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Atypically Located Osteoid Osteoma: Characteristics and Therapeutic Success After Image-Guided Thermal Ablation

Das atypisch lokalisierte Osteoidosteom: Charakteristiken und Therapieerfolg nach bildgesteuerter Thermoablation

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ABSTRACT

Purpose While ostoeid osteomas (OO) are typically located in long tubular bones, OO occurring elsewhere are referred to as “atypical”. Aim of our study was to review the characteristics of atypically located OO, course of symptoms and therapy, as well as clinical outcome, safety, and patient satisfaction of radiofrequency ablation (RFA).

Materials and methods In the period from 04/01 to 07/13, 33 patients were treated using thermal ablation (RFA or laser), partly with low temperature and short duration technique. Clinical records were analyzed. Additionally, 23 patients were interviewed via telephone. Primary endpoints were technical success, clinical success (recurrence rates), and adverse events. Secondary endpoints were course of symptoms and therapy as well as patient satisfaction.

Results Mean follow-up was 22.1 ± 21.5 months. Average patient age was 31.7 ± 16.3 years. Localization: Most atypical OO (61 %) were located in the lower extremity, followed by axial skeleton (26 %) and upper extremity (13 %). Pain anamnesis: 74 % of patients stated that their pain occured predominantly at night and responded to NSAID, as typical for OO. Diagnostics: Patients consulted on average 4 different doctors and in 52 % patients, ≥ 3 different radiologic imaging techniques where used before the diagnosis “OO” was made. Outcome: Technical success of thermal ablation was 100 %. Primary clinical success was 91 %. Patient satisfaction was 100 %. No major complications occurred.

Conclusion In ¼ of cases, atypical OO did not show the typical pain characteristics of OO. Image-guided thermal ablation is a promising and safe therapy also for patients with atypical OO.

Key points:

- Atypical OO are challenging regarding diagnostics and therapy
- Image-guided thermal ablation is a safe and effective procedure also for patients with atypical OO
- Image-guided thermal ablation shows high patient satisfaction

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ZUSAMMENFASSUNG

Ziel Während das Osteoidosteom (OO) typischerweise die diaphysären Anteile langer Röhrenknochen betrifft, werden OO anderer Lokalisationen als „atypisch“ bezeichnet. Zielsetzung unserer Studie war die Evaluation von lokalisationsbedingten Charakteristiken des atypischen OO, Krankheits- und Behandlungsverlauf sowie Therapieerfolg, Sicherheit und Patientenzufriedenheit der bildgestützten Thermoablation.

Patienten und Methoden Im Zeitraum von 04/2001–07/2013 wurden 33 Patienten mit atypischem OO mittels bildgesteuerter RFA und Laserablation therapiert, z. T. mit

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„low-temperature-and-short-duration-technique“. Die Analyse erfolgte jeweils über die Patienten- und Therapiedaten aus klinischen Datenbanken. Zudem wurden telefonische Patienteninterviews bei 23 Patienten durchgeführt. Primäre Endpunkte waren technischer Erfolg, klinischer Erfolg (Rezidivrate) und Komplikationen (SAE). Sekundäre Endpunkte waren Krankheitsverlauf und Therapiecharakteristiken sowie Patientenzufriedenheit.

Ergebnisse Das mittlere Follow-up betrug 22,1 ± 21,5 Monate, das mittlere Alter der Patienten 31,7 ± 16,3 Jahre. Lokalisation: Mit 61 % war die untere Extremität die häufigste Lokalisation des atypischen OO. 26 % waren im Stammskelett und 13 % im Bereich der oberen Extremität lokalisiert. Schmerzanamnese: 74 % der Befragten gaben die für das OO typischen nächtlichen Beschwerden und das Ansprechen auf NSAID an. Diagnostik: Im Mittel wurden ambulant 4 verschiedene Ärzte konsultiert und bei 52 % der Patienten wurden ≥ 3 unterschiedliche bildgebende Verfahren angewandt, bis die Diagnose OO gestellt wurde. Outcome: Der technische Erfolg der bildgesteuerten Thermoablation betrug 100 %. Der primäre klinische Erfolg betrug 91 %. Die Patientenzufriedenheit betrug 100 %. Es waren keine Major-Komplikationen zu verzeichnen.

