



Original article

Intra-medullary osteosclerosis of the tibia in children

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ABSTRACT

Background: Intra-medullary osteosclerosis of the tibia is a rare condition characterised by chronic pain due to diaphyseal hyperostosis with no detectable triggering factor. The main differential diagnoses are stress fracture and osteoid osteoma. Of the few cases reported to date, most were in adults. The objective of this study was to assess paediatric patients with intra-medullary osteosclerosis to determine whether the first visit provides sufficient information to establish the diagnosis and rule out both osteoid osteoma and stress fracture, whether a biopsy is required, and which treatment is optimal.

Hypothesis: The diagnosis of intra-medullary osteosclerosis of the tibia can be made at the first visit.

Patients and methods: Seven paediatric patients, 4 males and 3 females, with a mean age of 11 years, were included in this retrospective study. We evaluated the clinical features, findings from imaging studies (standard radiographs, computed tomography, magnetic resonance imaging, and bone scintigraphy), and treatment outcomes.

Results: At the first visit, all patients had a painful swelling at the middle of the shin and imaging study evidence of antero-lateral tibial cortical thickening extending into the medullary cavity; in 5 patients, a linear lucency was visible. No other bone abnormalities were seen. Treatments included non-operative measures, pinning, and nailing. None of these treatments provided permanent bone healing or pain relief, although transitory freedom from pain with or without radiological bone healing was achieved.

Discussion: Intra-medullary osteosclerosis of the tibia is rarely reported and therefore probably underdiagnosed. Distinctive characteristics of the cortical and endosteal thickening include location at the antero-lateral mid-diaphysis and, in some cases, the concomitant presence of a linear lucency that can provide the early diagnosis. The distinctive radiological features allow differentiation from a stress fracture. The management is challenging.

Level of evidence: IV, retrospective observational study.

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1. Introduction

Intra-medullary osteosclerosis is a rare condition first described by Abdul-Karim et al. in 1988 [1] and characterised by cortical thickening at the mid-third of one or both tibial shafts, with pain at the same level. Onset can occur at any age. No genetic, infectious, traumatic, or systemic cause has been identified, and neither is the disease associated with any laboratory test abnormalities. A 2001 report by Chanchairujira et al. details the imaging study results in

9 patients [2], and reports by Avinash et al. in 1999 and Rosenberg et al. in 2008 each describe a single adult with bilateral tibial involvement [3,4]. Only 2 paediatric cases have been published [1,2]. Osteoid osteoma and stress fracture are the main differential diagnoses, exhibiting similarities that may result in initial diagnostic wanderings. To our knowledge, no publications reporting the management of intra-medullary osteosclerosis are available.

Here, we report a multicentre retrospective observational study of 7 paediatric patients with intra-medullary osteosclerosis of the tibial shaft. The objective of this study was to assess paediatric patients with intra-medullary osteosclerosis to determine whether the first visit provides sufficient information to establish the diagnosis and rule out both osteoid osteoma and stress fracture,

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Table 1
Main clinical features of the 7 patients.

Patient #	Age at first visit, years	Time to visit, months	Follow-up, years	Sex	Side	History	Location of pain
1	9.9	36	0	F	R		Antero-lateral
2	5.8	1	8	M	R	Brother with CP of the tibia in a brother	Antero-lateral
3	4.3	3	7	M	R		Antero-lateral
4	13.8	7	0.5	M	L		Antero-lateral
5	13	7	0.5	F	R		Antero-lateral
6	12.7	1	8	F	R	Periosteal graft harvested	Antero-lateral
7	14.5	1	0.5	M	R	Periosteal graft harvested	Antero-lateral
Mean	10.6	8	3.5				
Minimum	4.3	1	0				
Maximum	14.5	36	8				
SD	4.1	12.6	3.9				

F: female; M: male; R: right; L: left; CP: congenital pseudarthrosis.

Table 2
Imaging study findings.

