Joint Bone Spine 86 (2019) 789–793

Available online at ScienceDirect www.sciencedirect.com

Elsevier Masson France EM|consulte www.em-consulte.com/en

Original article

Osseous sarcoidosis: A multicenter retrospective case-control study of 48 patients

Imen Ben Hassine[a,d,1], Christopher Rein[e,1], Cloé Comarmond[a,b,c,d,1], Camille Glanowski[f], Nathalie Saidenberg-Kermanac'h[g], Benoît Meunier[h], Nicolas Schleinitz[h], Noémie Chanson[i], Karim Sacré[i], Marc Scherlinger[j], Christophe Richez[j], Sandrine Hirschi[k], Matthieu Groh[l], Hervé Devilliers[m], Philip Bielefeld[m], David Saadoun[a,b,c,d], Catherine Chapelon-Abric[d], Laurent Arnaud[n,2], Patrice Cacoub[a,b,c,d,2,*]

[a] *Sorbonne Universités, UPMC Univ Paris 06, UMR 7211, and Inflammation-Immunopathology-Biotherapy Department (DHU i2B), 75005 Paris, France*
[b] *INSERM, UMR_S 959, 75013 Paris, France*
[c] *CNRS, FRE3632, 75005 Paris, France*
[d] *AP–HP, Groupe Hospitalier Pitié-Salpêtrière, Department of Internal Medicine and Clinical Immunology, 75013 Paris, France*
[e] *Service de Médecine Interne et Rhumatologie, HIA Legouest, Metz, France*
[f] *Hôpital d'instruction des armées de Bégin, Saint-Mandé, France*
[g] *AP-HP, Groupe Hospitalier Avicenne-Jean Verdier-René Muret, Service de Rhumatologie, et Sorbonne Paris Cité, Université Paris 13, INSERM U1125, Bobigny, France*
[h] *Service de Médecine Interne, CHU La Timone, Aix-Marseille Université, Marseille, France*
[i] *Service de Médecine Interne, CHU Bichat, Paris, France*
[j] *Service de Rhumatologie, CHU de Bordeaux, Bordeaux, France*
[k] *Service de Pneumologie, CHU de Strasbourg, Strasbourg, France*
[l] *Service de Médecine Interne, CH Foch, Suresnes, France*
[m] *Service de Médecine Interne, CHU Dijon Bourgogne, Dijon, France*
[n] *Service de Rhumatologie, Hôpitaux Universitaires de Strasbourg, Centre de Référence RESO, INSERM UMR-S1109, Université de Strasbourg, 67000 Strasbourg, France*

ARTICLE INFO

Article history:
Received 11 March 2019
Available online 30 July 2019

Keywords:
Sarcoidosis
Osseous manifestations
Bone involvement

ABSTRACT

Objective: To describe the clinical presentation, distribution of lesions, treatment, and outcomes of osseous sarcoidosis.
Methods: A French retrospective multicenter study of patients with biopsy-proven sarcoidosis analyzed patients with 1) a biopsy-proven granuloma without caseous necrosis, and either 2) osseous clinical manifestations, or 3) abnormal osseous imaging. Sarcoidosis patients with osseous involvement (cases) were compared with 264 age- and sex-matched sarcoidosis patients with no osseous manifestations (controls).
Results: In the osseous sarcoidosis group ($n = 88$), forty-two (48%) patients had osseous-related symptoms involving the axial (69%) and/or appendicular (58%) skeleton. On imaging, the most commonly affected bones were in the spine (52%), pelvis (42%), hands (22%) and femur (19%). Compared with controls, cases had higher rates of mediastinal (93% vs. 47%) and extra-thoracic lymph node involvement (66% vs. 21%), pulmonary (90% vs. 65%) and cutaneous involvement (44% vs. 23%) (all $P < 0.0001$), and hypercalcemia (8.5% vs. 2%, $P = 0.014$). Spleen/liver and gastrointestinal involvement were less frequent in the osseous sarcoidosis group (29% vs. 45%, and 1% vs. 17%, respectively, $P < 0.0001$). Response rates to with glucocorticoids alone, glucocorticoids plus methotrexate or glucocorticoids plus hydroxychloroquine were 23/44 (52%), 9/13 (69%) and 4/6 (67%), respectively.
Conclusion: In patients with osseous sarcoidosis the spine and pelvis were the most commonly affected bones. Compared with controls, cases with osseous sarcoidosis have higher rates of thoracic and extra-thoracic lymph node involvement, pulmonary and cutaneous involvement, and hypercalcemia. Most patients with osseous sarcoidosis had a good response to glucocorticoids in combination with methotrexate or hydroxychloroquine.