Schlussfolgerung Das atypische OO zeigte in ¼ der Fälle nicht die für das OO typischen Schmerzcharakteristiken. Auch für Patienten mit atypischem OO ist die bildgestützte Thermoablation, z. T. unter Einsatz einer „low-temperature-and-short-duration-technique“, eine erfolgversprechende und sichere Therapiemethode.

Purpose

Osteoid osteoma (OO) is a benign osteoblastic bone tumor of previously unexplained etiology that usually occurs in young adults and typically features nocturnal pain which responds well to aspirin (ASA) or other anti-inflammatory drugs (NSAID) [1]. The tumor is characterized by a central round-to-oval, hypervascularized osteolysis zone, the so-called nidus, which is regularly surrounded by reactive marginal sclerosis [2]. Similarly, a conventional X-ray image typically shows a central brightening zone with a sclerotic border [3]. In the case of ambiguous X-ray findings, computed tomography (CT) and, especially in younger patients, magnetic resonance imaging (MRI) are additional imaging options of choice [4]; a vascular groove sign in the CT image is highly specific for OO [5].

OO most frequently affects the long bones of the leg. Osteoid osteomas occur less commonly in the trunk skeleton (spinal column, shoulder girdle, pelvis) as well as in the hand and foot areas; these are regarded as atypical or “technically challenging” [1, 6, 7]. The presentation of typical radiographic features of OO may be more uncharacteristic at atypical sites [8, 9]. In such cases, additional imaging such as MRI or, as needed, histopathological confirmation may be required in order to establish a diagnosis [8, 9]. Likewise, recurrence can be identified via MRI [10].

Combined with the clinical observation that atraumatic pain in the trunk skeleton frequently cannot be precisely localized by the affected persons, diagnosis of an atypical OO can become a challenge, which in case of doubt means an extended period of time for the patient from the anamnesis to establishment of a diagnosis [7, 9].

Since the start of the 1990 s, minimally invasive methods have replaced open surgical resection [11] as the therapy of choice for osteoid osteomas [12]. These primarily include thermal ablative procedures such as CT- or MRI-guided radiofrequency or laser ablation (LA) [13, 14]. Clinical studies have demonstrated greater than 95 % success rates accompanied by increased patient satisfaction and low complication rates [15–18].

Most studies have investigated “typical” located osteoid osteomas; thus to our knowledge no extensive data on atypical OO are available so far. The aim of the present study was to characterize the pathology of atypical osteoid osteoma with regard to localization, symptoms and duration, as well as treatment success, complication rates and patient satisfaction after image-guided thermal ablation.

Materials and Methods

Baseline patient profile and endpoints

This was a prospective observational study with respect to characteristics and therapy of atypical osteoid osteomas. Between July 2001 and July 2013, 94 patients with symptomatic osteoid osteomas were interventionally treated radiologically using image-guided thermoablation, i. e. radiofrequency ablation (RFA) and laser ablation (LA). Of these 94 patients, 33 with atypically located OO were included in the study. At the time of intervention, the average age of these 33 patients was 31.7 years (youngest patient: 10 years old; oldest patient: 64 years of age); the female-to-male gender ratio was 11:22. Twenty-three of the 33 patients (70 %) were contacted by telephone and took part in the survey. The average follow-up time was 22.1 ± 21.5 months.

Technical success, clinical success (recurrence rate) and complications (serious adverse events, SAE) were defined as primary endpoints. A standardized questionnaire (▶ **Table 1**) surveyed the patient-specific characteristics of the atypical osteoid osteomas: symptoms, course and duration of the disease, physician contacts, diagnostics performed and patient satisfaction. In addition, special aspects of the therapy (low temperature, short duration) were identified. These represented secondary endpoints.

Interventional therapy

All interventions were performed under general anesthesia due to anticipated pain during drilling and ablation of the nidus. Patients were monitored post-interventionally, and discharge to home was

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▸ **Table 1** Questionnaire for telephone interviews.