Patient #	Plain radiographs					CT (6/7 patients)			MRI (4/7 patients)		Scintigraphy (2/7 patients)	
	Sclerosis					Linear lucency	Intra-medullary sclerosis	Linear lucency	Nidus	Transverse lucency	Nidus	High uptake
	Cortical	Intra-medullary	Location ^a (%)	Extent (%)								
1	Anterior	Lateral	55.6	16.7	None	Yes	No	No	ND	ND	ND	
2	Anterior	Lateral	52.3	20.4	Antero-lateral	ND	ND	ND	Yes	No	ND	
3	Anterior	Lateral	47.9	26.3	Anterior	Yes	Yes	Yes	ND	ND	ND	
4	Anterior	Lateral	51.9	21.2	Anterior	Yes	Yes	Yes	Yes	No	ND	
5	Anterior	Lateral	55.6	41.1	Anterior	Yes	Yes	Yes	Yes	Yes	Yes	
6	Anterior	Lateral	56.5	33.5	Antero-lateral	Yes	Yes	No	Yes	No	Yes	
7	Anterior	None	53.4	38.8	None	Yes	No	No	ND	ND	ND	
Mean	53.3	28.3										
Minimum	47.9	16.7										
Maximum	56.5	41.1										
SD	3.0	9.6										

T: computed tomography; MRI: magnetic resonance imaging.

^a Reported as the percentage of tibial length involved; tibial length was measured starting at the proximal physis.

whether a biopsy is required, and which treatment is optimal. The working hypothesis was that the diagnosis of intra-medullary osteosclerosis of the tibia can be made at the first visit.

2. Material and methods

2.1. Patients

We retrospectively identified 7 paediatric patients seen between 1993 and 2016 at any of four university hospitals (in Montpellier, Toulouse, Saint-Etienne, and Nancy; France) for shin pain with osteosclerosis and an unfavourable and unusual outcome after non-surgical orthopaedic treatment. Table 1 lists the main patient characteristics. Age at the first orthopaedic department visit ranged from 4.3 to 14.5 years.

In 2 patients, a periosteal graft had been harvested from the antero-medial tibia at 4 months of age for the surgical repair of complete orofacial clefts extending to the nose; donor-site pain had then developed after 12.4 and 14.1 years, respectively. None of the patients engaged in repetitive physical activities or in competitive sports, and none had a body mass index above the normal range. No skin abnormalities or dysmorphic features suggesting a syndromic disease were present in any of the patients.

All 7 patients had moderate mechanical pain at the middle of the shin. Pain onset was not preceded by a trauma or recent increase in the level of physical activity. A swelling was visible on the shin

at the site of the pain. None of the patients had pain at night or at rest.

2.2. Methods

Table 2 lists the imaging study findings, including the presence of open physes, the presence and location of a transverse linear lucency, the extent of the osteosclerosis, and whether the soft tissues were involved. Imaging studies consisted of standard radiographs ($n=7$), computed tomography (CT; $n=6$), magnetic resonance imaging (MRI; $n=4$), and Tc99m bone scintigraphy ($n=2$). No routine laboratory tests were performed, as none of the patients had any evidence of systemic or malignant disease.

The standard radiographs obtained during the first visit and the subsequent CT scans showed open physes, thickening of the anterior tibial cortex at the site of the pain, and endosteal hyperostosis partially occluding the lateral medullary cavity (Figs. 1 and 2). An antero-lateral linear lucency was visible in 5 patients (Fig. 3). The lateral radiographs showed that the osteosclerosis was confined to the mid-shaft, extending along about one-third of the tibia. The hyperostosis was consistently visible by standard radiography and/or CT. In 3 patients, CT visualised an image consistent with a nidus, suggesting an osteoid osteoma (Fig. 4). All MRIs disclosed an image consistent with a stress fracture grade IV in the Fredericson classification [5] (Fig. 5). No patient had soft-tissue oedema. An image suggesting a nidus was seen by MRI in 1 of the 3 patients



Fig. 1. Patient #6: standard antero-posterior (A) and lateral (B) radiographs taken at the first visit (1) and at last follow-up 8 years later (2). Antero-lateral cortical thickening with and without a transverse linear lucency in the middle of the tibial shaft.