* Corresponding author. Department of Internal Medicine and Clinical Immunology, Hôpital La Pitié-Salpêtrière, 47-83, boulevard de l'Hôpital, 75651 Paris cedex 13, France.
E-mail address: patrice.cacoub@aphp.fr (P. Cacoub).
[1] Co-first author.
[2] Co-senior author.

https://doi.org/10.1016/j.jbspin.2019.07.009
1297-319X/

Sarcoidosis is a multi-systemic inflammatory disease characterized by non-caseating granulomas in the affected organs [1–3]. Intrathoracic lymph nodes and pulmonary involvement are most common, affecting more than 90% of patients with this diagnosis [3]. Musculoskeletal manifestations of sarcoidosis are less common, observed in 25–33% of patients [4]. Osseous sarcoidosis is a rare manifestation, reported in 3–13% of sarcoidosis patients [1,5,6]. Some authors have noted that bone involvement in sarcoidosis occurs very rarely in the absence of skin lesions [7]. Since only half of the patients with osseous sarcoidosis are symptomatic, bone involvement may be more common than previously reported [8]. The most commonly affected regions are those of the appendicular skeleton, particularly the hands and the feet [1]. Magnetic resonance imaging (MRI) and positron emission tomography (PET/CT) are useful for describing bone lesions as permeative, destructive or lytic [9,10]. There is no general consensus for the treatment of osseous sarcoidosis, although glucocorticoids were the most common treatment used. There have been several reports of successful treatment of refractory osseous sarcoidosis with anti-tumor necrosis factor alpha (TNF) agents [11]. We aimed to describe the clinical presentation, distribution of bone lesions, treatment strategies and outcomes of patients with osseous sarcoidosis.

1. Methods

A French retrospective multicenter study of patients with biopsy-proven sarcoidosis and osseous manifestations was conducted. Patients with osseous sarcoidosis (cases) were identified through a regional (Paris area) call and a national call for medical records via the Club Rhumatismes et Inflammation (a working group of the French Society of Rheumatology). A group of 264 control subjects with biopsy-proven sarcoidosis without osseous involvement were screened in a national medical records database. Patients with osseous sarcoidosis were compared with age- and sex-matched sarcoidosis patients without osseous manifestations (controls). The inclusion criteria for adult patients with osseous sarcoidosis were:

- a biopsy-proven granuloma without caseous necrosis, and either;
- osseous clinical manifestations, or;
- abnormal osseous imaging.

Löfgren's syndrome, joint pain, or arthritis were considered non-osseous manifestations of sarcoidosis. Patients with the above abnormalities were eligible for inclusion only if they also had evidence of osseous involvement on imaging or bone biopsy.

For patients and controls, we retrospectively collected from medical records data concerning the characteristics of sarcoidosis at the initial diagnosis, the type of non-osseous sarcoidosis organ manifestations, osseous symptoms, the main laboratory tests values, osseous and non-osseous imaging findings, treatment, and pathology results. Osseous involvement was characterized according to the distribution of affected bones by biopsy or imaging. We defined the axial skeleton as the spine, pelvis, ribs, scapulae, clavicles, skull or facial bones. Appendicular bones included the femur, tibia, fibula, feet, humerus, ulna, radius, and hands. Imaging modalities included X-ray, computed tomography (CT), MRI, ^{99m}Tc-HDP bone scintigraphy and ^{18}FDG PET-CT.