QUESTION	RESPONSES
1. Call you recall when your symptoms first appeared?	Yes = 23; No = 0
2. Can you recall which symptoms you had? Can you describe your symptoms?	Yes = 23; No = 0
a) Localization: Where was your pain located?	Upperex = 3; Lowerex = 14; Trunk skeleton = 6
b) Quality of pain:	Dull/pressing = 12; Stabbing/burning = 11
c) Highest pain level on a scale of 0–10:	Min 3; Max 10; Mean 7.4; Median 7 (Missing n = 2)
d) Radiation: Was the pain limited to a single place or did it radiate into other regions?	Radiating = 9 (4 Trunk skeleton; 4 Lowerex; 1 Upperex); Clearly limited = 14
e) Were your symptoms strain-related?	Yes = 16 (13 Lowerex; 2 Trunk skeleton; 1 Upperex); No = 7
f) Was your pain continuous or intermittent?	Continuous = 7; Intermittent = 16
g) Did your symptoms respond well to aspirin or other analgesics?	Yes = 17; No = 6
h) Were your symptoms primarily at night?	Yes = 17; No = 6
3. Can you recall when you first consulted a physician because of your symptoms?	Yes = 23; No = 0
4. Can you remember which and how many different physicians treated you for your symptoms and which one made the correct diagnosis, and when?	Yes = 23; No = 0
a) Prior to the diagnosis of osteoid osteoma, did you receive other (mis)diagnoses?	Yes = 19; No = 4.
b) Have you also been treated due to other (mis)diagnoses?	Yes = 17; No = 6
6. Which diagnostic procedures were performed for your symptoms?	X-ray imaging = 18; CT = 12; MRI = 21; Scintigraphy = 6 (Multiple responses)
7. Were you pain-free one month after our therapy?	Yes = 20; No = 2 (Prolonged wound pain)
a) If so, after how many days?	Min 1; Max 42; Mean 8.14; Median 3 (Missing 2)
8. Do you have residual pain now?	Yes = 2; No = 20 (Missing 1)
9. Do you currently suffer from functional impairments?	Yes = 1; No = 21 (Missing 1)
10. Have you experienced a recurrence of osteoid osteoma"	Yes = 2; No = 20 (Missing 1)
11. Were you satisfied with you treatment?	Yes = 22; No = 0 (Missing 1)
12. Would you undergo this type of therapy again in case of recurrence?	Yes = 22; No = 0 (Missing 1)

possible 1–2 days postoperatively. The patients included in this study with atypically located OO were treated using image-guided thermal ablation, of whom 13 were treated with CT-assisted RFA and 20 with MR-assisted LA. Punch biopsies were taken from all patients for histological confirmation.

I. CT-assisted radiofrequency ablation (RFA)

The exact technique of CT-assisted RFA has been described in detail in the literature [15]. After CT-assisted drilling of the nidus, thermal ablation was performed using temperature-controlled radiofrequency ablation (RFA) (16G RITA Starburst SDE, Angiodynamics, Mountain View, USA) with a target temperature of 90 °C for 8 minutes (standard protocol). Depending on the localization of the osteoid osteoma, temperature and duration were reduced accordingly (< 90 °C, 4–6 minutes) in order to protect surrounding tissue, especially structures close to the joint, using the so-called low temperature and short duration technique (see ▸ **Fig. 1–3**).

II. MR-assisted laser ablation (LA)

This technique is likewise described in the literature [14]. Precise localization of the nidus, instrument guidance and insertion of the laser probe were performed in open 1.0 Tesla MRI (Panorama HFO, Phillips, Best, Netherlands). Opening of the nidus using MR-compatible bone biopsy drills (Invivo, Schwerin, Germany) was followed by insertion of MR-compatible intervention needles (16–18G, Somatex, Teltow, Germany) and a 600 µm laser fiber (Frank Optic Products, Berlin, Germany). Then ablation was performed using an Nd:YAG laser (1064 nm, Medilas fibertom, Dornier MedTech, Wessling, Germany) with constant energizing and effective 2–3 W output. Depending on the size and location of the lesion, the total energy input was 360–4300 Joules. Post-interventional subtraction imaging was performed both without and with contrast medium (Gadovist, Bayer-Schering, Berlin, Germany).

