dose/dosage regimen for further development.

The primary efficacy endpoint was the percentage of patients who achieved the ASAS20 response criteria at week 12. This was defined as an improvement of at least 20% and an absolute improvement of at least one unit relative to baseline on a 0–10 numerical rating scale (NRS) in at least three of the following four ASAS improvement criteria (ASAC-IC) domains: physical function (Bath AS Function Index (BASFI)),23 total back pain, patient global assessment and inflammation (mean of intensity and duration of morning stiffness components from the BASDAI); and no worsening ≥ 20% and ≥ 1 unit relative to baseline on a scale of 0–10 NRS in the remaining fourth domain.

Secondary efficacy end points at week 12 included the percentage of patients who achieved: ASAS40 response (as for ASAS20, with improvement ≥ 40% and absolute improvement ≥ 2 units), ASAS partial remission (value of ≤ 2 units on a 0–10 NRS in each of the four ASAS-IC domains), ASAS5/6 response (composite score of six domains ie, ASAS-IC, spinal mobility...
and hs-CRP response being 20% improvement in five domains without deterioration in the sixth), and change from baseline in: ASAS individual components, MRI score of the spine (AS spine MRI-active scoring system, ASpiMRI-a), AS Disease Activity Score (ASDAS) score, Bath AS Metrology Index (BASMI, 11-point scale), hs-CRP value and chest expansion. The incidences of swollen and tender joints were not captured, and the impact of sarilumab on peripheral disease was not assessed.

### Sample size calculation

On the basis of previous trials with biologics in AS, it was assumed that the response rates would be 25% in the placebo group and 60% in at least one of the active treatment groups. With 50 patients per group, the study had ~80% power to detect a difference of 35 percentage points between any dose of sarilumab and placebo using a two-sided test with α=0.01 due to the application of Hommel’s procedure to adjust for multiplicity.

### Statistical analyses

#### Primary efficacy analysis

The primary efficacy end point, ASAS20 response at week 12, was assessed to demonstrate that at least one sarilumab dose differed from placebo. Comparisons made between each sarilumab dose group and the placebo group were adjusted for multiplicity using Hommel’s procedure. ASAS20 response at week 12 was analysed using the two-sided Cochran–Mantel–Haenszel test stratified by screening hs-CRP and region. Pairwise comparisons of response rates and 95% CIs for ORs between each sarilumab dose and placebo were derived by testing each active dose group versus placebo separately. The Mantel–Haenszel estimate of the OR and the corresponding 95% CIs were derived the same way.

A last-observation-carried-forward procedure was used to impute any missing ASAS20 components for patients who missed at least one ASAS component at week 12 for any reason. Patients who discontinued study treatment due to lack of efficacy before week 12 were considered as non-responders. Treatment-by-subgroup interactions were also analysed for ASAS20 response.

#### Secondary efficacy analyses

Binary secondary efficacy end points, for example, ASAS40 response, ASAS partial remission and ASAS5/6 response at week 12 were analysed as defined above for the primary efficacy end point.