Response to treatment was evaluated 6 to 12 months after therapy initiation for sarcoidosis. Patients were classified as responders if they had clinical and/or radiological osseous improvement. Osseous non-responders were defined as patients with neither clinical nor radiologic improvement, and/or patients without capacity to reduce the daily dose of prednisone below 0.5 mg/kg. The study was approved by the Ethics Committee of the School of Medicine at Strasbourg University (Université de Strasbourg, Strasbourg, France).

Table 1
Main characteristics of cases with osseous sarcoidosis and controls with non-osseous sarcoidosis.

	Osseous sarcoidosis (n = 88)	Non-osseous sarcoidosis (n = 264)	P
Female, n (%)	44 (50)	132 (50)	1*
Median age at diagnosis, years [IQR]	41 [34–51]	39 [30–51]	0.174*
Ethnic origin; n (%)			0.725
White	42/83 (51)	128 (46)	
Black	24/83 (29)	70 (27)	
Asian	2/83 (2)	4 (2)	
Other	15/83 (18)	62 (24)	
Extra-osseous manifestations, n (%):			
Mediastinal lymph node	**78/84 (93)**	171 (65)	***<0.0001***
Pulmonary	**79/88 (90)**	124 (47)	***<0.0001***
Extra-thoracic lymph node	**56/85 (66)**	56 (21)	***<0.0001***
Cutaneous	**38/86 (44)**	61 (23)	***<0.0001***
ENT	26/85 (31)	55 (21)	0.076
Liver/spleen	25/86 (29)	**118 (45)**	***0.012***
Arthritis	25/88 (28)	73 (28)	0.891
Central nervous system	13/85 (15)	40 (15)	1
Eye	11/82 (13)	40 (15)	0.859
Heart	10/83 (12)	38 (14)	0.716
Peripheral nervous system	9/85 (11)	15 (6)	0.139
Muscular	7/86 (8)	45 (17)	0.054
Renal	4/84 (5)	14 (5)	1
Gastro-intestinal	1/86 (1)	**46 (17)**	***<0.0001***
Hypercalcemia, n (%)	**6/71 (8.5)**	5 (2)	**0.014**

*Osseous sarcoidosis (cases) and non-osseous sarcoidosis (controls) patients were matched for age and sex.

2. Statistical analysis

Data are expressed as medians and the interquartile range [IQR] for quantitative variables, or counts and percentages (%) for categorical variables. Comparison between quantitative variables was performed using the nonparametric paired Wilcoxon test, and the Fisher's exact test for categorical variables. P-values below 0.05 were considered to be significant. Tests were performed using SPSS Statistics version 17.0 for Microsoft Windows (Chicago, IL, USA).

3. Results

3.1. Characteristics of the study population

The demographics and organ involvement of patients with osseous sarcoidosis and controls are shown in Table 1. In the osseous sarcoidosis group (n = 88), the median age [IQR] at sarcoidosis diagnosis was 41 [34–51] years, and 44 (50%) patients were women. Forty-two out of 83 (51%) patients were white and 24 (29%) were black. All osseous sarcoidosis patients had numerous other extra-osseous manifestations of sarcoidosis. Compared with non-osseous sarcoidosis patients, those with osseous sarcoidosis showed significantly higher rates of mediastinal lymphadenopathy (93% versus 67%), pulmonary involvement (90% vs. 45%), extra-thoracic lymph node involvement (66% vs. 21%), cutaneous manifestations (44% vs. 23%) (P < 0.0001 for all), and hypercalcemia (8.5% vs. 2%) (P < 0.014). On the contrary, patients with bone sarcoidosis had significantly lower rates of liver/spleen (29% vs. 45%, P = 0.012) and gastrointestinal involvement (1% vs. 17%, P < 0.0001). Rates of other non-osseous sarcoidosis manifestations, i.e. ENT, central nervous system, ocular, cardiac, peripheral nervous system and renal involvement, were not different between the groups. Of note, non-osseous musculoskeletal sarcoidosis manifestations such as joint

Table 2
Main characteristics of bone involvement in patients with bone sarcoidosis.