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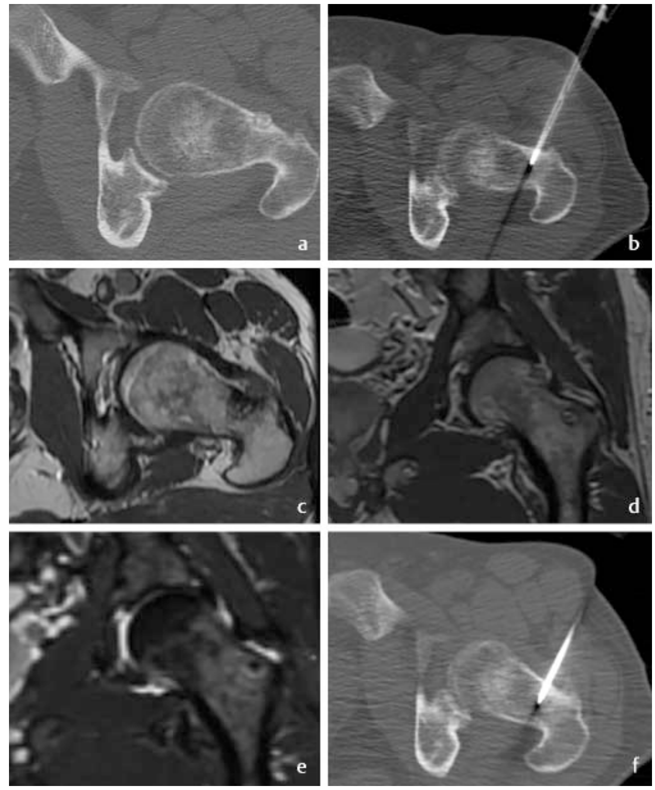
► **Fig. 1** 18-year-old patient (typical age) with atypical OO located in the left sulcus calcanei. Primary technical and clinical success, no complications. Conventional x-ray **a**. MRI **b** (sag T2 STIR), **c** (cor T2 STIR) 13 mm OO depicted. Freedom of symptoms after RFA with standard temperature 90° and slightly reduced duration 7 min **d** (axial CT fluoroskopy drill).



► **Fig. 2** 50-year-old patient (atypical age) with atypical OO located in the left ventral femoral neck. Primary technical success, recurrence after 8 months and repeated RFA with secondary clinical success, no complications. CT-scan **a**. After RFA with reduced temperature 80° and reduced duration 6 min ("low temperature and short duration technique" due to intracapsular location) **b** symptom-free interval for 8 months. After recurrence of symptoms, MRI was performed **c** (sag T2 STIR), **d** (cor T2 STIR). Note the perinidal edema and reactive effusion in hip joint **e** (cor T2 STIR). Repeated RFA with standard temperature 90° and standard duration 8 min **f** led to freedom of symptoms.

Statistical evaluation

The descriptive statistical evaluation was carried out using Excel (Microsoft Inc., Redmond, WA, USA) and SPSS (IBM, Armonk, NY, USA). The statistical significance level was defined as $p < 0.05$.

Results

Localization and pain history

The lower extremity, with 61 %, was the most frequent site of atypical osteoid osteomas (femoral neck: 6/20; heel bone: 4/20; talus: 2/20; in addition, trochanter major; femoral condyle; patella; tibia head, and metatarsal bone). Twenty-four percent were in the trunk skeleton (vertebrae: 4/8; acetabulum: 3/8 and ilium: 1/8), and 15 % in the region of the upper extremity (distal radius: 1/5; scaphoid: 1/5; fingers: 3/5) (► **Table 2**, ► **Fig. 4**). With almost the same frequency, pain quality was described as dull/pressing or stabbing/burning. On a pain scale of 0–10, an average pain intensity of 7 was indicated. Of the patients surveyed, 61 % reported clearly localizable, limited pain; 39 % reported pain radiating to adjacent body regions. Proportionally, "radiating pain" at 67 % (4 out of 6), the highest among patients with osteoid osteoma close to the trunk. Strain-related pain was reported by 70 % of patients (16 of 23). Thirteen of these patients (93 %) had an OO in the lower extremity. Typical reported pain characteristics included nocturnal pain among 74 % of patients; 70 % described intermittent pain-free intervals, and 74 % indicated that their pain responded to analgesics.

Course of illness and treatment

The surveyed patients initially sought medical advice on average 3 ± 4 months after the onset of their pain/symptoms. In more than half of the patients (52 %), 3 or more different imaging procedures were employed (mostly conventional X-rays, CT, MRI and scintigraphy; in individual cases, sonography), sometimes repeatedly, before the diagnosis "osteoid osteoma" could be made. Most patients (78 %) received at least one inaccurate diagnosis (range: 0–5) resulting in an attempt at therapy. The average time from first contact with the physician to diagnosis was 9 ± 10 months (range: 0–46). On average, 4 ± 3 different physicians were consulted (range 1–13).

