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FULL PAPER

Imaging features of chondromyxoid fibroma: report of 15 cases and literature review

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Objective: Chondromyxoid fibroma (CMF) is a rare benign bony tumour. Our objectives are three-fold: first, comparing MRI, conventional radiography (CR) and CT characteristics of CMF; second, providing a literature review; and third, summarizing the role of imaging landmarks in the differential diagnosis with other bony lesions.
Methods: 15 patients with histopathologically proven CMF were retrospectively included. MR images were reviewed for typical findings and compared with imaging features on CR and CT.
Results: All lesions were isointense on T_1 weighted images with a low intensity rim in nine cases corresponding to the perilesional sclerosis on CR and CT. Internal trabeculations were more prominent on CR than on CT due to corrugation and scalloping at the tumour's edge. CT was superior to CR in analysing the expansion of the lesion, cortical breakthrough and internal mineralization. T_2 short tau inversion recovery or T_2 weighted fat saturation images showed an intermediate to hyperintense signal in all lesions, mostly heterogeneous. Some lesions contained small internal cysts, and one lesion demonstrated a low signal intensity centrally, corresponding to internal mineralization on CT. Intense contrast enhancement was present in all lesions. Minimal bone and soft tissue oedema were seen in, respectively, six and three patients.
Conclusion: The diagnosis of CMF is difficult because of overlap of characteristics with other bony lesions. Our comparative study puts forward advantages and limitations of different imaging modalities in the diagnosis of CMF.
Advances in knowledge: For the first time, imaging features of CMF are analysed and compared on CR, CT and MRI.

INTRODUCTION

Chondromyxoid fibroma (CMF) is a rare entity, representing <1% of all primary bone neoplasms. It belongs to the group of benign cartilage tumours and has first been described in 1948 by Jaffe and Lichtenstein.[1] It is frequently diagnosed in the second decade of life and is slightly more frequent in males, with a male : female ratio of 1.28 : 1.[2] The final diagnosis is not always easy because of its rarity but also due to the overlap of characteristics with other bone tumours. Additionally, CMF can occur in any part of the skeleton, although it appears most commonly in long bones.[3] The radiographic features include a well-defined focal bone lesion with geographic bone destruction, a sclerotic rim, lobulated margins and internal trabeculations. Frequently, cortical ballooning and expansion is visible and even complete cortical destruction may be seen in almost one-third of the cases.[4] The differential diagnosis consists of aneurysmal bone cysts, giant-cell tumours (GCTs), chondrosarcoma, chondroblastoma, enchondroma and non-ossifying fibroma. The diagnostic difficulty also exists in the histopathological similarity of CMF with chondroblastoma and chondrosarcoma. CMF has a benign clinical behaviour, with only a few reported cases of malignant transformation. Therefore, it should be correctly differentiated from other lesions.[5,6] A multidisciplinary approach (clinical, radiological and pathological) is recommended to make the final diagnosis and to guide the treatment options. Although CMF is well known and some large studies have previously been reported, only one case series with MRI features has been published.[7] Besides that, most case reports discussed CMF at unusual sites with unusual appearance. Knowledge of MRI features of CMF at common sites can help us in establishing the diagnosis when differential diagnosis with other bone tumours is challenging.

METHODS AND MATERIALS

This retrospective study was approved by the ethical committee of the University Hospital Leuven. The histopathological database of the hospital was searched for

patients who were diagnosed with CMF between January 1995 and May 2015. Only patients with available radiological images were included. A total of 15 patients were identified.

All available images were independently analysed by a radiologist with 4 years' and a radiologist with 15 years' experience. Any disagreement was discussed until a consensus was reached.

Lesions were systematically analysed and classified as arising from long bones, flat bones, bones in the hand and feet or other. Within long bones, CMFs were divided into epiphyseal, metaphyseal, diaphyseal or a combination of these. On conventional radiography (CR) and CT images, lesions were screened for the following characteristics: osteoblastic or osteolytic appearance, sclerotic border, shape, internal bony trabeculation, internal mineralization, internal matrix, cortical changes, expansion, periosteal reaction and changes in the adjacent soft tissue. Signal intensity characteristics of the lesions were assessed on T_1 weighted images (T1WI), T_2 weighted images (T2WI), T_2 short tau inversion recovery (T2-STIR) and T_2 with fat suppression (T2-FS). Patterns of contrast enhancement were analysed, as was the presence of bone marrow oedema and soft tissue oedema.