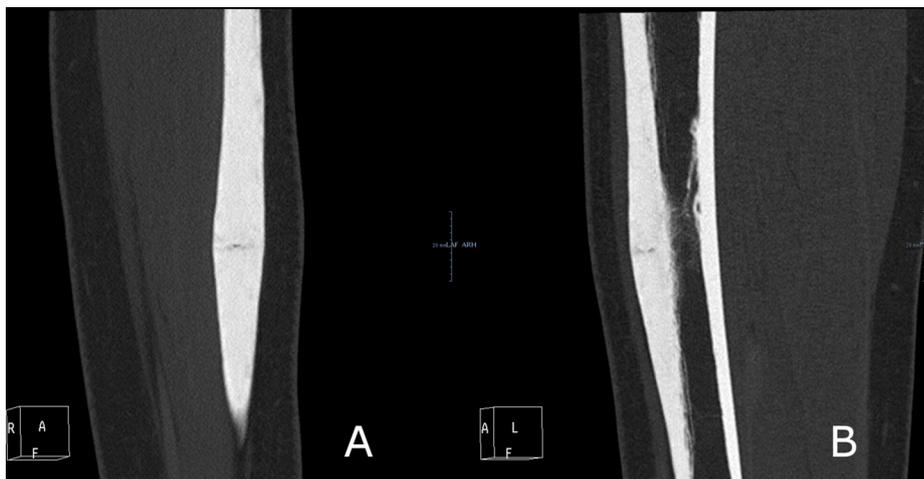


Fig. 2. Patient #6: computed tomography, bony window, coronal (A) and sagittal (B) views showing an antero-lateral linear lucency within a focus of cortical thickening.

with nidus-like images by CT; in this patient, the image was not visible during a CT-guided biopsy, and the histological findings were not in favour of an osteoid osteoma or fracture callus. Tc99m bone scintigraphy, performed in 2 patients, showed focal high uptake in the tibia at the site of the pain at the delayed phase, with no increase in uptake at the early phase. In addition, the entire affected tibia showed a slight increase in uptake. The contralateral tibia was normal in both patients.

All 7 patients were managed non-operatively by the elimination of weight-bearing alone or with a plaster boot for 4 weeks. During treatment, 1 patient was lost to follow-up. Permanent pain relief and resolution of the linear lucency was not achieved in any of the patients.

Patients #2 and #3 experienced pain relief for 1 year and 2 years, respectively, after which repeating the non-operative treatment was again effective in relieving the pain. However, 6 years 9 months

