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Myositis ossificans traumatica in young children: report of three cases and review of the literature

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Abstract Myositis ossificans traumatica (MOT) is a rare musculoskeletal disorder in young children. Clinical and imaging presentation in the early stage of disease makes it difficult to differentiate between infection and musculoskeletal neoplasms, particularly in the absence of a history of trauma. Three cases of MOT in children under the age of 10 years, two with inferential trauma, are presented and the findings on different imaging modalities are discussed with reference to the existing literature. While findings based on a single imaging technique, including MRI, may be rather non-specific and even misleading, the combination of different modalities can assist in the consideration of MOT as a possible diagnosis. For example, the demonstration of soft-tissue haematoma on US would suggest the traumatic origin. A rational imaging approach is proposed.

Introduction

Myositis ossificans (MO) comprises non-neoplastic heterotopic bone formation in skeletal muscle. Three types can be differentiated:

- Myositis ossificans progressiva (fibrodysplasia ossificans progressiva, FOP), a hereditary, ultimately lethal, severe generalised form that is unrelated to trauma.
- MO without a history of trauma, or non-traumatic MO, sometimes also referred to as pseudomalignant MO [1–7]. Included in this group is MO related to systemic conditions, such as paraplegia, poliomyelitis, burns and haemophilia [8–10].
- Myositis ossificans circumscripta or traumatica (MOT) that is related to either a severe direct blow or repeated minor trauma.

Comprising 60–75 % of cases, MOT represents the most common form of MO. While non-traumatic MO has been described in the literature, there exists debate as to whether unrecollected trauma is also present in these cases [8, 11, 12]. Although MO can be observed at any age, the highest incidence is in adolescents and young adults with around 50 % occurring in the third decade. Myositis ossificans, however, is extremely rare in children under the age of 10 years [3, 13–21]. One author states that less than 1 % of MO occurs in the first decade [22].

We report three cases of MOT in children under the age of 10 years. In two cases minor repeated trauma was not recollected as the underlying cause by the parents or the child itself in the first instance. Typical imaging features and a possible appropriate imaging approach in those cases are discussed.