Presentation of osseous sarcoidosis	
Median duration of sarcoidosis prior to osseous sarcoidosis, years (mean ± SD)	2.8 ± 4.35
Osseous sarcoidosis diagnosed at initial presentation of sarcoidosis, *n* (%)	33/85 (39)
Type of osseous manifestations, *n* (%)	
No symptoms	42/88 (48)
Digital pain, swelling and erythema (dactylitis)	13/46 (28)
Back pain	11/46 (24)
Digital pain	7/46 (15)
Pelvic pain	4/46 (9)
Mandibular pain	4/46 (9)
Teeth loss	1/46 (2)
Fracture	0/46 (0)
Laboratory measurements	
Serum ACE level elevated at osseous diagnosis, *n* (%)	42/71 (59%)
Median serum calcium at osseous diagnosis, mmol/L	2.46
Serum calcium level elevated at osseous diagnosis, *n* (%)	6/71 (8%)
Pathology, *n* (%)	
Bone biopsy	25/88 (28)
Bone biopsy showing typical features of osseous sarcoidosis	17/25 (68)
Distribution of bone lesions, *n* (%)	
Axial skeleton involvement	59/85 (69)
Only axial	34/59 (58)
Spinal bone	46/59 (78)
Cervical	16/46 (35)
Dorsal	36/46 (78)
Lumbar	37/46 (80)
Pelvic bone	37/59 (63)
Skull	11/59 (19)
Rib	11/59 (19)
Scapular	11/59 (19)
Sternum	14/59 (24)
Facial bones	2/59 (3)
Appendicular skeleton involvement	47/81 (58)
Only appendicular	26/47 (55)
Hand	19/47 (40)
Phalanx	17/47 (36)
Metacarpal	5/47 (11)
Carpal	2/47 (4)
Femur	17/47 (36)
Feet	10/47 (21)
Phalanx	8/47 (17)
Tarsal	2/47 (4)
Humerus	9/47 (19)
Tibia	2/47 (4)
Ulna	1/47 (2)
Radius	1/47 (2)
Fibula	1/47 (2)

ACE: angiotensin-converting enzyme; SD: standard deviation.

pain and muscular symptoms were noted in 28% vs. 28% ($P = 0.891$), and 8% vs. 17% ($P = 0.054$) in cases and controls, respectively.

3.2. Characteristics of bone sarcoidosis

The median duration of sarcoidosis prior to the diagnosis of osseous sarcoidosis was 2.8 years (Table 2). Thirty-three out of 85 (39%) patients had bone involvement at the initial presentation of sarcoidosis. Osseous sarcoidosis was incidentally detected in 42 (48%) cases on imaging abnormalities. Among patients with no osseous symptom, 4 (9.5%) patients had elevated serum calcium and 21 (50%) patients had elevated serum angiotensin-converting enzyme (ACE). Forty-six patients experienced bone symptoms, mainly dactylitis (28%); and back (24%), digital (15%) and pelvic pain (9%). Fifty-nine out of 85 (69%) patients had axial bone involvement, and 34 of them were solely affected at the axial skeletal bones. The two most common axial sites were the spine (46/59; 78%) and the pelvis (37/59; 63%). Forty-seven out of 81 (58%) cases had appendicular bone involvement, and 26 of them were solely affected at the appendicular skeletal bones. The hands (19/47; 40%), femur (17/47; 36%), feet (10/47; 21%) and humerus (9/47; 19%) were the most affected sites. Six out of 71 (9%) osseous sarcoidosis cases had elevated serum calcium, and 42 out of 71 (59%) had elevated serum angiotensin-converting enzyme levels.