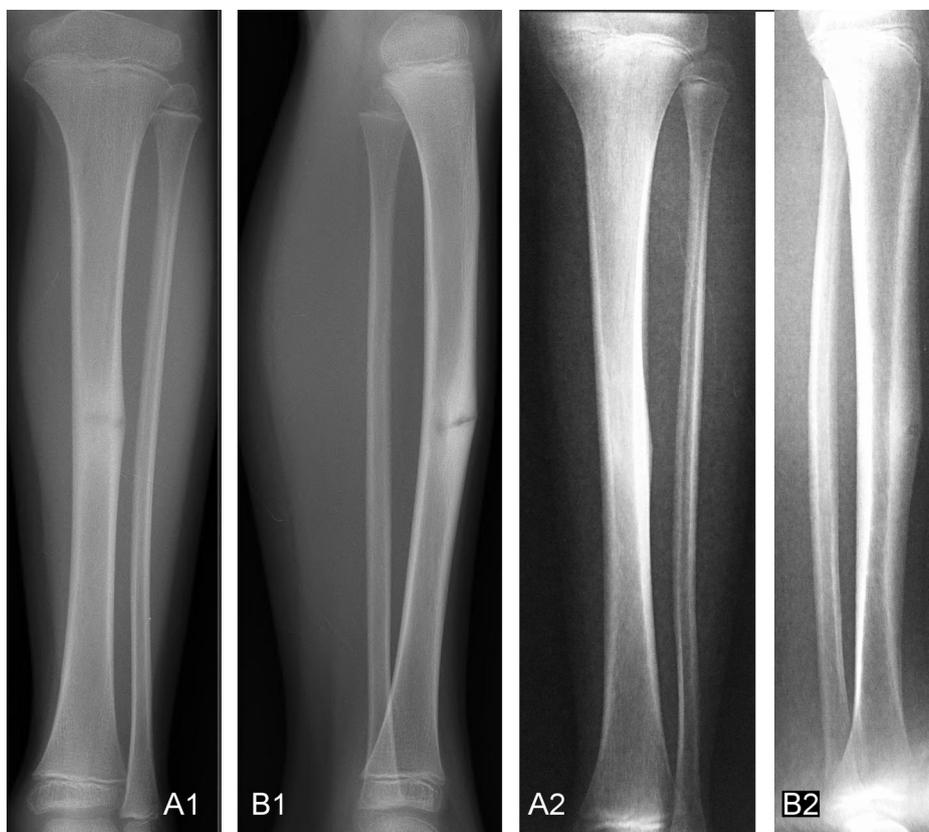


Fig. 3. Patients #2 (1) and #4 (2): standard antero-posterior (A) and lateral (B) radiographs taken at the first visit showing antero-lateral cortical thickening and a transverse linear lucency in the middle of the tibial shaft.



Fig. 4. Patient #4: computed tomography, sagittal views showing a nidus-like image suggestive of an osteoid osteoma, as well as thickening of the anterior cortex.

and 6 years after the initial treatment, respectively, at a time when the radiological abnormalities had improved, a bicortical fracture occurred at the site of the initial abnormalities; one patient then experienced persistent pain despite radiological healing of the fracture and the other was pain-free with a persistent linear lucency. In 2 patients the pain persisted after radiofrequency treatment for suspected osteoid osteoma. Elastic stable intra-medullary pinning used in another patient 1 year after the initial management was followed by pain relief and radiological bone healing; removal of the pin 1 year later was followed by the recurrence of the pain, which was alleviated by repeat pinning but recurred 2 years later. Finally intra-medullary nailing failed to relieve the pain despite radiological evidence of bone healing.

3. Results

None of the 7 patients had the diagnosis established during their first visit. The standard radiographs were initially deemed suggestive of a stress fracture in all patients. Additional investigations were performed subsequently because the pain persisted despite non-operative treatment and neither repetitive micro-trauma nor a recent increase in physical activities were noted. The initial standard radiographs consistently showed anterior cortical osteosclerosis confined to the middle third of the length of the tibial shaft. Lateral osteosclerosis was also visible in 6 patients. An anterior or antero-lateral linear lucency was visible within the cortical osteosclerosis in 5 patients. Consequently, the diagnosis of intra-medullary osteosclerosis of the tibia could have been established at the first visit in 5 of the 7 patients.

The antero-lateral and mid-diaphyseal location of the clinical and radiographic abnormalities was not consistent with a stress fracture. Other arguments against a diagnosis of stress fracture