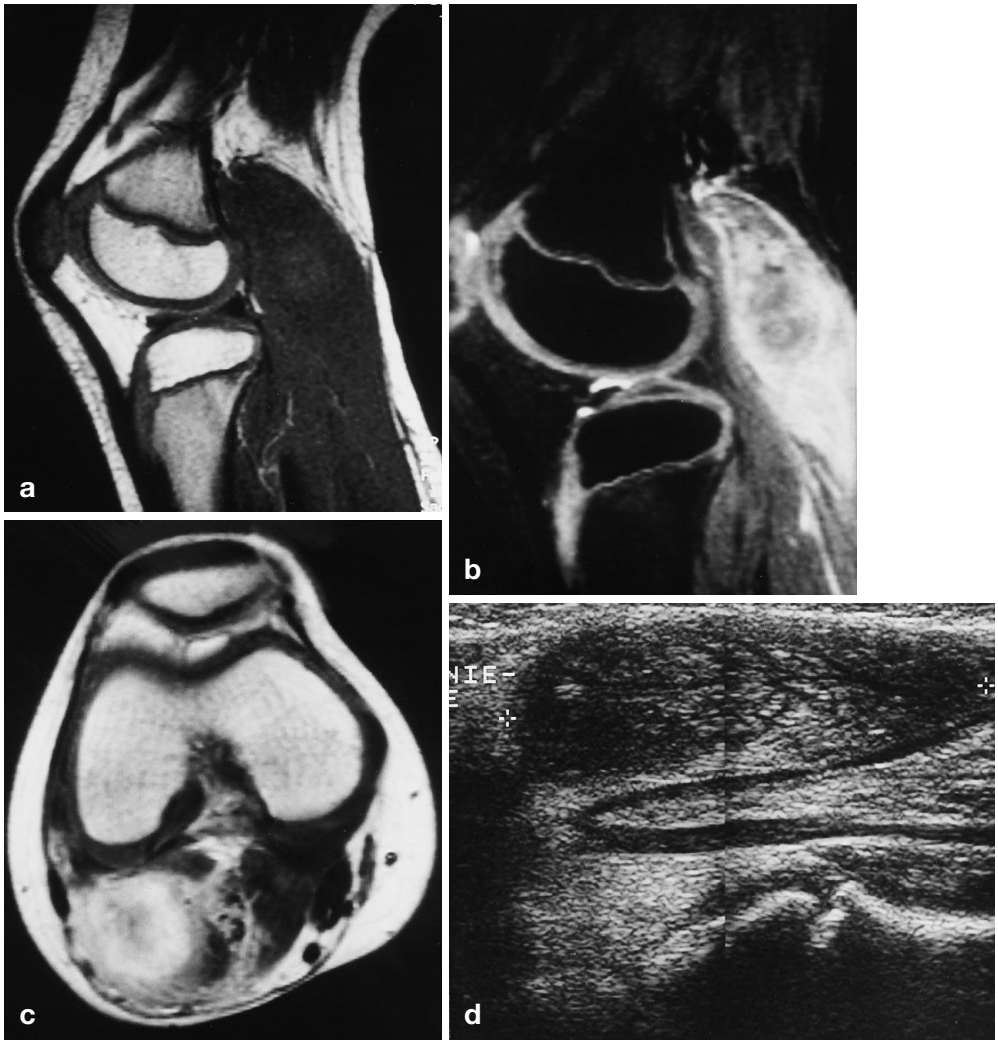

Fig. 1 a–d MOT of the right knee in a 71/2-year-old boy. **a** Sagittal T1-W SE MRI shows swelling of the lateral head of gastrocnemius and a central faintly hyperintense zone compared to muscle. **b** Sagittal T2-W FS GRE (T2*) MRI shows an inhomogeneous intermediate to high-intensity mass with perifocal muscle oedema. There are no cortical or bone marrow abnormalities. **c** Axial post-contrast T1-W SE MRI demonstrates a strongly enhancing soft-tissue lesion with a central hypointense area and diffuse enhancement of the surrounding muscle due to oedema. **d** Longitudinal US scan of the right popliteal fossa shows a well-circumscribed hypoechoic mass with focal calcifications

Case reports

Patient 1

A 71/2-year-old boy was referred to the Department of Paediatric Oncology of the University Children's Hospital because of a suspected malignant musculoskeletal tumour of the right knee.

History. Increasingly painful swelling at the posterior aspect of the right knee with restricted mobility for three weeks. There was no history of injury.

Physical examination. A rather firm swelling was palpable in the postero-lateral aspect of the knee. There were no visual signs of injury; no redness of the skin and no tenderness to palpation. There was restricted range of motion, predominantly reduced extension. Blood tests showed no evidence of inflammation.

MRI. T1-weighted (T1-W) spin-echo images showed the proximal portion of the lateral head of gastrocnemius to be thickened with a faint central area slightly hyperintense to surrounding muscle (Fig. 1 a). T2-weighted (T2-W) fat-suppressed (FS) gradient-echo images showed an inhomogeneous intermediate to high-signal-intensity lesion with no clear delineation from adjacent soft tissue (Fig. 1 b). Surrounding muscle oedema was indicated by diffuse high signal intensity on the T2-W gradient-echo images and diffuse contrast enhancement after Gd-DTPA administration. Post-contrast T1-W images showed marked enhancement of the lesion with some irregular non-enhancement of the central portion (Fig. 1 c). Bone marrow signal and cortical structures of adjacent bones were normal. There was no synovial thickening, internal knee derangement or significant joint effusion.

Radiographs. These showed a soft-tissue mass with small flocculent calcifications at the posterior aspect of the knee. There were incidental bilateral fibrous cortical defects.

US. This demonstrated a fairly well circumscribed hypoechoic mass with focal calcifications located within the lateral head of gastrocnemius muscle, well separated from underlying bone (Fig. 1 d). There were no cystic or necrotic changes. Surrounding muscles were normal and there was no joint effusion.

