Risk of vertebral and non-vertebral fractures in patients with sarcoidosis: a population-based cohort

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Abstract

Summary In this retrospective cohort study using the Clinical Practice Research Datalink (CPRD), patients with sarcoidosis have an increased risk of clinical vertebral fractures and when on recent treatment with oral glucocorticoids, also an increased risk of any fractures and osteoporotic fractures.

Introduction Sarcoidosis is a chronic inflammatory disease, in which fragility fractures have been reported despite normal BMD. The aim of this study was to assess whether patients with sarcoidosis have an increased risk of clinical fractures compared to the general population.

Methods A retrospective cohort study was conducted using the CPRD. All patients with a CPRD code for sarcoidosis between January 1987 and September 2012 were included. Cox proportional hazards models were used to derive adjusted relative risks (RRs) of fractures in all sarcoidosis patients compared to matched controls, and within the sarcoidosis group according to use and dose of systemic glucocorticoids.

Results Five thousand seven hundred twenty-two sarcoidosis patients (mean age 48.0 years, 51 % females, mean follow-up 6.7 years) were identified.

Compared to 28,704 matched controls, the risk of any fracture was not different in patients with sarcoidosis. However, the risk of clinical vertebral fractures was significantly increased (adj RR 1.77; 95 % CI 1.06–2.96) and the risk of non-vertebral fractures was decreased although marginally significant (adj RR 0.87; 95 % CI 0.77–0.99). Compared to sarcoidosis patients not taking glucocorticoids, recent use of systemic glucocorticoids was associated with an increased risk of any fracture (adj RR 1.50; 95 % CI 1.20–1.89) and of an osteoporotic fracture (adj RR 1.47; 95 % CI 1.07–2.02).

Conclusions Patients with sarcoidosis have an increased risk of clinical vertebral fractures, and when using glucocorticoid therapy, an increased risk of any fractures and osteoporotic fractures. In contrast, the risk of non-vertebral fractures maybe decreased. Further investigation...
is needed to understand the underlying mechanisms of these contrasting effects on fracture risk.

**Keywords** Bone · Epidemiology · Fractures · Glucocorticoids · Osteoporosis · Sarcoidosis

**Introduction**

Sarcoidosis is a multi-organ, chronic inflammatory, granulomatous disorder that can affect almost any organ of the body. It may occur at any age, but most frequently in adults younger than 50 years. It is more common in women and certain racial groups, such as African–Americans and northern Europeans [1–4]. Around 300–400 new cases of sarcoidosis are diagnosed per year in the UK [5].

Bone mineral density (BMD) is decreased and the risk of clinical and radiological vertebral fractures is increased in chronic inflammatory diseases such as asthma and chronic obstructive pulmonary disease (COPD) [6, 7], rheumatoid arthritis [8–10], ankylosing spondylitis [11, 12], systemic lupus erythematosus [13], and inflammatory bowel disease [14]. In addition, treatment with glucocorticoids has been associated with a dose-dependent increase in fracture risk [9, 15–17], at a higher level of BMD than in patients who do not use glucocorticoids.

In patients with sarcoidosis, small cohort studies have demonstrated a high prevalence of fragility fractures (23.5%) [18] and radiographic vertebral fractures (20–30%) [19], with an increase of incidence (up to 32%) of vertebral fractures during follow-up [20]. In contrast, BMD has been found to be normal in most patients with sarcoidosis [19, 21–24] and BMD did not change over time [20, 25]. Furthermore, the effect of glucocorticoids on bone might be reversible [26, 27]. No studies are available that investigated the prevalence of vertebral and non-vertebral fractures in patients with sarcoidosis compared to a control population and the effect of glucocorticoid therapy on fracture risk in sarcoidosis.

The first objective of this study is to determine whether patients with sarcoidosis have an increased risk of clinical fractures compared to the general population. The second objective is to estimate their fracture risk, stratified by glucocorticoid use.

**Methods**

**Source population**

A retrospective cohort study was conducted using the Clinical Practice Research Datalink (CPRD), formerly known as the General Practice Research Database. The CPRD contains computerized medical records of 625 primary care practices in the UK, representing 8% of the British population. The database provides detailed information on demographics, drug prescriptions, clinical events, specialist referrals, and hospital admissions. Previous studies of CPRD data have shown a high level of data validity with respect to the reporting of fractures (>90% of fractures were confirmed) [16]. The protocol number is 2010_060.