Technical success, complications and patient satisfaction

The technical success of image-guided thermal ablation was 100 %. Primary clinical success was 91 %; two of the 23 patients (9 %) surveyed experienced a relapse within the post-treatment period (see ► **Fig. 1**). After the second intervention, however,

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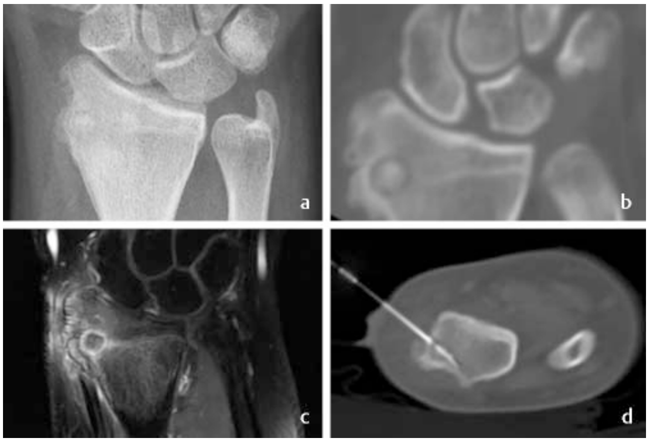

▶ **Fig. 3** 44-year-old patient (atypical age) with atypical OO located in the left distal radius. Primary technical and clinical success, no complication. Conventional x-ray **a**. CT shows typical „nidal sign" **b**. MRI **c** (T1 SE Cor fs contrast enhanced). Freedom of symptoms after RFA with standard temperature 90° and standard duration 8 min (axial CT fluoroskopy applicator) **d**.

both patients were symptom-free and reported no residual pain or post-interventional functional deficits, thus the secondary clinical success was likewise 100 %. Ninety-three of the patients indicated that they were pain-free within one month after interventional therapy with RFA. Two patients reported prolonged wound pain, which, however, had stopped by the time of the interview. In our study cohort there was one minor complication (post-interventional transient reactive effusion in the knee joint) and no major complications. On the whole, the therapy resulted in a high level of patient satisfaction and acceptance (100 %) when image-guided thermal ablation was used. All interviewed patients stated that they could imagine using this form of therapy again if needed.

Conclusions

This study analyzed characteristics of atypical osteoid osteoma with regard to localization, symptoms, intervention, therapeutic success and follow-up after image-guided thermal ablation. With a technical and clinical success of 100 % and 91 %, respectively, the success rates are comparable to the limited study data on atypical osteoid osteoma and also comparable to typical OO, which range between 91–95 % [16, 19–21].

In our patient cohort, the lower extremity (61 %) and trunk skeleton (24 %) were the most frequent manifestation sites of atypical osteoid osteoma, while the upper extremity was affected in only 15 % of cases. This corresponds approximately to the described distribution frequency of "classical" OO in the respective body regions [22, 23].

We were not able to determine a consistent clinical picture of atypical osteoid osteoma with respect to the quality and intensity of pain. While the characteristic pain of typical osteoid osteomas is described as clearly localized, nearly 40 % of our patients surveyed reported pain radiating to adjacent body regions, and a tendency to frequent occurrence of radiating pain with tumor localization in the trunk skeleton – mainly the spinal column – was recognizable. An explanatory approach could provide the subjective superposition of different organ systems in the region of the trunk skeleton and the associated difficulty of assigning pain to them; at the same time a convergence of nociafferents is

▶ **Table 2** Main results: Location, primary and secondary endpoints.

Selected data	
Location	
Upper extremity n = 5	Distal radius n = 1
	Scaphoid n = 1
	Fingers n = 3
Lower extremity n = 20	Femoral neck n = 6
	Trochanter major n = 1
	Femoral condyle n = 1
	Patella n = 1
	Tibia head n = 2
	Talus n = 2
	Heel bone n = 4
	Cuneiform n = 1
	Metatarsals n = 1
	Toes n = 1
Trunk skeleton n = 8	Spine n = 4
	Acetabulum n = 3
	Ilium n = 1
Primary endpoints	
Technical success	100 %
Primary clinical success	91 %
Secondary clinical success	100 %
Certainty and undesired events	Minor n = 1
	Major n = 0
Secondary endpoints	
Interval between initial physician contact and diagnosis	8 months (Min 0; Max 46; Mean 8.8; Median 5)
Duration of disease process	12 months (Min 0; Max 46; Mean 12.3; Median 8)
Number of physicians consulted	4 physicians (Min 1; Max 13; Mean 4; Median 3.5)
Number of inappropriate suspected diagnoses	1 suspected diagnosis (Min 0; Max 5; Mean 1.5; Median 1)
Number of imaging procedures performed	3 procedures (Min 1; Max 5; Mean 2.7; Median 3)
	X-ray = 18
	CT = 12
	MRI = 21
	Scintigraphy = 6
	Other = 5