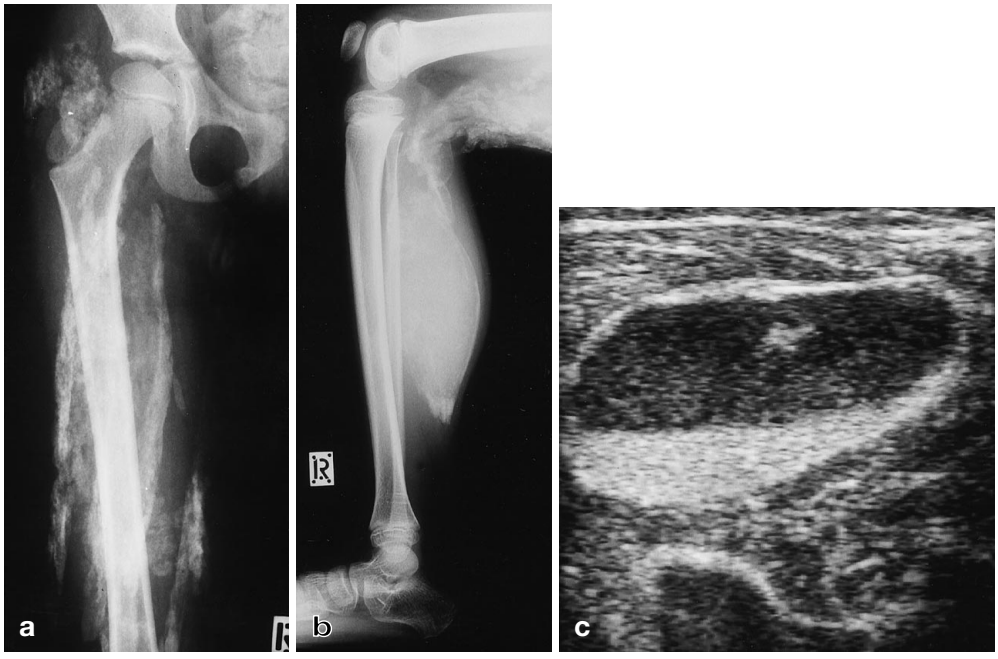

Fig. 2 a–c MOT of the right leg in a 61/2-year-old girl. **a** AP radiograph shows extensive ossification of the thigh muscles. There are no cortical abnormalities. **b** Lateral radiograph shows prominent ossification of the posterior and medial muscles of the distal thigh. There is a diffusely dense well-delineated mass in the calf in the position of the soleus muscle with ossification at the distal musculotendinous junction. Note separation of the ossification from adjacent bone. **c** Longitudinal US of the right calf shows a well-delineated mass with a fluid-fluid level within the soleus muscle

Comment. Because of pain and restricted range of motion, the mass was surgically removed.

Histology. Showed typical features of MO.

After repeated questioning the boy recalled that he had often slid down a pole, always with his right knee clasped around it.

Patient 2

A 61/2-year-old girl was referred to the University Children's Hospital with a tender swelling of the right calf.

History. The first episode of pain and limping occurred at 2 years of age. Since then, she had suffered recurrent painful swelling of right thigh and, for about 1 month, also of the right calf. There was no history of injury. No definite diagnosis or treatment had been proposed despite several visits to practitioners and different hospitals.

Physical examination. The right calf was swollen and painful to palpation and there was rigidity of the muscles of the right thigh. There were no external signs of injury or inflammation. There was restricted range of movement in the right foot. Blood tests were unremarkable.

Radiographs (6 months before admission). Showed extensive ossification in the thigh, oriented along the course of the muscle fibres (Fig. 2 a).

Whole-body bone scintigram (performed around the same time). Demonstrated isolated irregular radionuclide uptake at the right hip and thigh.

Radiographs (at the time of referral). Showed extensive soft-tissue ossification in the right thigh, ossification in the popliteal fossa and a partially calcified mass in the posterior aspect of the right calf (Fig. 2 b).

US (right calf). Demonstrated a large, well-delineated mass with a fluid-fluid level within the soleus muscle (Fig. 2 c). There was a small focal calcification at the distal tendinous junction. The lesion was separate from the subjacent bone and was considered to represent a subacute haematoma.

Follow-up. Seven weeks later the girl complained of a painful swelling in the medial aspect of the right thigh.

US. At this stage there was a well-defined, homogeneous hyperechoic mass within the adductor muscles of the right thigh, consistent with an acute haematoma. The lesion in the right calf had shown considerable reduction in size and now showed surrounding soft tissue calcification.