### Table 1 Patient demographics and baseline characteristics—randomised population

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Placebo (n=50)</th>
<th>100 mg qw* (n=49)</th>
<th>150 mg qw* (n=50)</th>
<th>100 mg qw (n=50)</th>
<th>200 mg qw (n=50)</th>
<th>150 mg qw (n=50)</th>
<th>All (n=301)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years, mean (SD)</td>
<td>40.3 (11.7)</td>
<td>42.4 (10.8)</td>
<td>43.0 (11.3)</td>
<td>40.4 (11.5)</td>
<td>37.2 (10.4)</td>
<td>41.1 (11.1)</td>
<td>40.7 (11.2)</td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>38 (76.0)</td>
<td>30 (61.2)</td>
<td>34 (68.0)</td>
<td>37 (71.2)</td>
<td>40 (80.0)</td>
<td>39 (78.0)</td>
<td>218 (72.4)</td>
</tr>
<tr>
<td>Caucasian/white, n (%)</td>
<td>49 (98.0)</td>
<td>49 (100)</td>
<td>48 (96.0)</td>
<td>49 (94.2)</td>
<td>48 (96.0)</td>
<td>49 (98.0)</td>
<td>292 (97.0)</td>
</tr>
<tr>
<td>BMI (kg/m²), mean (SD)</td>
<td>26.97 (5.30)</td>
<td>26.12 (4.83)</td>
<td>25.43 (3.93)</td>
<td>27.31 (4.61)</td>
<td>27.10 (5.24)</td>
<td>26.88 (4.21)</td>
<td>26.64 (4.72)</td>
</tr>
<tr>
<td>Region, n (%)</td>
<td>39 (78.0)</td>
<td>39 (79.6)</td>
<td>40 (80.0)</td>
<td>41 (78.8)</td>
<td>39 (78.0)</td>
<td>40 (80.0)</td>
<td>238 (79.1)</td>
</tr>
<tr>
<td>Western countries*</td>
<td>11 (22.0)</td>
<td>10 (20.4)</td>
<td>11 (22.0)</td>
<td>11 (22.0)</td>
<td>10 (20.0)</td>
<td>10 (20.0)</td>
<td>63 (20.9)</td>
</tr>
<tr>
<td>HLA-B27 positive, %</td>
<td>74.0</td>
<td>78.7</td>
<td>76.0</td>
<td>78.8</td>
<td>78.0</td>
<td>81.6</td>
<td>77.9</td>
</tr>
<tr>
<td>Duration of AS (years since diagnosis), mean (SD)</td>
<td>9.45 (8.31)</td>
<td>8.50 (10.30)</td>
<td>8.55 (10.65)</td>
<td>7.13 (7.96)</td>
<td>7.13 (7.08)</td>
<td>5.55 (5.31)</td>
<td>7.71 (8.48)</td>
</tr>
<tr>
<td>Screening hs-CRP level, n (%) ≤1.5 mg/dL</td>
<td>28 (56.0%)</td>
<td>27 (55.1%)</td>
<td>27 (54.0%)</td>
<td>29 (55.8%)</td>
<td>28 (56.0%)</td>
<td>27 (54.0%)</td>
<td>166 (55.1%)</td>
</tr>
<tr>
<td>Number of prior DMARDs, n (%)</td>
<td>41 (82.0%)</td>
<td>41 (83.7%)</td>
<td>39 (78.0%)</td>
<td>39 (75.0%)</td>
<td>40 (80.0%)</td>
<td>44 (88.0%)</td>
<td>244 (81.1%)</td>
</tr>
<tr>
<td>Alcohol use, n (%)</td>
<td>8 (16.0%)</td>
<td>8 (16.3%)</td>
<td>11 (22.0%)</td>
<td>13 (25.0%)</td>
<td>10 (20.0%)</td>
<td>6 (12.0%)</td>
<td>56 (18.6%)</td>
</tr>
<tr>
<td>History of smoking n (%)</td>
<td>27 (54.0%)</td>
<td>30 (61.2%)</td>
<td>21 (42.0%)</td>
<td>27 (51.9%)</td>
<td>28 (56.0%)</td>
<td>31 (62.0%)</td>
<td>164 (54.5%)</td>
</tr>
<tr>
<td>ASAS individual core components (0–10 scale)</td>
<td>33 (66.0%)</td>
<td>36 (73.5%)</td>
<td>33 (66.0%)</td>
<td>33 (63.5%)</td>
<td>32 (64.0%)</td>
<td>36 (72.0%)</td>
<td>203 (67.4%)</td>
</tr>
<tr>
<td>Back pain, mean (SD)</td>
<td>6.62 (2.14)</td>
<td>6.73 (1.88)</td>
<td>6.60 (1.57)</td>
<td>6.91 (1.70)</td>
<td>6.90 (1.66)</td>
<td>6.52 (1.63)</td>
<td>6.72 (1.76)</td>
</tr>
<tr>
<td>Physical function, mean (SD)</td>
<td>4.44 (1.63)</td>
<td>4.24 (1.58)</td>
<td>4.05 (1.45)</td>
<td>4.25 (1.66)</td>
<td>3.99 (1.68)</td>
<td>3.95 (1.62)</td>
<td>4.15 (1.60)</td>
</tr>
<tr>
<td>Patient global assessment, mean (SD)</td>
<td>6.88 (1.97)</td>
<td>6.82 (1.88)</td>
<td>6.44 (1.75)</td>
<td>6.94 (1.70)</td>
<td>6.78 (1.67)</td>
<td>6.48 (1.62)</td>
<td>6.72 (1.76)</td>
</tr>
<tr>
<td>Inflammation, mean (SD)</td>
<td>6.91 (2.12)</td>
<td>6.21 (1.73)</td>
<td>6.55 (1.56)</td>
<td>6.49 (1.96)</td>
<td>7.05 (1.82)</td>
<td>6.26 (1.88)</td>
<td>6.58 (1.87)</td>
</tr>
<tr>
<td>MRI (ASpiMRI) total score</td>
<td>49</td>
<td>48</td>
<td>50</td>
<td>52</td>
<td>49</td>
<td>50</td>
<td>298</td>
</tr>
<tr>
<td>Number</td>
<td>8.8 (8.8)</td>
<td>6.8 (7.6)</td>
<td>7.8 (11.1)</td>
<td>9.1 (11.0)</td>
<td>9.2 (10.2)</td>
<td>9.7 (9.7)</td>
<td>8.6 (9.8)</td>
</tr>
</tbody>
</table>