**Study population**

All patients with a CPRD read code for sarcoidosis during the study period (from January 1987 through September 2012) were included in the study population. In order to ascertain a more probable diagnosis of sarcoidosis, these patients were stratified into probable and possible cases of sarcoidosis. Probable cases had at least one sarcoidosis CPRD record and any of the following: (1) treatment with methotrexate, azathioprine, leflunomide, chloroquine, hydroxychloroquine, and systemic/inhaled glucocorticoids at any time during follow-up, (2) two or more subsequent diagnoses of sarcoidosis, and/or (3) a specialist diagnosis of sarcoidosis. All other sarcoidosis patients were defined as possible cases. The index date was defined as the first record for sarcoidosis. Each patient was matched by age, sex, calendar time, and practice to up to four patients without a history of sarcoidosis ever during the study period.

**Outcomes**

All patients had a follow-up from the index date to either the end of data collection, the date of transfer of the patient out of the practice area, the patient’s death, or fracture (GPRD read codes), whichever came first.

Earlier studies have demonstrated that there is a high level of data validity with respect to reporting of fractures from CPRD databases and >90% of reported fractures were confirmed [16].

The primary outcome of this study was to determine whether patients with sarcoidosis have an increased risk of clinical fractures compared to the general population. For additional analyses, fracture type was stratified according to the WHO Fracture Risk Assessment Tool into osteoporotic (spine, hip, forearm, or humerus fracture), and non-osteoporotic fractures (all other fractures) and also stratified into vertebral and non-vertebral fractures. The second objective was to estimate their fracture risk, stratified by glucocorticoid use.

**Potential confounders**

Total follow-up was divided into 30-day intervals. Before the start of each 30-day interval, the presence of general risk factors for fracture was evaluated. At
baseline, information was available about age, sex, smoking status, body mass index, alcohol use, a record of falls in the previous 6–12 months, and a history of fracture. Furthermore, we assessed if there was a history of a chronic disease (rheumatoid arthritis, cerebrovascular disease, heart failure, inflammatory bowel disease, asthma/chronic obstructive pulmonary disease, secondary osteoporosis, anaemia, and dementia). Prescriptions for glucocorticoids (systemic and local separately), hypnotic/anxiolytic, antipsychotic, antidepressant, proton pump inhibitor, antidiabetic, or antiepileptic agents, as well as drugs for the treatment of Parkinson’s disease, in the 6 months before inclusion, were recorded.

For each sarcoidosis patient, the use of systemic glucocorticoids in the previous 6 months before inclusion was evaluated. Systemic glucocorticoid users were further stratified according to their average and cumulative dose using the World Health Organisation’s defined daily dosages (DDD) [28]. Exposure was expressed as oral prednisone equivalents. For the cumulative exposure, all prescriptions of the most recent treatment period (allowing a maximum non-use gap of 6 months between two prescriptions) were considered. For the average daily dose, the cumulative exposure of the most recent treatment period was divided by the number of days between start and end of the treatment period. When data on the prescribed quantity were missing, the median expected quantity was used.

### Statistical analysis

Cox proportional hazards models were used to derive adjusted relative risks (adj RR) for fracture (any, osteoporotic, and non-osteoporotic) in sarcoidosis patients compared with matched control subjects (SAS 9.2, PHREG procedure). Potential confounders were entered into the final model if they independently changed the beta coefficient by at least 5 %. This main analysis was repeated for possible and probable cases of sarcoidosis. For all other analyses, the full cohort of sarcoidosis patients (probable and possible cases) was used. Within sarcoidosis patients, the individuals were stratified according to their cumulative and average daily dose of systemic glucocorticoid exposure. Furthermore, absolute incidence rates for fractures in sarcoidosis patients and matched controls were calculated.

Timing of fracture occurrence following first sarcoidosis record was examined by including time interaction terms into the model for the following time intervals: < 6 months, 6–12 months, 1–2 years, 2–5 years, 5–10 years, and >10 years. Using smoothing spline regression, the time trend for risk of fracture for these given time intervals was visualized.