Comment. Because of the severity of the musculoskeletal changes FOP and battered child syndrome were initially considered in the differential diagnosis. The scintigraphic findings and absence of any typical physical abnormalities allowed these to be excluded and the changes were diagnosed as due to MO. It was noted that only the posterior and, to a lesser extent, the medial muscles of the right thigh and calf showed soft tissue calcifications. After repeated questioning, the father told that he had begun rather vigorous massage of the back of his daughter's right leg in the belief that it would relieve her pain.

Patient 3

An 81/2-year-old boy was referred to the Paediatric Department of Leverkusen Hospital with constant knee pain and swelling of the right foot for 2 weeks.

History. He had been kicked against the right calf when playing soccer 3 weeks previously and had later fallen on his right knee. Since that time he had experienced severe pain in the right knee and limping.

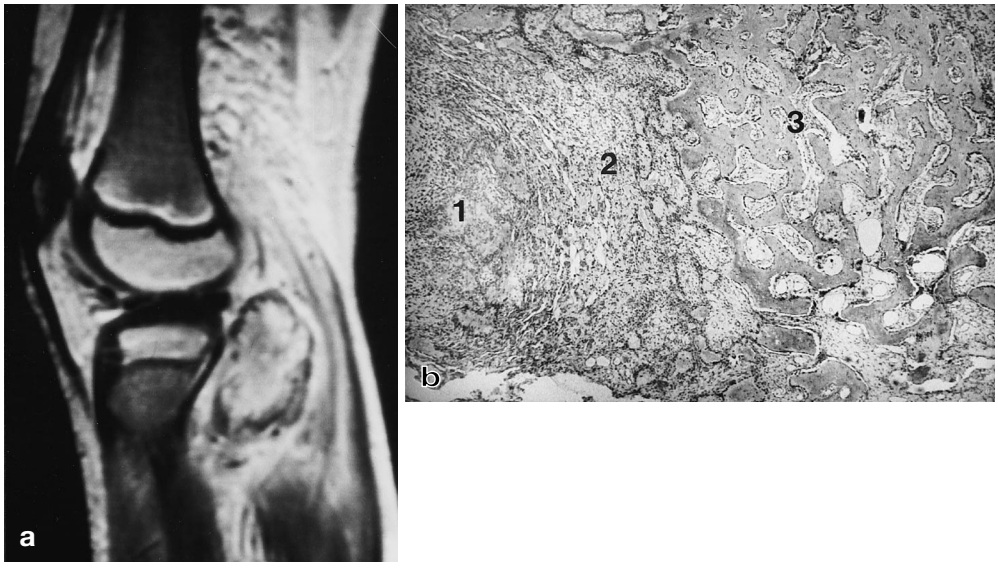

Fig. 3 a, b MOT of the right knee in an 81/2-year-old boy. **a** Sagittal T2-W GRE (T2*) MRI shows an inhomogeneous intermediate to high signal-intensity-lesion with a hypointense peripheral rim in the popliteal fossa. There is diffuse perifocal muscle oedema. **b** Photomicrograph of MO (original magnification × 10, H&E stain). [*1* Central proliferative fibroblastic cells, *2* islands of immature osteoid with osteoclast-like, multinucleated giant cells, *3* osteoid trabeculae rimmed by osteoblasts and bone (image courtesy of Rolf Jaussi, MD, Department of Pathology, Leverkusen Hospital)]

Physical examination. There were no external signs of injury or inflammation and joint mobility was normal. Diffuse tenderness to palpation in the popliteal fossa was noted. Apart from microcytic anaemia due to incidental heterozygous β-thalassaemia, laboratory tests were unremarkable.

Radiographs. These did not show any soft tissue or bone abnormalities.

US. A mass with some calcifications in the soft tissues posterior to the proximal tibia was thought to represent a partially calcified haematoma.

MRI. T1-W spin-echo images showed a lesion in the popliteal fossa medial to the lateral head of gastrocnemius which was isointense to muscle and had a somewhat irregular peripheral low-signal rim. T2-W gradient-echo images showed an inhomogeneous intermediate to high-signal-intensity lesion, again with a peripheral low-signal rim (Fig. 3 a). The lesion was well delineated from surrounding soft tissue and bone. There was moderate perifocal muscle oedema. Post-contrast T1-W images showed diffuse enhancement of the lesion and surrounding muscle. Bone-marrow signal was normal, as were cortical structures of the adjacent bones; there were no signs of internal derangement of the knee or significant joint effusion.