*Inflammation* represents mean of intensity and duration of morning stiffness from BASDAI. *Alcohol use* is defined as any consumption of an alcoholic beverage that occurs at least monthly or more frequently (this is ‘daily’ or ‘weekly’ or ‘monthly’).

Australiasia, Austria, Belgium, Canada, Czech Republic, France, Germany, Hungary, Spain, The Netherlands, USA.

†Lithuania, Poland, Turkey.

AS, ankylosing spondylitis; ASAS, Axial SpondyloArthritis international Society; ASpiMRI, Ankylosing Spondylitis spine MRI-active score; BASDAI, Bath Ankylosing Spondylitis Disease Activity Index; BMI, Body Mass Index; DMARD, disease modifying anti-rheumatic drug; hs-CRP, high-sensitivity C-reactive protein; RoW, rest of world.
An analysis of covariance model, including terms for baseline, treatment, screening hs-CRP level and region, was used to assess treatment differences in change from baseline for continuous efficacy variables. Descriptive statistics including number of subjects, mean, median, minimum and maximum were provided. Additionally, difference in least-square means, the corresponding 95% CIs and the p values were provided for comparisons of each sarilumab dose versus placebo.

Active inflammation in the spine visible on MRI short tau inversion recovery sequence was analysed by applying the MRI score for ASpiMRI-a, as has been described before.24

Safety analysis
Safety summaries were descriptive and no hypothesis testing was conducted. Summary of treatment-emergent adverse events (TEAEs) was based on Medical Dictionary for Regulatory Activities coding of verbatim terms reported by investigators. TEAEs were defined as any AEs that newly developed or worsened, or became serious on or after the day of first dose intake of study drug, up to the day of end of study. The incidences of abnormal laboratory values, vital signs and ECG parameters were recorded.

RESULTS
Patients
Overall, 301 patients comprised the intention-to-treat (ITT) population and were randomised to treatment between 4 February 2010 and 21 June 2011 (figure 1). One patient (150 mg qw group) withdrew informed consent prior to the first scheduled treatment and is included in ITT efficacy analyses and excluded from safety analyses. Thirty-nine patients discontinued study treatment before week 12. AEs or lack of efficacy were the most common reasons for treatment discontinuation; other reasons included withdrawal of consent (three patients), randomisation by mistake before week 12. AEs or lack of efficacy were recorded.

Demographics, baseline and treatment characteristics
Baseline demographic and disease characteristics were similar across all treatment groups (table 1). The majority of patients had the HLA–B27 antigen.