### Results

We identified 5722 sarcoidosis patients along with 28,704 age- and sex-matched controls (mean age 48.0 years, 51 % females), with a mean follow-up of 6.7 years per patient. Baseline characteristics of patients with sarcoidosis and age- and sex-matched controls are shown in Table 1. There were substantially fewer smokers among the sarcoidosis patients than in the matched controls (current smokers 13.8 vs. 25.4 %). Furthermore, patients with sarcoidosis were more likely to have used medical drugs in the previous 6 months, in particular systemic/local glucocorticoids, antidiabetics, antidepressants, benzodiazepines, and calcium/vitamin D supplements. Bisphosphonate use was higher among sarcoidosis patients (4.3 %) compared to matched controls (1.0 %), whereas no differences were observed for use of HRT and other antiosteoporotic drugs.

In the sarcoidosis cohort, 406 patients had at least one fracture; 203 osteoporotic fractures occurred (37 clinical vertebral fractures, 22 hip fractures, 144 other osteoporotic fractures, i.e., forearm or humerus fractures) and 263 non-osteoporotic fractures (Table 2). There was no difference between patients with sarcoidosis and matched controls in the risk of any fracture (adj RR 0.90; 95 % CI 0.80–1.02), an osteoporotic fracture (adj RR 1.02, 95 % CI 0.85–1.23) or non-osteoporotic fracture (adj RR 0.89, 95 % CI 0.76–1.03). Further adjustments for antiosteoporotic drugs did not alter the relative risk estimates (e.g., for any fracture: HR 0.91 (95 % CI 0.81–1.03). The risk of clinical vertebral fractures was significantly increased in patients with sarcoidosis (adj RR 1.77; 95 % CI 1.06–2.96), and the risk for non-vertebral fractures was decreased (adj RR 0.87; 95 % CI 0.77–0.99).

The adj RR was not modified by the sarcoidosis case definition (possible sarcoidosis: adj RR 0.92; 95 % CI 0.76–1.13; probable sarcoidosis: adj RR 0.89; 95 % CI 0.76–1.04 for any fracture) and there was no statistical interaction with age, sex, or type of fracture. When plotted against time since diagnosis, the risk of any fracture was temporarily decreased during the first years after diagnosis, but was not different during longer follow-up (Fig. 1).

Use of systemic glucocorticoids in the previous 6 months increased the risk of any fracture (adj RR 1.50; 95 % CI 1.20–1.89) and of an osteoporotic fracture (adj RR 1.47; 95 % CI 1.07–2.02) compared to no use of systemic glucocorticoids (Table 3). The risk of any fracture and of an osteoporotic fracture increased already with a daily dose of < 5 mg prednisone equivalents per day (adj RR 1.49; 95 % CI 1.12–1.97 and adj RR 1.52; 95 % CI 1.04–2.23 for any and osteoporotic fracture, respectively) and with the lowest cumulative doses (< 1820 mg; adj RR 1.67; 95 % CI 1.08–2.59 and adj RR 2.02; 95 % CI 1.14–3.59 for any and osteoporotic fracture, respectively). The fracture risk did not increase significantly with higher dose or higher cumulative dose.
Table 1  Baseline characteristics of sarcoidosis patients and matched controls