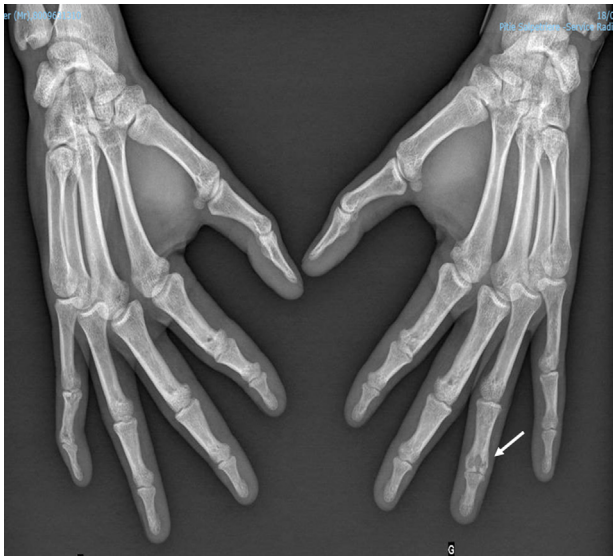

Fig. 1. X-ray of hands showing cysts known as Perthes' disease and Jüngling's disease.

Imaging modalities were used for the diagnosis of bone involvement, i.e. MRI in 42 (48%), PET/CT-scan in 42 (48%), and X-rays in 33 (38%) patients (Figs. 1 and 2). Bone scan was performed in 22 (25%) patients, and bone scintigraphy in 16 (18%) patients. The classic lesions in the small bones of the hands and feet are known as Perthes' disease and Jüngling's disease. They are well characterized on standard X-rays (Fig. 1). MRI findings included T1 hypo intensity and T2 and STIR hyper intensity lesions (Fig. 2).

Twenty-five out of 88 (28%) patients had a bone biopsy that showed typical non-caseating granulomas in 17 of 25 patients. The bone biopsy site was determined by clinical manifestations or imaging abnormalities. Fifteen out of 88 (17%) patients had both abnormal bone biopsy and imaging for the diagnosis. The other non-osseous tissue sites of biopsy showing typical features of sarcoidosis were the lymph nodes (26/76; 34%), lungs (21/76; 28%), skin (21/76; 28%), liver (6/76; 8%), thyroid (1/76; 1%) and lip (1/76; 1%).

3.3. Treatment and outcomes

Patients with osseous sarcoidosis received glucocorticoids alone (54%), methotrexate alone (53%) or hydroxychloroquine alone (31%) (Table 3). Glucocorticoid therapy was combined with methotrexate or hydroxychloroquine in 16% and 7% of cases, respectively. Only 7 out of 88 (8%) patients had no specific treatment. Rates of clinical and/or radiological response of bone sarcoidosis in patients treated with glucocorticoids alone, glucocorticoids plus methotrexate or glucocorticoids plus hydroxychloroquine were 25/44 (57%), 9/13 (69%) and 4/6 (67%), respectively ($P = 0.50$). Only 3 of the 19 (16%) patients who were treated with glucocorticoids alone were non-responders. TNF-alpha inhibitors were given to 10 out 81 patients, and all patients had a good response. Other immunosuppressive drugs were given mostly for severe or refractory non-osseous sarcoidosis, and in most of these cases patients had a good response for osseous sarcoidosis.

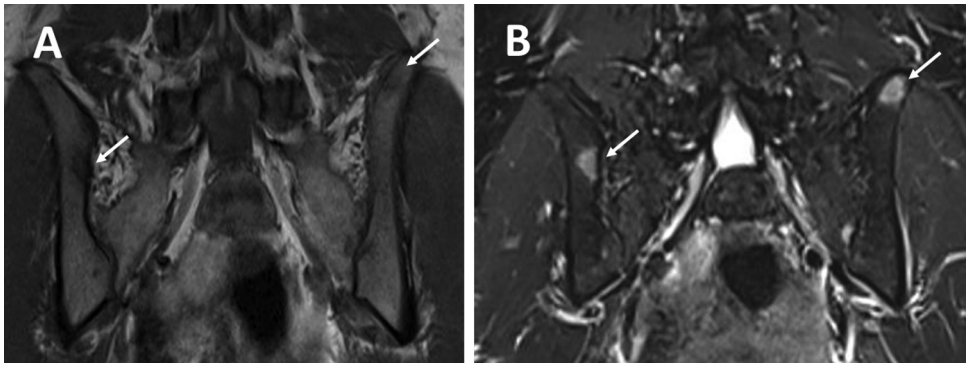

Fig. 2. MRI coronal sequences demonstrating T1 hypo intensity (A) and STIR hyper intensity (B) pelvic lesions.