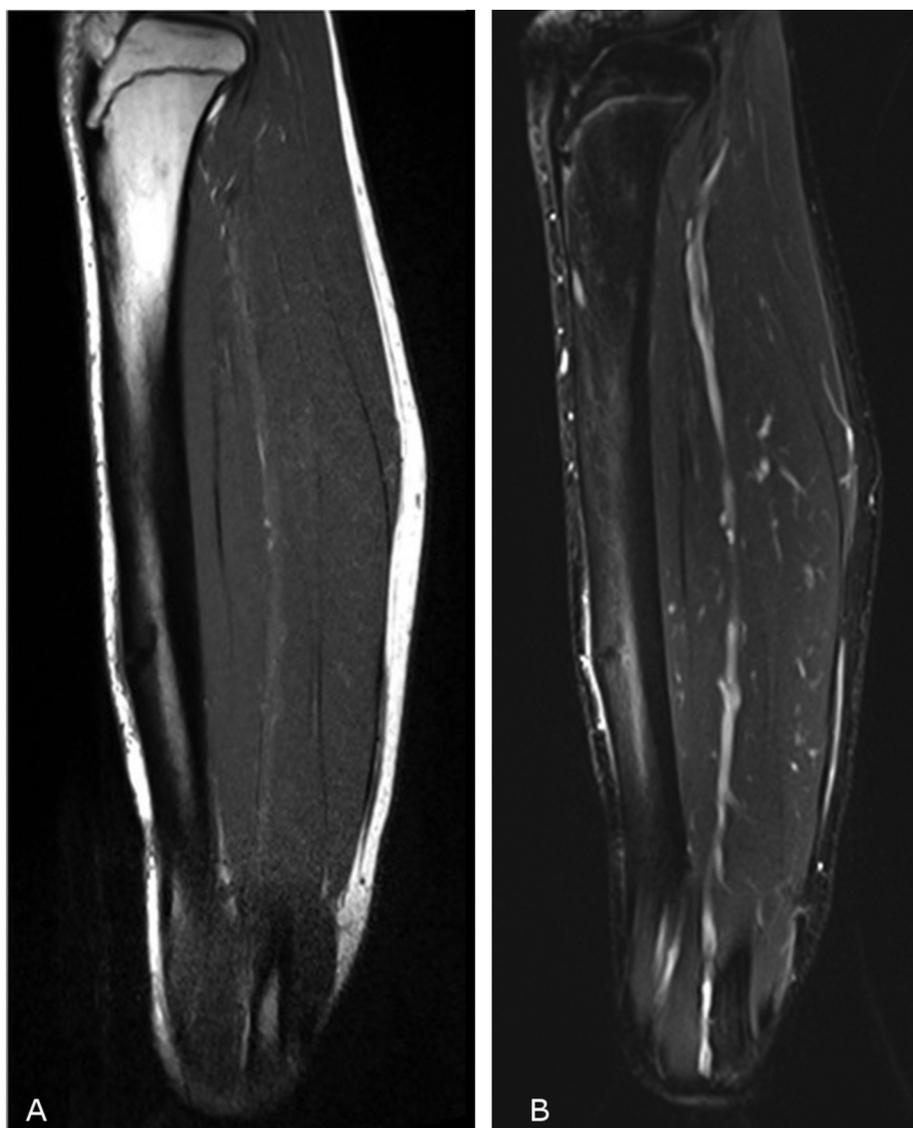


Fig. 5. Patient #5: magnetic resonance imaging, sagittal views, T1-weighted sequence (A) and T1-weighted sequence with fat saturation and gadolinium injection (B) showing a transverse linear lucency with no soft-tissue abnormalities.

included failure of the non-operative treatment used in all patients and the outcome after a mean follow-up of 3.5 years.

Osteoid osteoma was suspected despite the absence of inflammatory pain, based on the slice-imaging findings in 3 patients. In 1 of these patients, the image suggesting a nidus was not seen during CT done to guide radiofrequency treatment. The CT scan did not visualise the characteristic feeding vessel, and neither was there any evidence of increased vascularity by MRI [6,7]. Radiofrequency treatment was applied in 2 patients, neither of whom experienced any clinical improvements. The remaining patient experienced a bicortical fracture after 6 years but never had any symptoms consistent with osteoid osteoma; although the fracture healed with non-operative treatment, the pain persisted. A biopsy was collected from 1 patient during radiofrequency treatment. The histological findings were not consistent with osteoid osteoma or a fracture callus. Slight bone tissue remodelling was noted (“lamellar bone tissue with no congestive lesions; medullary tissue between the trabeculae, containing a few lymphocytes but no neutrophils”).

Thus, none of the treatments used (immobilisation and elimination of weight-bearing, intra-medullary nailing, or intra-medullary pinning) provided permanent pain relief or ensured the resolution of the antero-lateral linear lucencies.

4. Discussion

We report 7 paediatric cases of intra-medullary osteosclerosis of the tibia, whose diagnosis was confirmed by the mid- and long-term course of the manifestations. The radiological findings could have provided the diagnosis at the first visit in 5 patients, confirming our working hypothesis. The typical finding was cortical thickening of the tibia confined to the antero-lateral part of the mid-shaft and extending along one-third of the length of the tibia. Osteoid osteoma and stress fracture are the two main differential diagnoses [8].