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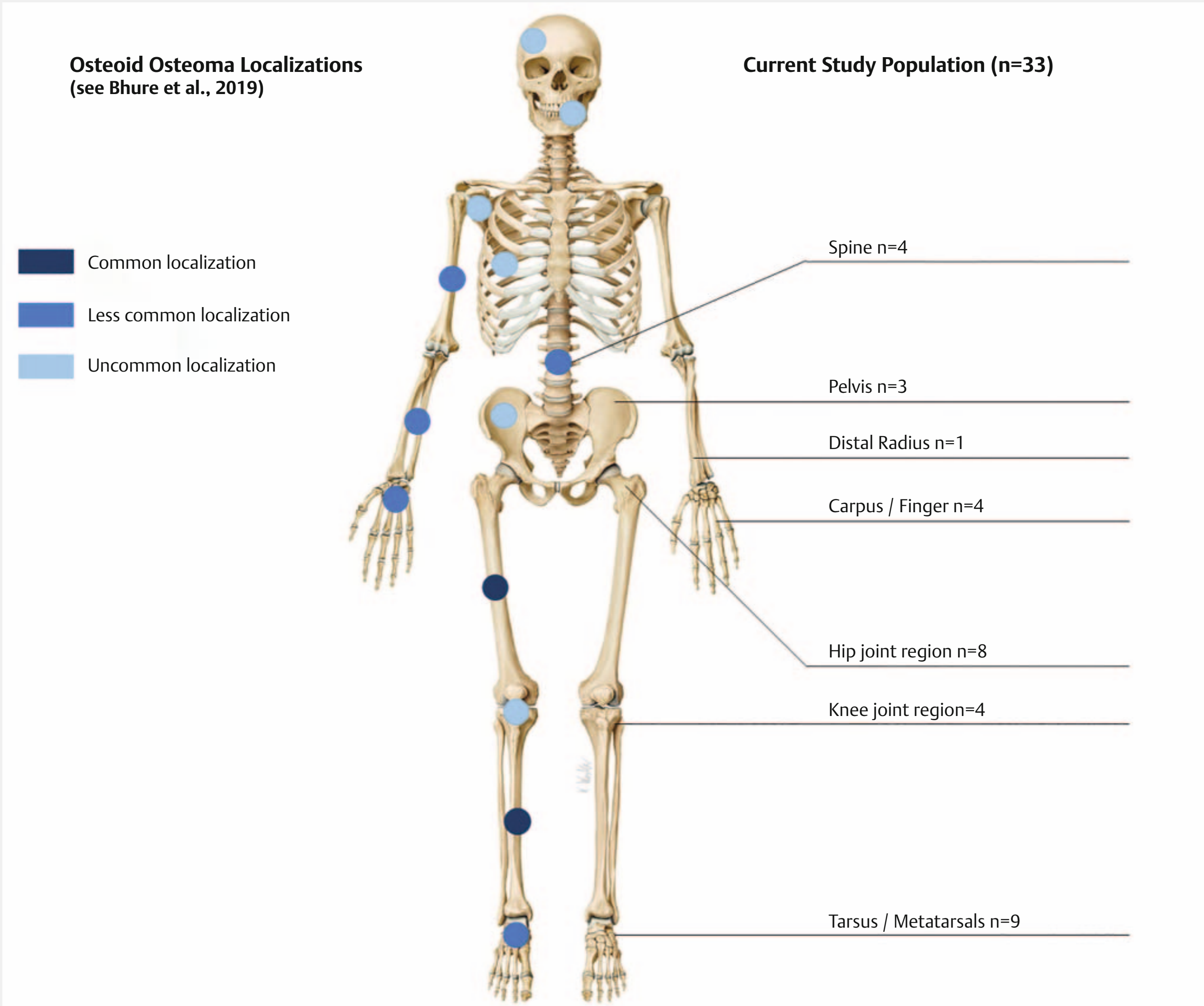

▶ **Fig. 4** Distribution of OO of all locations (cf. Bhure et al., 2019) compared to our study population with atypically located resp. technical challenging OO (Image source: Schünke M, Schulte E, Schumacher U, Prometheus LernAtlas der Anatomie. Band 1. Illustrationen von Voll M und Wesker K. 4. Auflage. Stuttgart: Thieme, 2014).

possible due to neuroanatomical conditions in the trunk skeleton [24]. Atypically located osteoid osteoma can imitate functional symptoms in the area of supporting structures (blockages, concatenation syndromes), but can also mimic radicular syndromes [24]. On the whole, atypical OO appears to differ from the typical form of the disease not only with respect to localization, but also in terms of symptoms, and presents a more heterogeneous pathology, as Szendroi et al. has postulated for intra-articularly located osteoid osteoma [9].