Table 3
Treatment of osseous sarcoidosis patients.

Treatment	Patient treated *n* (%)	Osseous responder *n* (%)
Glucocorticoid	63 (71.5)	38 (60)
Glucocorticoid alone	44 (50)	25 (57)
Methotrexate alone	43 (49)	41 (95)
Hydroxychloroquine alone	25 (28)	20 (80)
Glucocorticoid plus methotrexate	13 (15)	9 (69)
TNF-alpha inhibitor	10 (11)	10 (100)
Azathioprine	10 (11)	10 (100)
IV cyclophosphamide	7 (8)	7 (100)
Glucocorticoid plus hydroxychloroquine	6 (7)	4 (67)
Mycophenolate	4 (4.5)	4 (100)
Thalidomide	1 (1)	1 (100)
Rituximab	1 (1)	1 (100)
None	7 (8)	–

IV: intravenous.

4. Discussion

Based on a large French multicenter study of patients with sarcoidosis and osseous manifestations, we found that:

- although the axial and appendicular skeletons were similarly affected, dactylitis and osseous pain were the first main clinical symptoms;
- osseous involvement was frequently asymptomatic and was incidentally detected in half of the patients;
- compared to sarcoidosis patients with no osseous involvement, cases with osseous sarcoidosis had higher rates of thoracic and extra-thoracic lymph nodes, pulmonary and cutaneous involvement, and hypercalcemia;
- most patients had a good response to corticosteroids used in combination with methotrexate or hydroxychloroquine.

Earlier studies reported that bones of the hands and feet were the most commonly affected by osseous sarcoidosis. Axial skeleton involvement was rarely reported [12]. In the present study, sarcoidosis affected the axial as well as the appendicular skeleton. Axial bone involvement from sarcoidosis mostly affected the spine. On either MRI with hyperintense lesions in multiple vertebral bodies and gadolinium enhancement of osseous lesions or PET/CT with active metabolism in bone, no feature can reliably distinguish sarcoidosis from malignant lesions, particularly in the spine and the pelvis. Bone biopsies may be required to exclude malignancy. Sparks et al. and Zhou et al., respectively, identified 90% and 87.5% of patients with the spine and pelvis as the most affected sites [1,5]. The hands were the third most affected site, while no patient demonstrated foot involvement [5]. This difference in distribution of osseous involvement may reflect the frequent use of MRIs and PET-CTs in recent decades. Symptoms of osseous sarcoidosis include pain, swelling, erythema or distortion of the fingers. Pain is often a prominent feature of axial skeletal sarcoidosis [1,5]. In this study, we did not find serious manifestations related to pathological fractures, vertebral compression fractures, nerve compression or hypercalcemia [1,5]. Gowani et al. [1,5] reported pathological fractures in only 6 out of 118 (5%) patients, and radicular pain in 10 out of 118 (8.5%) patients. However, vitamin D status was not available for these patients, this might be of interest since serum 25(OH)D levels above 20 ng/mL has been associated with lower bone mineral density values and a higher risk of fractures in patients with sarcoidosis [13]. Increased serum calcium levels remains a rare manifestation of osseous sarcoidosis [1,5].

Most patients in this study showed systemic manifestations of sarcoidosis other than osseous sarcoidosis, a feature found by others [1]. Patients with osseous involvement experienced a higher prevalence of involvement of three or more organs compared with the non-osseous sarcoidosis control group [5]. This can be accounted for by the long duration between the diagnosis of sarcoidosis and the osseous involvement [14]. In line with other studies, cutaneous involvement was common in this study [7]. Osseous sarcoidosis patients also have high rates of mediastinal lymphadenopathy, pulmonary involvement, and extra-thoracic lymph nodes [1]. Results are less clear for rates of arthritis, and liver/spleen and gastrointestinal manifestations [5]. Many hypotheses have been suggested for the pathogenesis of osseous sarcoidosis, although without a clear picture between the hematogenous theory, the airway route of lung involvement and musculocutaneous disruption of skin involvement [15].