RESULTS

Patient population

From 15 patients, 8 were female. The median age was 31 years (range: 16–54 years). Approximately 47% of the patients were younger than 30 years. Of 15 tumours, 6 occurred in the long bones, 7 in flat bones and 2 in the bones of the feet. From the six CMFs affecting the long bones, three occurred in the fibula and three in the tibia. Among the six lesions involving the long bones, one was epiphyseal, two were metaepiphyseal, one was metaphyseal and two were metadiaphyseal. All seven lesions in the flat bones were located in the iliac bone. The other two lesions affected the navicular bone and the calcaneus.

Radiological characteristics

Available imaging modalities are summarized in Table 1.

Conventional radiography and CT

CRs and CTs were available in 14 and 13 patients, respectively. All lesions presented as osteolytic tumours on both imaging modalities. An overview of imaging characteristics is provided in Table 2.

MRI

MRI was available in 12 patients. Nine lesions had a low-signal-intensity peripheral rim on all MRI sequences. All lesions were isointense on T1WI. T2-STIR or T2-FS images were available in 11 patients. The signal intensity on T2-STIR and T2-FS differed from intermediate to hyperintense.

After intravenous administration of gadolinium, all lesions showed an intense contrast enhancement. Table 3 provides an overview of MRI characteristics.

DISCUSSION

Because of its rarity and the variety in localization, the diagnosis of CMF is difficult and it is often one of exclusion. The

Table 1. Available imaging modalities for each patient

Patients	CR ($n = 14$)	CT ($n = 13$)	MRI ($n = 12$)			
			T1WI	T2WI	T2-FS/T2-STIR	T_1 + gadolinium
1	x	x	x	x	x	x
2			x		x	
3	x	x	x	x	x	x
4	x	x	x		x	x
5	x	x	x		x	x
6	x					
7	x	x				
8	x	x	x		x	x
9	x	x	x		x	x
10	x	x	x		x	x
11	x	x				
12	x	x	x		x	x
13	x	x	x	x		x
14	x	x	x		x	x
15	x	x	x	x	x	x

CR, conventional radiography; T1WI, T_1 weighted images; T2-FS, T_2 with fat suppression; T2-STIR, T_2 short tau inversion recovery; T2WI, T_2 weighted images.

Table 2. Imaging characteristics on conventional radiography ($n = 14$) and CT ($n = 13$)

Characteristics		Number of patients
Shape	Oval	4
	Round	0
	Lobulated	10
Delineation	Well defined	12
	Moderately defined	1
	Ill defined	1
Expansion	Minimal	5
	Important	7
Border	Sclerotic rim	12
	No sclerotic rim	2
Cortex	Normal	1
	Thinned	13
	Breakthrough	13
	Destruction	6
Trabeculation		9
Mineralization		2
Internal matrix	Homogeneous	9
	Heterogeneous	4
Perilesional sclerosis		11
Surroundings	Periosteal reaction	2
	Soft tissue changes	0

prognosis of CMF is excellent with a risk of malignant transformation up to 1–2% and high recurrence rates (up to 80%) in cases treated with curettage alone.[8] Treatment with intralesional curettage and additional cementation has shown a further decrease of the recurrence rate (up to 22%) and resulted in excellent functional results.[9] Consequently, differential diagnosis with chondrosarcoma is of paramount importance. Integration of clinical, pathological and imaging is helpful. To our knowledge, only one article in the radiology literature reviewed a case series of 19 patients with histopathologically proven CMF with MRI.[7] Other reported studies have focused on treatment options and clinical outcome rather than on comparing radiology characteristics of the tumour.[9] A few case reports have been published, discussing the MRI features of CMF. However, many of them focused on atypical presentations of CMF (*e.g.* facial and skull base CMF).[10–20] Our goal was to analyse the histopathologically proven CMF cases in University Hospital Leuven, focusing on imaging landmarks which can help us in the diagnostic work-up and to compare these with the published literature.

Approximately half of the CMFs in our series presented under the age of 30 years, with slightly more females than males. In the literature, a male : female ratio of 1.28 : 1 and a peak incidence in the second decade of life is reported.[2] A second peak incidence has been described around the fifth to seventh decade. In older patients, lesions are more frequently seen at rare localizations.[16–23] In our study group, three patients were diagnosed in the fifth and one patient in the sixth decade of life. However, these lesions did not appear in atypical localizations. Most lesions occurred around the knee, iliac bone or bones of the foot, which are the three most common localizations of CMF described in the literature.[3]

In accordance with published articles, a CMF presented most frequently as an osteolytic, expansile lobulated or oval lesion, with well-defined borders and a sclerotic rim on CR (Figure 1). Only one lesion presented with ill-defined borders. This could be explained by its post-treatment status by curettage of the lesion. CR was equally sensitive for the perilesional sclerosis compared with CT. A correlation for this sclerosis on MRI was found in our patients and presented as a T_1 hypointense border on all sequences.