Primary efficacy
At week 12, there was no statistically significant difference in ASAS20 response between placebo (24.0%) and any of the sarilumab doses (24.5, 30.0, 19.2, 30.0 and 38.0%, respectively for 100 mg qw, 150 mg qw, 100 mg qw, 200 mg qw and 150 mg qw) (figure 2A). The response was greatest in the highest dose regimen tested, 150 mg qw (38.0%), but was not statistically significant versus placebo (nominal and adjusted p values >0.05 vs placebo).

A treatment interaction was observed based on screening hs-CRP value with evidence of a significant ASAS20 treatment response among patients with hs-CRP >1.5 mg/dL (p=0.0493). However, this effect appears to be limited to one dose group only (150 mg qw) (figure 2B). Other subgroup interaction analyses for ASAS20 were not significantly different, including gender (men vs women, p=0.8571), race (Caucasian vs all other races, p=0.9998), past history of anti-TNFs (yes vs no, p=0.8373), region (Western countries vs non-Western countries) (p=0.9082), number of prior DMARDs (none, 1, 2, ≥3, p=0.2342) and smoking history (yes vs no, p=0.7207).

Secondary efficacy
Secondary efficacy end points at week 12 showed that the rates of ASAS40 response, ASAS partial remission, and ASAS5/6 response were generally not significantly different from placebo. Only the ASAS5/6 response rate in the 150 mg qw group (n=16, 32.0%) showed a significant difference versus placebo (n=3, 6.0%; p=0.001; OR 6.4 (CI 1.8 to 22.8)) (table 2). In regard to the four individual ASAS core components (back pain, physical function, patient global assessment and inflammation) at week 12, only back pain in the 150 mg qw dose group showed a statistically significantly higher treatment effect (change from baseline) compared to placebo: mean (SD) change −1.6 (2.1) vs −0.8 (1.8), p=0.0344. A significantly higher treatment effect was seen at the higher sarilumab doses compared to placebo for ASDAS score mean (SD) change −0.4 (0.7), −0.8 (1.2), −1.1 (0.8), −1.2 (0.9), and −1.6
Tropenia (n=6), gastrointestinal disorders (n=5) and increased
led to treatment discontinuation, the most frequent being neu-
all cases were asymptomatic.

Twelve cases of
(94
score and change from baseline in hs-CRP value at week 12 were
MRI spine score in all groups (table 2), which did not differ signi-
change that is, placebo
mean (SD) mg/dL
hs-CRP (mg/dl) change, mean (SD)
ASAS5/6 response, n (%) 3 (6.0) 6 (12.2) 5 (10.0) 7 (14.0) 16 (32.0)*
Chest expansion (cm) change, mean (SD) 0.2 (1.0) 0.2 (1.2) 0.0 (1.2) 0.1 (1.3) 0.3 (1.3)

n = number of patients with assessment at baseline and week 12. Percentages calculated using the number of ITT patients in the corresponding treatment group as denominator.

DISCUSSION
The ALIGN study showed that SC-administered sarilumab was
generally well tolerated but did not demonstrate a statistically or
clinically significant effect compared to placebo in patients with
active AS who had an inadequate response to, or were intolerant of,
NSAIDs. A statistically significant reduction in hs-CRP following
SC sarilumab treatment demonstrated that a biological
effect of IL-6 blockade was achieved. However, lack of
associated clinical or imaging improvement that is, similar
reductions in functional and clinical parameters as measured by
MRI, BASDAI, BASMI and BASFI scores in placebo-treated and
sarilumab-treated patients, further suggests that IL-6 may not
play a major role in the inflammatory process underlying AS.
The significant reduction observed in the ASAS score with sar-
ilumab likely reflects inclusion of hs-CRP in this composite
measure, suggesting that ASAS may not be a robust outcome
parameter when changes in CRP values could be dissociated

(0.9) respectively for placebo, 150 mg q2w, 100 mg qw,
200 mg q2w and 150 mg qw; p=0.0112 for 150 mg q2w versus
p<0.0001 for placebo.