Osseous lesions of sarcoidosis can be incidentally detected with imaging modalities, especially MRI and PET/CT [1,5]. However, histological proof remains necessary since imaging modalities have limited specificity in differentiating between sarcoidosis and malignancy [16–18]. All patients in our study had histological confirmation of sarcoidosis with evidence of non-caseating epithelioid cell granulomas in the bones or in other sites [5]. In one study however, non-caseating granulomas were identified in all thirty-five patients with positive MRI or PET/CT who underwent bone biopsy [5]. This observation suggests that pathological confirmation may not be required for patients with typical imaging patterns.

There is no consensus for the treatment of osseous involvement in sarcoidosis. Asymptomatic patients do not appear to require treatment [19]. However, since osseous sarcoidosis patients often present with a systemic disease, many patients will receive treatment for other non-osseous manifestations. Glucocorticoid therapy was the most frequently used treatment [1,5,14]. Glucocorticoids were very effective in providing symptomatic relief, but they have been shown to result in persistent radiographic

abnormalities despite clinical resolution [20]. In their literature review, Gowani et al. found that glucocorticoids were used in 70 out of 95 patients with osseous sarcoidosis, with all cases reporting clinical improvement and half of the cases radiographic improvement [14]. Methotrexate used alone has been reported to be useful for the treatment of osseous sarcoidosis [5]. Methotrexate has shown equal efficacy when compared with corticosteroids as a primary treatment [14,21]. Patients treated with anti-TNF also showed a good response in all cases; of note however is that this treatment was mainly given to patients with systemic sarcoidosis [1,5,11,14,22,23]. Surgery was resorted to in rare cases with irreversible bone pain, neurological involvement, and pathological fractures [14].

This study has several limitations. It was a retrospective multicenter study. The imaging modalities used were not the same for all patients and osseous sarcoidosis can be asymptomatic and incidentally detected with PET-scan. However, concomitant osseous PET positivity might be non-specific and scintigraphy might reflect arthrosis or overuse. While we analyzed each treatment received by osseous sarcoidosis patients and therapeutic response, all centers in this study did not share the same therapeutic protocol. This represents rather a real-life clinical practice and observational data since no current standard therapy exist for osseous sarcoidosis.

In conclusion, the axial as well as the appendicular skeleton are affected in patients with osseous sarcoidosis. Compared with those having sarcoidosis without osseous involvement, patients with osseous sarcoidosis have higher rates of thoracic and extrathoracic lymph nodes, pulmonary and cutaneous involvement, and hypercalcemia. Most patients with osseous sarcoidosis had a good response to glucocorticoids used alone or in combination with methotrexate or hydroxychloroquine.

Financial support

No financial support or other benefits from commercial sources was provided for this work.

Disclosure of interest

The authors declare that they have no competing interest.

Investigator list

Thomas Papo (Paris), Mathilde Versini (Nice), Véronique Breuil (Nice), Emmanuel Chatelus (Strasbourg), Claude Heuschling (Luxembourg), Arsène Mekinian (Paris), Jérémie Sellam (Paris), Alessio Imperiale (Strasbourg), Nathalie Morel (Paris), Nathalie Costedoat-Chalumeau (Paris), François Chasset (Paris), Vincent Poindron (Strasbourg), Thierry Martin (Strasbourg), Daniel Wendling (Besançon), Marie-Françoise Avril (Paris), Vannina Seta (Paris), Edouard Pertuiset (Pontoise), Raphaele Mestiri (Paris), Lisa Biale (Paris), Thierry Carmoi (St Mandé), Dominique Lechevallier (Paris).