Comment. Based on the MRI findings, the possibility of a malignant tumour was proposed and the lesion was removed surgically.

Histology. This excluded a malignant tumour and revealed the typical features of MO (Fig. 3 b).

Discussion

Myositis ossificans is a benign heterotopic bone formation. First named myositis by Von Dusch in 1868, a number of different names exist for the disease, including localised MO, ossifying haematoma, extra-osseous localised non-neoplastic bone, myo-osteosis and MO circumscripta [11]. The most common locations for MO lesions to arise are the large muscle groups of the thigh (patient 2; patients 1 and 3 had lesions at a musculotendinous junction) and the upper arm, more often in the anterior than the posterior aspects of the limb, but they can occur at any other anatomical location and have been described at the neck, scapula, axillary region, hand, hip, chest and abdominal wall [11, 12, 18, 20, 22].

Although in the later stages of MO pain and swelling eventually diminish, in the early stage children will present with increasing pain and swelling that may alarm the doctor into suggesting soft-tissue infection or tumour. All three children in this report, while suffering from pain and swelling, did not have any fever. Also, there were no signs of inflammation in the blood tests, which is in accordance with most reports in the literature. Rarely, moderate laboratory signs of inflammation are present [5, 6, 20].

Only intensive interviews revealed repeated trauma in patients 1 and 2. The aetiology and circumstances that led to the first episode of right leg pain in patient 2, before parental intervention began, remain unclear. It can be assumed that the single direct blow to the knee had been the causative event for MO in patient 3. Absence of a history of trauma does not necessarily exclude the presence of MOT since often, particularly in small children, trauma may have been forgotten and is not recollected unless asked for explicitly. This is also supported by the fact that no differences with regard to clinical and imaging presentation as well as histopathological changes exist between traumatic and non-traumatic MO, and hence both forms are included in the general category of MO [2, 8, 13].

Nevertheless, the absence of a history of trauma initially can be misleading and prevent the inclusion of MOT into the differential diagnosis. This is well demonstrated by the alternative terms 'pseudomalignant MO' or 'tumour of soft tissue' also used for these lesions in the literature [11]. Accordingly, patient 1 was referred to hospital with the suspected diagnosis of a malignant musculoskeletal tumour, solely based on the MRI findings and absence of a history of trauma.

To understand the imaging features of MO it is important to know the underlying histology and its evolution. While the exact pathogenesis is still uncertain, these histological changes have been well described and vary according to the stage of evolution. Contrary to the name, MO is not an inflammatory process but a proliferative mesenchymal response to a sufficient initiating injury to the soft tissue, not necessarily a muscle, eventually leading to localised ossification [23].

In the first few days there are richly vascularised proliferative fibroblastic cells. These primitive mesenchymal cells with prominent mitotic activity can mimic fibro- or myosarcoma on biopsy (the early pseudosarcomatous phase). With maturation of the lesion, which is variable, a typical zonal pattern develops with three distinct zones: the centre consists of rapidly proliferating fibroblasts with areas of haemorrhage and necrotic muscles; the intermediate or middle zone is characterised by osteoblasts with immature osteoid formation. Enchondral ossification with islands of cartilage preceding bone formation may occur. The peripheral or outer zone is composed of mature bone, frequently well separated from surrounding tissue by myxoid fibrous tissue.

Peripheral bone formation begins usually at 6–8 weeks, but can occur earlier. In the late phase, at 5–6 months, the lesion can completely ossify with formation of a cortex and marrow spaces [13]. With maturation, the lesion classically regresses in size, and in about 30 % of cases may eventually resolve spontaneously [4, 5, 24]. If biopsy is performed due to doubts about the differential diagnosis, it is important to be aware of the sometimes misleading histological picture which resembles a malignant lesion in early MO, or if the biopsy specimen has been sampled only from the lesion's centre and does not show the typical zonal pattern.