Insufficient

incident between change from baseline in MRI

0.03 to 0.19 for the

sarilumab groups; of these,

 waiver

significant

(200 mg q2w and 150 mg qw; p=0.0112 for 150 mg q2w and
100 mg qw

Mean treatment duration (76.2–81.4 days), treatment exposure
(10.5–11.0 patient-years) and overall treatment compliance
(94–100%) were comparable across all treatment groups. The
proportion of patients who experienced at least one TEAE was
∼twofold higher in the sarilumab groups (64%–78%, and with
no clear dose response relationship), compared with 36%

Safety
Mean treatment duration (76.2–81.4 days), treatment exposure
(10.5–11.0 patient-years) and overall treatment compliance
(94–100%) were comparable across all treatment groups. The
proportion of patients who experienced at least one TEAE was
∼twofold higher in the sarilumab groups (64%–78%, and with
no clear dose response relationship), compared with 36%

Other patients experienced a TEAE that led to treatment discontinuation, the most frequent being neu-
(≥100/mm³) neutropenia, and no deaths were reported.

Sarilumab was associated with neutropenia and elevations in ALT (>3×upper limit of normal), total cholesterol and low-density lipoprotein. Generally, changes in other laboratory tests, vital signs and ECG parameters were not considered clinically

nificantly

inflammation

Sarilumab at doses greater than 150 mg q2w significantly
reduced hs-CRP values compared to placebo; mean (SD) mg/dL
change that is, placebo −3.7 (19.1), 100 mg q2w −1.2 (17.9,
not significant (ns)), 150 mg q2w −5.8 (27.6, ns), 100 mg qw
−13.5 (20.3, p=0.0007), 200 mg q2w −11.5 (17.5, p<0.0001),
and 150 mg qw −14.3 (15.3, p<0.0001).

Changes from baseline for BASDAI and BASMI scores and
chest expansion, were not statistically different from placebo at all
sarilumab doses tested. Only small changes were observed for the
MRI spine score in all groups (table 2), which did not differ signifi-
cantly between the placebo-treated and sarilumab-treated groups.
Correlation coefficients between change from baseline in MRI
score and change from baseline in hs-CRP value at week 12 were
0.04 for the placebo group and ranged from −0.03 to 0.19 for the
sarilumab groups (p=ns for all groups).

The signiﬁcant reduction observed in the ASAS score with sar-
ilumab likely reﬂects inclusion of hs-CRP in this composite
measure, suggesting that ASAS may not be a robust outcome
parameter when changes in CRP values could be dissociated