References

[1] Sparks JA, McSparron JI, Shah N, et al. Osseous sarcoidosis: clinical characteristics, treatment, and outcomes–experience from a large, academic hospital. Semin Arthritis Rheum 2014;44:371–9.
[2] Thomas KW, Hunninghake GW. Sarcoidosis. JAMA 2003;289:3300–3.
[3] Baughman RP, Teirstein AS, Judson MA, et al. Clinical characteristics of patients in a case control study of sarcoidosis. Am J Respir Crit Care Med 2001;164:1885–9.
[4] Bechman K, Christidis D, Walsh S, et al. A review of the musculoskeletal manifestations of sarcoidosis. Rheumatol Oxf Engl 2018;57:777–83.
[5] Zhou Y, Lower EE, Li H, et al. Clinical characteristics of patients with bone sarcoidosis. Semin Arthritis Rheum 2017;47:143–8.
[6] Salmon J-H, Perotin J-M, Direz G, et al. Vertebral sarcoidosis. Spontaneous favorable outcome: a case report and literature review. Rev Med Interne 2013;34:42–6.
[7] James DG. Dermatological aspects of sarcoidosis. Q J Med 1959;28:108–24.
[8] Neville E, Carstairs LS, James DG. Sarcoidosis of bone. Q J Med 1977;46:215–27.
[9] Rao DA, Dellaripa PF. Extrapulmonary manifestations of sarcoidosis. Rheum Dis Clin North Am 2013;39:277–97.
[10] Sobic-Saranovic D, Artiko V, Obradovic V. FDG PET imaging in sarcoidosis. Semin Nucl Med 2013;43:404–11.
[11] Hasni SA, Kunz D, Finzel K, et al. Osseous sarcoidosis treated with tumor necrosis factor-inhibitors: case report and review of the literature. Spine 2010;35:E904–7.
[12] Wilcox A, Bharadwaj P, Sharma OP. Bone sarcoidosis. Curr Opin Rheumatol 2000;12:321–30.
[13] Saidenberg-Kermanac'h N, Valeyre D, Boissier M-C. Vitamin D supplementation in patients treated for sarcoidosis: controversy or consensus? Jt Bone Spine Rev Rhum 2017;84:521–3.
[14] Gowani ZS, Sathiyakumar V, Holt GE. Osseous sarcoidosis. JBJS Rev 2015:3.
[15] Heffner DK. Explaining sarcoidosis of bone. Ann Diagn Pathol 2007;11:464–9.
[16] Moore SL, Kransdorf MJ, Schweitzer ME, et al. Can sarcoidosis and metastatic bone lesions be reliably differentiated on routine MRI? Am J Roentgenol 2012;198:1387–93.
[17] Caobelli F, Gabanelli SV, Brucato A, et al. Unsuspected active sarcoidosis diagnosed by 18F-FDG PET/CT during the search for a primary tumour in a patient with bone lesions. Nucl Med Mol Imaging 2013;47:205–7.
[18] Conte G, Zugni F, Colleoni M, et al. Sarcoidosis with bone involvement mimicking metastatic disease at (18)F-FDG PET/CT: problem solving by diffusion whole-body MRI. Ecancer Med Sci 2015;9:537.
[19] Sweiss NJ, Lower EE, Korsten P, et al. Bone health issues in sarcoidosis. Curr Rheumatol Rep 2011;13:265–72.
[20] Liu B, Zhang X, Zhang W, et al. Solitary osseous sarcoidosis: a rare reason for pathologic fracture. Rheumatol Int 2012;32:2535–8.
[21] Maña J, Gómez-Vaquero C, Dorca J, et al. Vertebral and rib sarcoidosis: long-term clinical remission with methotrexate. Clin Rheumatol 1999;18:492–4.
[22] Garg S, Garg K, Altaf M, et al. Refractory vertebral sarcoidosis responding to infliximab. J Clin Rheumatol 2008;14:238–40.
[23] Patel SR. Systemic sarcoidosis with bone marrow involvement responding to therapy with adalimumab: a case report. J Med Case Reports 2009;3:8573.