| Characteristic                          | Sarcoidosis patients | Matched controls |
|----------------------------------------|----------------------|------------------|
|                                        | N=5722   Percent     | N=28,704         Percent |
| Follow-up (years, mean, SD)            | 6.7 (5.2) | 6.7 (5.2)        |
| Females                                | 2918 (51.0) | 14,637 (51.0)   |
| Age (years, mean, SD)                  | 48.0 (13.4) | 48.0 (13.4)      |
| 18–39 years                            | 1691 (29.6) | 8479 (29.5)     |
| 40–59 years                            | 2847 (49.8) | 14,284 (49.8)   |
| 60–79 years                            | 1115 (19.5) | 5598 (19.5)     |
| 80+ years                              | 69 (1.2)  | 343 (1.2)       |
| BMI (kg/m², mean, SD)                  | 27.9 (5.9) | 26.8 (5.4)      |
| <20.0 kg/m²                             | 232 (4.1)  | 1301 (4.5)      |
| 20–24.9 kg/m²                          | 1468 (25.7) | 8745 (30.5)    |
| 25.0–29.9 kg/m²                        | 1943 (34.0) | 8614 (30.0)    |
| 30.0+ kg/m²                            | 1505 (26.3) | 5538 (19.3)    |
| Unknown                                | 574 (10.0) | 4506 (15.7)     |
| Smoking status                         |              |                  |
| Never                                  | 3763 (65.8) | 15,215 (53.0)  |
| Current                                | 792 (13.8)  | 7304 (25.4)     |
| Ex                                     | 1041 (18.2) | 4537 (15.8)     |
| Unknown                                | 126 (2.2)  | 1648 (5.7)      |
| Alcohol use                            |              |                  |
| No                                     | 1104 (19.3) | 4210 (14.7)     |
| Yes                                    | 3973 (69.4) | 19,972 (69.6)   |
| Unknown                                | 645 (11.3)  | 4522 (15.8)     |
| Falls (6–12 months before)             | 230 (4.0)  | 1050 (3.7)       |
| Fracture ever before                   | 1079 (18.9) | 5096 (17.8)     |
| History of disease                     |              |                  |
| Rheumatoid arthritis                   | 79 (1.4)   | 238 (0.8)       |
| Cerebrovascular disease                | 111 (1.9)  | 452 (1.6)       |
| Inflammatory bowel disease             | 87 (1.5)   | 237 (0.8)       |
| COPD                                   | 157 (2.7)  | 381 (1.3)       |
| Asthma                                 | 923 (16.1) | 3008 (10.4)     |
| Hypertension                           | 900 (15.7) | 3784 (13.2)     |
| Dementia                               | 21 (0.4)   | 70 (0.2)        |
| Heart failure                          | 98 (1.7)   | 199 (0.7)       |
| Drug use within 6 months               |              |                  |
| Systemic glucocorticoids               | 953 (16.7) | 492 (1.7)       |
| Topical glucocorticoids                | 618 (10.8) | 1782 (6.2)      |
| Antidiabetics                          | 263 (4.6)  | 810 (2.8)       |
| Anticonvulsants                        | 166 (2.9)  | 467 (1.6)       |
| Loop diuretics                         | 294 (5.1)  | 568 (2.0)       |
| Proton pump inhibitors                 | 825 (14.4) | 1869 (6.5)      |
| Antipsychotics                         | 59 (1.0)   | 298 (1.0)       |
| Antidepressants                        | 658 (11.5) | 2418 (8.4)      |
| Antianxiety/hypnotics                  | 360 (6.3)  | 1166 (4.1)      |
| Calcium/vitamin D                      | 251 (4.4)  | 412 (1.4)       |
| Bisphosphonates                        | 254 (4.3)  | 283 (1.0)       |
| Hormone replacement therapy            | 206 (3.6)  | 1093 (3.8)      |
| Other antiosteoporotic drugs           | 1 (0.0)    | 6 (0.0)         |

*BMI* body mass index, *SD* standard deviation
Discussion

In this large population-based study, patients with sarcoidosis had an increased risk of clinical vertebral fractures compared to matched controls and, when on recent therapy with systemic glucocorticoids, an increased risk of any fractures and osteoporotic fractures. In contrast, the risk of non-vertebral fractures was decreased, although marginally significant. To our knowledge, this study is the first population-based study that assessed vertebral and non-vertebral fracture risk in patients with sarcoidosis compared to matched control subjects.

The risk of clinical vertebral fractures was increased, which is in line with findings in other inflammatory diseases such as rheumatoid arthritis [9, 29, 30], ankylosing spondylitis [11, 12], SLE [13, 31], COPD [6, 7] and inflammatory bowel disease [14]. Possible explanations for the increased vertebral fracture risk can be found in other studies regarding patients with sarcoidosis, such as the finding of a decreased trabecular BMD within the vertebrae [26], a decreased BMD in the spine in postmenopausal women [22], and an increased bone resorption [19]. In spite of the increased risk of clinical vertebral fractures in patients with sarcoidosis, the total number of vertebral fractures was low. This is in contrast with other studies in patients with sarcoidosis where vertebral fractures were assessed by systemic radiographic evaluation [19, 20], suggesting that most radiographic vertebral fractures are not accompanied by typical signs and symptoms of an acute vertebral fracture. This is also the case for vertebral fractures in postmenopausal osteoporosis [32, 33].