Table 2  Secondary efficacy endpoints at week 12—ITT population

<table>
<thead>
<tr>
<th></th>
<th>Placebo (n=50)</th>
<th>100 mg q2w (n=49)</th>
<th>150 mg q2w (n=50)</th>
<th>100 mg qw (n=52)</th>
<th>200 mg q2w (n=50)</th>
<th>150 mg qw (n=50)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ASAS50, n (%)</strong></td>
<td>4 (8.0)</td>
<td>7 (14.3)</td>
<td>8 (16.0)</td>
<td>3 (5.8)</td>
<td>9 (18.0)</td>
<td>10 (20.0)</td>
</tr>
<tr>
<td><strong>ASAS partial remission, n (%)</strong></td>
<td>1 (2.0)</td>
<td>4 (8.2)</td>
<td>1 (2.0)</td>
<td>1 (1.9)</td>
<td>1 (2.0)</td>
<td>4 (8.0)</td>
</tr>
<tr>
<td><strong>ASAS5/6 response, n (%)</strong></td>
<td>3 (6.0)</td>
<td>6 (12.2)</td>
<td>5 (10.0)</td>
<td>7 (13.5)</td>
<td>7 (14.0)</td>
<td>16 (32.0)*</td>
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<tr>
<td><strong>Change from baseline in key secondary efficacy components</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>ASAS individual core component change, mean (SD) (0–10 scale)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Back pain</td>
<td>−0.8 (1.8)</td>
<td>−1.3 (2.2)</td>
<td>−1.2 (2.4)</td>
<td>−0.5 (1.8)</td>
<td>−0.9 (2.2)</td>
<td>−1.6 (2.1)</td>
</tr>
<tr>
<td>Physical function</td>
<td>−0.6 (1.2)</td>
<td>−0.5 (1.7)</td>
<td>−0.4 (2.0)</td>
<td>−0.1 (1.4)</td>
<td>−0.6 (1.9)</td>
<td>−1.1 (1.9)</td>
</tr>
<tr>
<td>Patient global assessment</td>
<td>−1.0 (1.9)</td>
<td>−1.1 (2.3)</td>
<td>−0.8 (2.3)</td>
<td>−0.4 (2.2)</td>
<td>−0.9 (2.2)</td>
<td>−1.6 (2.0)</td>
</tr>
<tr>
<td>Inflammation</td>
<td>−1.4 (1.8)</td>
<td>−0.8 (2.0)</td>
<td>−1.1 (2.0)</td>
<td>−0.7 (2.1)</td>
<td>−1.0 (1.9)</td>
<td>−1.8 (2.3)</td>
</tr>
<tr>
<td>AsspiMRI total score change, mean (SD)</td>
<td>−0.5 (2.2)</td>
<td>−0.5 (1.8)</td>
<td>−0.1 (3.4)</td>
<td>0.1 (2.4)</td>
<td>−0.3 (3.3)</td>
<td>0.3 (3.3)</td>
</tr>
<tr>
<td>ASDAS score change, mean (SD)</td>
<td>−0.4 (0.7)</td>
<td>−0.5 (0.9)</td>
<td>−0.8 (1.2)</td>
<td>−1.1 (0.8)</td>
<td>−1.2 (0.9)</td>
<td>−1.6 (0.9)</td>
</tr>
<tr>
<td>BASDAI score change, mean (SD)</td>
<td>−0.9 (1.7)</td>
<td>−0.8 (1.9)</td>
<td>−1.1 (2.0)</td>
<td>−0.4 (1.4)</td>
<td>−0.9 (1.8)</td>
<td>−1.2 (1.8)</td>
</tr>
<tr>
<td>BASMI score change, mean (SD)</td>
<td>−0.2 (0.8)</td>
<td>−0.2 (0.9)</td>
<td>−0.2 (0.8)</td>
<td>−0.4 (0.9)</td>
<td>−0.1 (0.8)</td>
<td>−0.2 (0.7)</td>
</tr>
<tr>
<td>hs-CRP (mg/dl) change, mean (SD)</td>
<td>−3.7 (19.1)</td>
<td>−1.2 (17.9)</td>
<td>−5.8 (27.6)</td>
<td>−13.5 (20.3)**</td>
<td>−11.5 (17.5)**</td>
<td>−14.3 (15.3)**</td>
</tr>
<tr>
<td>Chest expansion (cm) change, mean (SD)</td>
<td>0.2 (1.0)</td>
<td>0.2 (1.2)</td>
<td>0.0 (1.2)</td>
<td>−0.1 (0.9)</td>
<td>0.1 (1.3)</td>
<td>0.3 (1.3)</td>
</tr>
</tbody>
</table>
from changes in disease activity, as with anti-IL-6 therapies. Variability in the observed efficacy of sarilumab among individual treatment groups in the ALIGN study most likely reflects the inclusion of only 49–52 subjects in each individual treatment group, since no sarilumab dose group yielded a statistically significantly greater proportion of ASAS20 responders when compared to the placebo group (figure 2A, p > 0.05 for all groups). Variability of ASAS20 response at week 12 by hs-CRP stratification among sarilumab groups (figure 2B) potentially supports this assertion.

There was no relationship between changes in hs-CRP and changes in the MRI scores, suggesting that the drug did not have an effect on AS disease-specific inflammation.