This symptom variability could be one reason why many of the patients included in the study reported a long course of disease with an average of 12 months of continuing pain before a correct diagnosis was made, which only then resulted in sufficient therapy. The literature contains similar observations [6, 25]. In addition to the extended duration of the disease for patients, the consultation of several physicians and frequent implementation of unnecessary diagnostic measures with associated health economic implications should also be critically assessed. One patient with osteoid osteoma in the region of the lumbar spine reported having seen 13 different doctors.

A further goal was the evaluation of the therapeutic results and patient satisfaction. Gebauer et al. recently compiled the results of 21 clinical studies that dealt with the clinical results of RFA in symptomatic OO, [15], the largest of which investigated 557 cases [17]. Among over 1350 patients, the success rate lay between 65 % and 100 % (average: 92 %). Our results, with 91 %, are in line with these positive study results. Two recurrences could be treated again with RFA without problems and without changing to another form of therapy such as open surgical resection or medication; to date, the affected patients are still symptom-free. In both cases localization of the osteoid osteoma was in the femoral neck (▶ **Fig. 1**), so that due to the proximity to the hip joint, the low temperature and short duration technique strategy was used in the initial therapy to avoid complications (cartilage damage, re-

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active effusion, etc.). The time was reduced (4–6 minutes) and the temperature was lowered (70–80 °C). Treatment of recurrence then employed the standard parameters (90 °C/8 minutes). The recurrence rate of 9 % is at the lower end of the range described in the literature which extends up to 35 % [15]. In our study cohort there was one minor complication (post-interventional transient reactive effusion in the knee joint with juxta-articular osteoid osteoma in the tibia head) and no major complications such as nerve damage in the case of OO in the trunk skeleton. This concurs with the literature which describes a complication rate of between 0–2 % [16, 19–21]. It should be noted that due to the anatomical proximity to the spinal canal and nerve roots and the associated risk, some of the spine-associated cases of osteoid osteoma were not indicated for treatment with thermoablation in our center, but were treated with open surgery after prior identification. To minimize risk, monitoring such as derivation of somatosensory evoked potential (SSEP) or measuring cerebrospinal fluid (CSF) is possible during thermal ablation of osteoid osteoma in the spinal column [26–28]; this was not performed in these study patients, however.

Several studies have investigated the treatment of technically challenging located osteoid osteomas [6, 25–30]. We demonstrated that image-guided thermal ablation is also well-suited for atypically located OO and represents a safe procedure. RFA and laser ablation are equally effective at different costs [31]; selection of the type of therapy relies on the preferences and experience of the interventionalist. In the event of recurrence, repeated therapy is also effective and safe for atypical osteoid osteoma.

Patients accept therapy using RFA/LA well and rate it positively without exception. In our opinion, this very good result is due to the rapid pain relief after intervention and the subjectively low impairment of daily life with a very short hospital stay as well as few postoperative restrictions as also described by Gebauer et al. [15].

Important limitations of our study are the retrospective study design and the high variance in the follow-up time. Unfortunately, three patients for whom no clinical follow-up data were available could not be contacted by telephone. At first glance, the seemingly small number of 33 patients, 23 of whom took part in the interview, can certainly compete with the comparative literature (the majority of the studies summarized by Gebauer et al. deal with an average number of 28 patients); the relative rarity of atypically located osteoid osteoma compared to the typically located form of the disease is of additional importance.

KEY POINTS

Image-guided thermal ablation has become the standard procedure in the treatment of typical located osteoid osteoma. Atypical osteoid osteomas differ from typical forms not only in their localization, but also in their symptoms and disease progression, and thus represent a diagnostic and therapeutic challenge. We were able to show that minimally invasive thermal ablation can also be safely applied to atypically located osteoid osteomas and has a high success rate as well as excellent patient satisfaction.

Conflict of Interest

The authors declare that they have no conflict of interest.

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