The decreased adjusted risk of non-vertebral fractures in our study is an unexpected finding and only marginally statistically significant. It is in contrast with the increased risk of

Table 2  Risk of fracture in sarcoidosis patients compared with matched controls, stratified by age, sex, and type of fracture

| Fracture                      | Person years | Events | Age–sex adj RR (95% CI) | Adj RR (95% CI) (a) |
|-------------------------------|--------------|--------|-------------------------|---------------------|
| No sarcoidosis                |              |        |                         |                     |
| Any fracture                  | 183,514      | 1815   | Reference               | Reference           |
| By age (years)                |              |        |                         |                     |
| 18–39                         | 36,760       | 406    | 1.14 (1.02–1.27)        | 0.90 (0.80–1.02)    |
| 40–59                         | 7384         | 48     | 0.67 (0.49–0.91)        | 0.60 (0.42–0.85)    |
| 60–79                         | 19,763       | 171    | 1.17 (0.99–1.39)        | 0.95 (0.78–1.15)    |
| 80+                           | 9012         | 166    | 1.41 (1.18–1.68)        | 1.07 (0.87–1.31)    |
| By sex                        |              |        |                         |                     |
| Males                        | 17,529       | 143    | 0.98 (0.81–1.18)        | 0.79 (0.64–0.97)    |
| Females                      | 19,231       | 263    | 1.24 (1.08–1.43)        | 0.97 (0.83–1.13)    |
| Osteoporotic fracture         | 37,670       | 203    | 1.37 (1.17–1.60)        | 1.02 (0.85–1.23)    |
| Hip fracture                  | 38,397       | 22     | 0.93 (0.59–1.48)        | 0.61 (0.35–1.04)    |
| Vertebral fracturea           | 38,363       | 37     | 3.10 (2.04–4.70)        | 1.77 (1.06–2.96)    |
| Non-osteoporotic fracture     | 37,256       | 263    | 1.07 (0.93–1.23)        | 0.89 (0.76–1.03)    |
| Non-vertebral fracturea       | 38,852       | 377    | 1.08 (0.96–1.21)        | 0.87 (0.77–0.99)    |

Adjusted for smoking status, a history of heart failure, asthma/COPD, and use of systemic glucocorticoids, calcium/vitamin D supplements, loop diuretics, benzodiazepines, antidepressants, proton pump inhibitors, and anticonvulsants in the previous 6 months

Adj adjusted, CI confidence interval, RR relative risk

a There were eight patients that sustained both a vertebral and non-vertebral fracture

Fig. 1 Spline regression plot of time since first sarcoidosis record and risk of any fracture in sarcoidosis patients versus matched controls. Adjusted for confounders as shown in Table 2
vertebral fractures in this study and with the increased risk of non-vertebral fractures in inflammatory rheumatic diseases such as rheumatoid arthritis [9, 34, 35], ankylosing spondylitis [36], and JIA [36]. Another study did find a high fracture incidence in patients with sarcoidosis [18]. However, in the latter study there was no control population, and the study population consisted of patients at a pulmonary outpatient clinic where 62.0 % of patients were treated with glucocorticoids (vs. 16.7 % in our study). In most studies in patients with sarcoidosis, BMD was normal in all patients [18, 19, 21, 23, 24] even in those treated with glucocorticoids [18, 19], with the exception of one study that showed a decreased BMD in postmenopausal but not in premenopausal women [22]. Why BMD in the spine and hip is normal in most patients with sarcoidosis, is unclear and it does not explain the slightly decreased risk of non-vertebral fractures in patients with sarcoidosis compared to matched controls.

The increased risk of any and of osteoporotic fractures in patients with recent use of systemic glucocorticoids is in line with findings of increased fracture risk in glucocorticoid users in other inflammatory diseases [15–17]. However, we did not find a further increase in fracture risk with higher daily or cumulative doses of glucocorticoids. Treatment of inflammatory diseases for example rheumatoid arthritis results in lower disease activity and adequate disease control which contributes to bone protection, even when glucocorticoids are used [37]. The time relation between onset of sarcoidosis and initial but not persisting decrease of risk of any fracture indicates that disease or treatment related factors early in the disease could play a protective role on non-vertebral fracture risk.

In population-based cohort studies, a relation between CRP and fracture risk has been reported even after adjustment for confounding factors [38–40], however this relation could be U-shaped [41] or only present when CRP was >3 mg/l [42, 43]. In patients with sarcoidosis, however, no correlation was found between bone turnover markers or CRP and BMD or fractures [18]. In our study, we did not have additional information on markers for inflammation (IL2R, ACE) or disease activity.