Although case reports of treatment with TCZ have suggested benefit of IL-6Rα blockade in AS,16–19 a recent 12-week phase II multicentre, randomised, double-blind, placebo-controlled study of TCZ in AS patients did not confirm this. That study used the same primary efficacy end point as the ALIGN study to compare intravenous TCZ 8 mg/kg versus placebo in 102 AS patients (TCZ, n = 51; placebo, n = 51). Similar to sarilumab, TCZ also failed to reach its primary efficacy end point despite reducing hs-CRP and ASDAS scores.20 These results caution that positive case reports or evidence for a certain pharmacological intervention based on preclinical data, may not always predict the clinical efficacy of a targeted drug in complex diseases of unknown aetiology such as AS. Anti-IL-6Rα therapies have shown efficacy in RA.15 23 26 Sarilumab was studied in the treatment of RA in the phase II/III MOBILITY study (NCT01061736) using the same five doses as in the current trial. Part A of this study demonstrated efficacy of sarilumab in addition to MTX in patients with active, moderate-to-severe RA who had inadequate response to MTX.27 Several other drugs with proven efficacy in RA, including sulfasalazine, leflunomide, MTX, anakinra, rituximab and abactept, have been investigated for the treatment of AS and, thus far, none has shown any clear therapeutic efficacy.28 TNF-blockers appear to be effective across a number of inflammatory rheumatic diseases, including RA and AS, whereas, the efficacy of other targeted therapies may be limited to fewer specific indications. Encouraging data from a small study in AS patients evaluating IL-17 blockade, which has shown clinical efficacy in the treatment of psoriasis,29 30 will require further confirmation.31

In the current study in AS patients, sarilumab showed a safety profile similar to reports with other IL-6 inhibitors. Infections and laboratory abnormalities, including neutropenia, elevated transaminases and hyperlipidaemia, were the most commonly observed safety findings.

CONCLUSION

The ALIGN study did not demonstrate efficacy of sarilumab versus placebo for the treatment of active AS, irrespective of a marked reduction in hs-CRP. Thus, the IL-6 pathway does not appear to play an essential role in AS clinical disease activity and may not be an effective drug target for the disease.

Acknowledgements The authors would like to thank the study participants, staff and co-investigators at participating centres. The contribution of Celine Luscan (Clinical Trial Manager, Sanofi R&D) is greatly appreciated. Medical writing support was provided by Helen Fosam PhD and Carl V Felton PhD of Prime Medica during the preparation of this paper, supported by Sanofi and Regeneron Pharmaceuticals Inc., Responsibility for opinions, conclusions, and interpretation of data lies with the authors. A full list of ALLIGN study investigators is provided in the supplemental materials.

Competing interests The ALIGN study was funded by Sanofi and Regeneron Pharmaceuticals, Inc. Joachim Sieper has received research support from AbbVie, Janssen, Merck, and Pfizer, and consultancy/speaker bureau fees from AbbVie, Merck, Eli Lilly, Novartis, Pfizer, Roche and Sanofi. Jürgen Braun has received research support from AbbVie, Janssen, Merck Sharp & Dohme, and Pfizer, and consultancy/speaker bureau fees from AbbVie, Celtrion, Merck Sharp & Dohme, Novartis, Pfizer, Roche and Sanofi. Jonathan Kay has received research support (provided to University of Massachusetts Medical School) from Abbott Laboratories, Ardea Biosciences, Eli Lilly, Fidia Farmaceutici, SpA, Roche Laboratories, and consultancy fees from AbbVie, AstraZeneca, Bristol-Myers Squibb, Celgene, Crescendo Bioscience, EPIRUS Biopharmaceuticals, Genentech, Hospira, Janssen Biotech, medac Pharma, PanGenetics, Pfizer, Roche Laboratories, and Sun Pharmaceutical Industries. Robert D Inman has received consultancy fees from Sanofi-Aventis, Pfizer, Amgen, AbbVie, Janssen, and UCB. Salvatore Badalamenti, Licia Jiao, Stefano Fiore, and Tanya Moltmahn are full-time employees and shareholders of Sanofi. Allen R Radin, George D Yancopoulos, and Neil Stahl are full-time employees and shareholders of Regeneron Pharmaceuticals.

Ethics approval Appropriate institutional review boards/ethics committees approved the study and written informed consent was obtained from each patient before study participation.

Provenance and peer review Not commissioned; externally peer reviewed.

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REFERENCES