In general, MRI findings in MO are rather nonspecific. Only in the later stages will imaging findings be present which suggest MO. Some authors stress the importance of a low-signal-intensity rim on T1-W and T2-W images as a common finding that reflects the beginning of peripheral ossification [25–27]. This feature could be observed on the MRI in patient 3, but was not present in patient 1, although the histological finding of early peripheral formation of lamellar bone on histology (Fig. 3 b) in both cases suggests that a low-signal-intensity rim was imminent. This is likely explained by the rather unreliable detection of sometimes even large calcifications and ossifications with MRI that can be easily detected with CT. In addition, it should be noted that well-defined margins with low-signal-intensity border, although usually attributed to benign lesions, also occur in malignant soft tissue tumours (the pseudocapsule in liposarcoma) [28].

It has been stressed that in the early stages MO lesions share many features commonly found in malignant musculoskeletal tumours [25–27]. These are inhomogeneous signal changes on T2-W images, likely due to the lesion's structure that is composed, to a variable degree, of different tissues including cellular, bony and cartilaginous components. Similar signal inhomogeneity on T2-W images is commonly attributed to malignant musculoskeletal tumours. Although the uniformity of signal intensities on T1-W and T2-W images can help to differentiate benign from malignant lesions, this criteria is neither accurate nor specific [28, 29]. Also, early MOT lesions demonstrate indistinct margins and are commonly accompanied by oedema of surrounding tissues like musculoskeletal neoplasms and inflammatory processes (Fig. 1 b). In children with musculoskeletal tumours, peritumoural oedema has been reported to be present around both benign and malignant lesions in equal incidence [30].

Although no cortical or bone marrow abnormalities were present in patients 1 and 3 (Figs. 1a–c, 3 a), there have been reports of MOT showing signal abnormalities in adjacent bony structures; these may be encountered more often with the use of fat-suppressing or STIR techniques [31, 32]. Whether these changes reflect reactive response, underlying inflammatory changes or simply bone contusion due to antecedent trauma remains speculative. However, extensive muscle oedema without bone marrow and cortical abnormalities are considered rather uncommon in neoplasms and infection, and their absence may aid in the differentiation of MO from infection or tumour [33].

The use of Gadolinium-DTPA does not facilitate the diagnosis. While De Smet et al. [25] and Ehara et al. [33] did not comment on the pattern of MO lesions on contrast-enhanced images, Cvitanic and Svedlak [34] and Shirkoda et al. [27] presented cases of early MO that showed rim-like enhancement after Gd-DTPA, making early abscess formation or necrotic tumour still possible [27, 34]. The MOT lesion in patient 1 showed more diffuse enhancement on T1-W post-contrast images, with a central non-enhancing area likely corresponding to small haemorrhagic parts and central osteoid formation as demonstrated by the histological findings (Fig. 1 c). In contrast, the lesion in patient 3 showed only diffuse enhancement, again demonstrating the variability and nonspecifity of MRI findings in MO lesions that, from a histopathological point of view, were at the same stage of evolution. It should be noted

that on precontrast T1-W images early to intermediate stage MO lesions may be invisible and only give evidence of a mass by muscle enlargement or displacement of fat planes, as can be observed in patient 1 (Fig. 1 a).

Ultrasound is the cross-sectional imaging method of choice to evaluate soft-tissue lesions in children. Ultrasound findings of MO lesions reported in the literature include a hypoechoic ovoid mass with a central reflective core, and even a so-called zone phenomenon matching the evolution and maturation process has been described [35, 36]. In the latter study, the early lesion had a thin hypoechoic zone enclosing a broader highly reflective zone that again surrounded a third central hypoechoic zone. With maturation, the peripheral rim became more reflective due to increasing ossification [36]. The MO lesions in patients 1 and 3 did not demonstrate any zonal pattern, but each presented as a well-circumscribed, homogeneous hypoechoic mass with scattered calcifications (Fig. 1 d). These calcifications and more centrally located calcifications are not specific and may also be associated with a malignant musculoskeletal tumour. In patient 3, the lesion was interpreted as an old haematoma. The typical pattern of calcification that is very suggestive for MO includes peripheral rim-like calcification. Sheet-like calcifications have also been described and proposed as a specific sonographic sign of early MO [37, 38].