Stress fractures occur after strenuous physical activities and heal after elimination of weight-bearing or cast immobilisation for a few weeks [9,10]. These fractures are caused by repeated episodes of bone overloading [11]. None of our patients engaged in repetitive physical activities or sports competitions, and none had had a recent increase in physical activity. The non-operative treatment failed. In a study by Devas of 43 children with stress fractures, the lesions were located postero-laterally and in the proximal third of the tibia, whereas the abnormalities in our patients were antero-medial and located in the middle third [12]. Other studies confirm the postero-medial proximal location of stress fractures [13–15].

Osteoid osteoma is a benign bone tumour that chiefly affects children and young adults and usually arises in the diaphysis of long bones. The pain typically has an inflammatory time pattern. Imaging studies show focal hyperostosis and a nidus smaller than 20 mm in diameter [16]. Both CT and MRI visualise an abundant vascular supply to the nidus, often with a visible feeding vessel, a sign not seen in our patients [6,7]. Furthermore, the pain did not have an inflammatory time pattern in any of our patients. Radiofrequency ablation has been proven effective for treating osteoid osteoma in paediatric studies but failed in our patients [17].

Whether a biopsy is indicated deserves discussion. Based on a study of 3 patients with stress fractures, Waisman et al. concluded that a healing lesion consistent with a stress fracture requires a biopsy only if the radiological findings remain unchanged after several weeks [18]. The biopsy performed in 1 of our patients failed to establish a diagnosis. We believe that a biopsy is not warranted in patients who have a linear lucency within a focus of antero-lateral cortical hyperostosis with no evidence of a nidus or malignant tumour.

The management of intra-medullary osteosclerosis is not described in the literature. Green et al. reported 6 cases of non-union in patients diagnosed with stress fractures of the middle third of the tibia [19]. These patients had antero-lateral cortical and intra-medullary hyperostosis of the middle third of the tibial shaft with an antero-lateral linear lucency, similar to the findings in our patients. Non-operative treatment failed to ensure healing, and excision with bone grafting was required. Several other cases of non-union of tibial shaft lesions diagnosed as stress fractures have been reported [20–22]. Mabit et al. and Rettig et al. reported 2 similar cases in which excision and grafting was successful after failure of non-operative treatment and electromagnetic stimulation [21,22]. Excision with autologous bone grafting was not performed in any of our patients. Neither non-operative treatment nor intra-medullary nailing or pinning ensured a full recovery, although these methods provided pain relief for several months to several years.

A limitation of this retrospective study is the small sample size, which is ascribable to the low incidence of the condition and wide variations in follow-up and management. However, the radiological abnormalities were identical in all patients. The history of periosteal harvesting in 2 patients may be a source of bias. We are not aware of any reports of pain or fracture at periosteal-graft donor sites [23,24]. In addition, the periosteum was harvested from the antero-medial aspect of the tibia whereas the lesions developed at the antero-lateral aspect. Finally, 1 patient was lost to follow-up immediately after the initial non-operative treatment. Consequently, we can neither fully evaluate this patient nor be certain that the non-operative treatment was consistently ineffective.

5. Conclusion

Intra-medullary osteosclerosis of the tibia manifests as chronic mechanical pain located at the middle of the shin, in the absence of trauma or microtrauma. The radiological finding of a transverse linear lucency confined to the antero-lateral part of the mid-shaft and located within a focus of cortical and intra-medullary hyperostosis differentiates intra-medullary osteosclerosis from the other causes of osteosclerosis described to date.

The management of intra-medullary osteosclerosis remains controversial and needs to be investigated in further studies. In patients who have an antero-lateral mid-diaphyseal lucent line within a focus of cortical and intra-medullary tibial hyperostosis and no signs suggesting a stress fracture or other diagnosis, we recommend first-line non-operative treatment, as lack of

efficacy of this approach remains unproven. If this treatment fails, excision and bone grafting may deserve consideration.

Disclosure of interest

The authors declare that they have no competing interest.

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Authors' contribution

D.B: data collection, writing.
P.J, P.L, B.D, J.C, J.S.D.G.: revising.

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