Other factors, such as low dietary calcium intake, low creatinine clearance, and higher 25(OH)D and 1,25(OH) are associated to an increased fracture risk and bone resorption in sarcoidosis [18, 44], but no data were available on these parameters in our study. Besides BMD and bone-related risk factors, other factors could influence fracture risk in patients with sarcoidosis. Patients with sarcoidosis have an increased risk of sarcopenia, which could increase the risk of falls and bone loss [45]. We did not have information on diagnostic

| Table 3 | Risk of any and osteoporotic fractures within sarcoidosis patients, stratified by use of drugs |
|-----------------|---------------------------------|-----------------|-----------------|
|                | Any fracture | Osteoporotic fracture |                |
|                | Events | Adj RR (95 % CI)a | Events | Adj RR (95 % CI)a |
| By use of systemic glucocorticoids in the previous 6 months (reference=no use)b | | | | |
| No | 263 | 1.00 | 126 | 1.00 |
| Yes | 143 | 1.50 (1.20–1.89) | 77 | 1.47 (1.07–2.02) |
| By average daily dose of systemic glucocorticoid exposure in the previous year, expressed as prednisone equivalents | | | | |
| ≤5 mgc | 66 | 1.49 (1.12–1.97) | 37 | 1.52 (1.04–2.23) |
| 5.1–10 mg | 45 | 1.36 (0.97–1.90) | 21 | 1.13 (0.69–1.84) |
| >10 mg | 32 | 1.88 (1.26–2.79) | 19 | 2.09 (1.24–3.53) |
| By cumulative dose of systemic glucocorticoid exposure, expressed as prednisone equivalentsd | | | | |
| <1820 mgc | 22 | 1.67 (1.08–2.59) | 13 | 2.02 (1.14–3.59) |
| 1820–7300 mg | 41 | 1.37 (0.97–1.93) | 22 | 1.36 (0.85–2.17) |
| >7300 mg | 80 | 1.53 (1.16–2.03) | 42 | 1.39 (0.94–2.04) |
| By use of antidepressants in the previous 6 months (reference=no use)b | | | | |
| No | 318 | 1.00 | 157 | 1.00 |
| Yes | 88 | 1.25 (0.97–1.61) | 46 | 1.08 (0.76–1.55) |
| By use of anxiolytics/hypnotics in the previous 6 months (reference=no use)b | | | | |
| No | 364 | 1.00 | 176 | 1.00 |
| Yes | 42 | 1.16 (0.83–1.63) | 27 | 1.37 (0.89–2.12) |

Adj adjusted, CI confidence interval, RR relative risk
a Adjusted for confounders shown in footnote Table 2
b Reference=no use in the previous 6 months
c Excluding no use of systemic glucocorticoids in the previous 6 months
d Cumulative amount of all previous systemic glucocorticoid prescriptions
tests for sarcopenia, such as muscle strength and mass. Body mass index (BMI) in patients with sarcoidosis was not different compared to controls. Sarcoidosis can also be localised in bone, as has been demonstrated by a study with PET scans which show extensive bone marrow involvement in sarcoidosis [46]. Sarcoïd granulomas are surrounded by osteoclasts, but a local focus of osseous sarcoidosis resulting in a fracture is rare [47]. Pulmonary \( Wnt \) signalling is altered in patients with sarcoidosis [48]; however, whether \( Wnt \) signalling in bone is also altered in patients with sarcoidosis is unknown. The fact that the risk of clinical vertebral fractures was increased, whereas the risk of all fractures was not different compared to matched controls, suggests that sarcoidosis probably has a negative impact on the trabecular bone without affecting the cortical bone. The finding of a decreased risk of non-vertebral fractures in this study was only marginally significant and in combination with data from literature the question is whether non-vertebral fracture risk is actually decreased in patients with sarcoidosis.

Limitations of our study were the lack of information on markers for inflammation (IL2R, ACE), disease activity, and BMD, so we could not adjust for these possible confounders. In addition, no information was available on muscle strength or mass and fall risk. The sarcoidosis case definition was described, but we were not able to confirm the diagnosis based on direct data from rheumatologists, pulmonologists, or other physicians.

In conclusion, patients with sarcoidosis have an increased risk of clinical vertebral fractures, and when on recent treatment with oral glucocorticoids, also an increased risk of any fractures and osteoporotic fractures. The decreased risk of non-vertebral fractures was an intriguing and unexpected finding, however with marginal statistical significance, and further studies should be performed to understand more about the factors that could protect against bone loss and non-vertebral fracture risk in sarcoidosis.

Compliance with ethical standards

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