The ability of US to detect the separation of the MO lesion from the adjacent cortex is well demonstrated by patient 1. With maturation, however, this becomes difficult because of acoustic shadowing, as in patient 2 [35, 39, 40]. In addition to the severe ossifications in patient 2, US revealed a well-defined lesion with a fluid-fluid level that, in the context of this particular patient, was considered to be a subacute haematoma. However, as an isolated finding it would have been nonspecific because soft tissue tumours may also show fluid-fluid levels (Fig. 2 c) [41]. At examination 7 weeks later, a homogeneous hyperechoic mass in the medial thigh was found on US and considered to be an acute haematoma.

We do not propose that haematoma is the primary focus of bone formation since histological examinations by Curran and Collins [42] have failed to establish haematoma as the initial lesion in heterotopic bone formation. However, against this view is the observation of MO in haemophiliacs and patients with minor clotting deficiencies since previous haemorrhage or haematoma could be presumed to precede the development of MO in these patients [9, 10]. Even calcification of damaged muscle fibres is thought to be a transient phenomenon and unrelated to subsequent bone formation. It is assumed that connective tissue rich in acid mucopolysaccharides is predominantly involved in heterotopic bone formation.

While the isolated finding of a haematoma in patient 2 would have been nonspecific, based on the previous findings it ultimately led to establish trauma as the underlying cause of the observed soft-tissue changes and obviated the need for other diagnostic tests.

Conventional radiography is crucial for the differentiation of MO from musculoskeletal neoplasms. Osteosarcoma, with its parosteal and extra-osseous variants (the latter showing higher age incidence) is most important to differentiate from MO. The pattern of ossification is helpful in the differential diagnosis, with osteosarcomas showing more dense ossification in the central areas while in MO there is a central radiolucent zone and the most dense ossification is at the periphery [8]. However, this latter pattern can be absent in atypical cases and can only be observed in mature lesions around the 6th week of evolution. It has been reported that maturation and consequent ossification is more rapid in children than in adults, and this would allow for a conservative approach by observing the typical maturation of a soft-tissue lesion suspected of being MO on conventional radiographs [18]. The initial plain radiograph in patient 1 revealed a soft-tissue mass with some nonspecific flocculent calcifications. This has been called the 'dotted veil' pattern and can usually be seen between 2 and 4 weeks after the onset of symptoms as the osteoid becomes calcified [13, 43]. Synovial sarcoma still has to be considered, since about 30 % calcify [7, 12]. Similar calcifications can be observed in rhabdomyosarcoma [20]. Another soft tissue lesion that needs to be differentiated is malignant fibrous histiocytoma since it may exhibit an osteocartilaginous component similar to MO [18].

In patient 2, the characteristic pattern of ossification following the course of the muscle fibres, as well as location solely in the posterior aspect of the right leg (best appreciated on the lateral view) was diagnostic of MOT (Fig. 2 a, b). It has to be noted that patient 2 is somewhat exceptional in that the calcifications affected the whole of the right lower extremity. This is likely explained by the continuous massage admitted by the girl's father. In this regard it is important to know that passive exercises as well as massage are considered to increase the extent of ossification in early MO due to further muscle injury, worsening symptoms in the acute phase and hence should be strictly avoided [11, 21, 44].

Although rare, periosteal reaction may be present in MO, depending on the location of injury and topographic development of the lesion [18]. Gilmer and Anderson [23] have classified MO according to its anatomical location into three types. The three patients reported here fall into the extra-osseous group of MO that arises within the muscle and is not in continuity with adjacent bone. The other two types include parosteal MO evolving in the immediate vicinity or against a bone and periosteal lesions, thought to result from an injury to the cambium [12, 23]. Periosteal reactions that may even simulate the so-called sunburst appearance typically

seen in malignant osseous sarcoma can also be observed in periosteal MO, also referred to as ossifying subperiosteal haematoma or periostoma and parosteal MO [23]. Neither cortical bone destruction nor periosteal reaction could be observed on the initial plain radiographs of the knee in either of the presented patients and made the diagnosis of osteosarcoma or Ewing's sarcoma unlikely.

Bone scintigraphy, usually performed with ^{99m}Tc-diphosphonate, is very sensitive in the early detection of MO, demonstrating increased uptake in damaged muscle, as seen in patient 2, but is not specific. Musculoskeletal tumours and osteomyelitis cannot be excluded since similar nuclide uptake on three-phase bone scans is present in early MO [11, 45]. When FOP or battered-child syndrome are suspected or have to be excluded, bone scans are helpful to evaluate and detect multiple lesions and their approximate location. In patient 2, scintigraphy showed localised uptake in the right thigh when performed the first time.

CT probably best demonstrates the zonal pattern in MO by showing low attenuation of the central core and peripheral calcification more clearly than does conventional radiography. Due to its high sensitivity for the detection of calcification, CT allows the peripheral rim of ossification in MO to be visualised within 2 weeks of evolution and decisively earlier than any other imaging modality. With regard to the histopathological finding of early peripheral ossification in patients 1 and 3, this feature of MO most likely would have been detected if CT had been performed. CT also best demonstrates the thin lucent stripe separating MO from adjacent bone. When MO is suspected, a limited number of CT slices through the area of interest can help to establish the diagnosis [45–47]. In patients 1 and 3, CT was not performed because the painful restriction of motion due to the juxta-articular location of the MOT lesions prompted surgical intervention in any case.

Angiography may differentiate MO from various sarcomas by the presence or absence of arteriovenous shunting, venous lakes or amputated vessels, but cannot differentiate MO from hypovascular periosteal sarcoma. It has the disadvantage of invasiveness, radiation and cost [48].

Depending on anatomical location, therapy of MO is usually conservative because of its benign character. In the case of juxta-articular MO, however, painful restricted motion often necessitates surgical removal of the lesion in order to restore function, as in patients 1 and 3. A similar case has been described in the literature [20]. Under these circumstances, rapid intervention is warranted, and it is unrealistic to wait for the lesion to mature, a policy that has been recommended to avoid the risk of recurrence. Describing their experience of removal of early MO lesions in the fingers, Nuovo et al. [18] reported no increased risk of recurrence. In our two reported cases with MOT lesions at the knee, no recurrence has been observed on follow-up.

If left unresected, MO lesions, particularly with periosteal adherence, may result in osteochondromas, with two cases being reported by Nuovo et al. [18] One case report describes the complication of MO by a secondary aneurysmal bone cyst [49]. The possibility of secondary malignancy in MO is controversial because the reported cases either lack histological verification of antecedent MO, occurred in FOP, or developed years after radiation exposure. In one case of dermatomyositis, osteosarcoma developed in a soft-tissue ossification after 30 years, and in another case, extra-osseous osteosarcoma developed 2 years after MOT in the back [18].

Conclusion

Myositis ossificans is a rare condition in children, but has to be considered alongside infection and musculoskeletal neoplasm in the differential diagnosis when a child presents with a tender soft-tissue swelling. Trauma is the main cause for MO in children, and its documentation an important clue to the diagnosis. Inferential trauma may often not be remembered due to its minor character and should be addressed explicitly.

Although imaging characteristics suggestive for MO exist, these features need to evolve with successive maturation of the lesion and development of the characteristic zonal pattern before they become diagnostic. The sensitivity of the chosen imaging technique is determined by the stage of evolution at which it is used to identify the specific features, e. g. the peripheral rim of ossification. Difficulties in the differential diagnosis arise with early MO lesions since imaging findings on conventional radiography, US and MRI are often nonspecific. The combination of different imaging techniques can facilitate the diagnosis. One should be particularly cautious in using MRI since imaging findings may be more confusing than diagnostic. Therefore, in a child suffering from a soft-tissue swelling suspicious of MO, a possible diagnostic imaging approach could be as follows:

- US may detect calcifications at an early point in time and, additionally, when haematoma is demonstrated can give evidence of trauma as the possible cause.
- Conventional radiographs in two planes should be taken to evaluate the pattern of calcification, if already visible, and to demonstrate or exclude bone involvement.
- Bone scintigraphy is suitable to differentiate uni- from multifocal lesions and exclude FOP and bat-

tered child syndrome. Differentiation between MO and osteomyelitis is not possible in the early stages.
- CT best and earliest demonstrates the typical pattern of ossification in selected cases where MO is suspected and can confirm the diagnosis.
- MRI should be performed only if the above imaging techniques have failed to establish the diagnosis of MO and a neoplasm is still suspected. It is used to evaluate the presence and extent of soft-tissue and bone-marrow changes.

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