In long bones, the metaphysis is most frequently involved and lesions are typically eccentric. A typical appearance of CMF is a nearly hemispherical "bite" from the cortical margin without periosteal reaction.[4,24,25] This characteristic finding has been found in three of our patients (Figure 2).

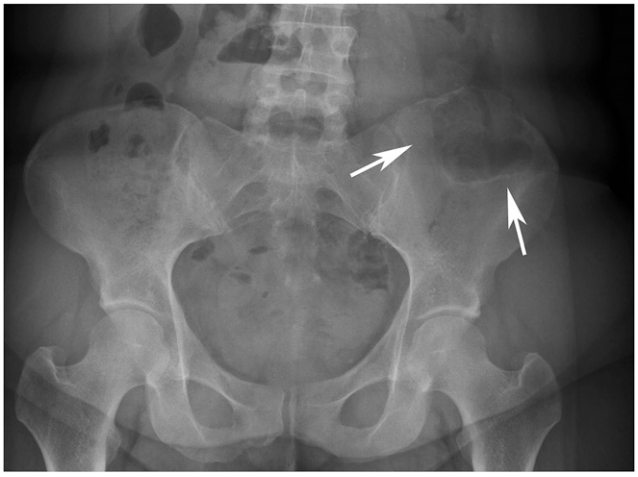
Cortical changes are best evaluated on CT and range from cortical thinning, breakthrough to destruction of the cortex. In fact, CR was not sensitive in the diagnosis of cortical

Table 3. MRI characteristics ($n = 12$)

Characteristics		Number of patients
Border	Hypointense rim	9
T_1	Isointense	12
	Homogeneous	10
	Heterogeneous	2
T_2	Intermediate intense	3
	Hyperintense	1
T2-STIR/T2-FS	Intermediate–hyperintense	11
	Heterogeneous	9
	Homogeneous	2
	Internal cysts	4
	Internal hypointensities	1
Contrast enhancement	Homogeneous	3
	Heterogeneous	2
	Peripheral	6
Surroundings	Bone marrow oedema	6
	Soft tissue oedema	3
	Periosteal reaction	2

T2-FS, T_2 with fat suppression; T2-STIR, T_2 short tau inversion recovery.

Figure 1. Chondromyxoid fibroma of the left iliac wing (arrows). Lobulated osteolytic lesion with well-defined borders, sclerotic margins, apical cortical thinning and multifocal breakthrough.



breakthrough, and as for us, it was only seen in important expansile lesions. Internal bony trabeculation is often present on CT and was overrated on CR, which implies an existence of pseudotrabeculations due to corrugation and scalloping at the edge of the tumour. Internal mineralization is rare, appearing in only 2–13% of lesions[2] (Figure 3). In our case series, internal mineralization was easier to diagnose on CT than on CR, yet both modalities underestimated the mineralization compared with the histopathological findings.

On MRI, all lesions are homogeneous isointense to muscle tissue on T1WI and mostly heterogeneous intermediate signal intensity on T2-STIR or T2-FS images due to the different composition of fibrous, chondroid and myxoid components. This is the reason why we observed internal cystic changes on some of these sequences which had no correlation on soft-tissue images in CT. However, no correlation could be found between imaging appearance and the ratio of chondromyxoid components on pathology specimens. Bone marrow oedema and perilesional oedema were absent or rather minimal, independent of their expansile character.

Kim et al[7] identified a nodular peripheral contrast enhancement in 11 of 16 lesions, whereas in our group, 6 of 11 tumours showed a linear peripheral enhancement with foci of low signal intensity centrally (Figure 4). This nodular enhancement has not been reported by others. Kim et al[7] described another helpful feature to diagnose a CMF, namely a hyperintense T_2 peripheral signal corresponding to this nodular enhancement. This feature could not be identified in any of our cases. Periosteal reaction, bone marrow oedema and soft tissue oedema were more frequently diagnosed in their case series than in ours (respectively, in 11, 12 and 14 out of the 19 cases *vs* 2, 6 and 3 out of the 15 cases).

Differential diagnosis

Unfortunately, radiographic features of CMF are not specific and can occur in other, more common types of bony lesions. When the epiphysis is involved, lesions can present as a chondroblastoma or GCT. CMF, as its name reveals, consists of both myxoid, chondroid and fibrous tissue and lobulated areas of spindle-shaped or stellate cells. CMFs also contain multinucleated giant cells of different sizes. If lesions are large, differential diagnosis with chondrosarcoma can be challenging.[26] Sometimes, histopathological analysis is not able to differentiate

Figure 2. Chondromyxoid fibroma (CMF) of the fibula metaphysis (arrows). Oval lytic well-defined lesion with a typical hemispherical "bite" at the posterior site of the fibula metaphysis (arrows in right panel). This has been described as a diagnostic feature of CMF.

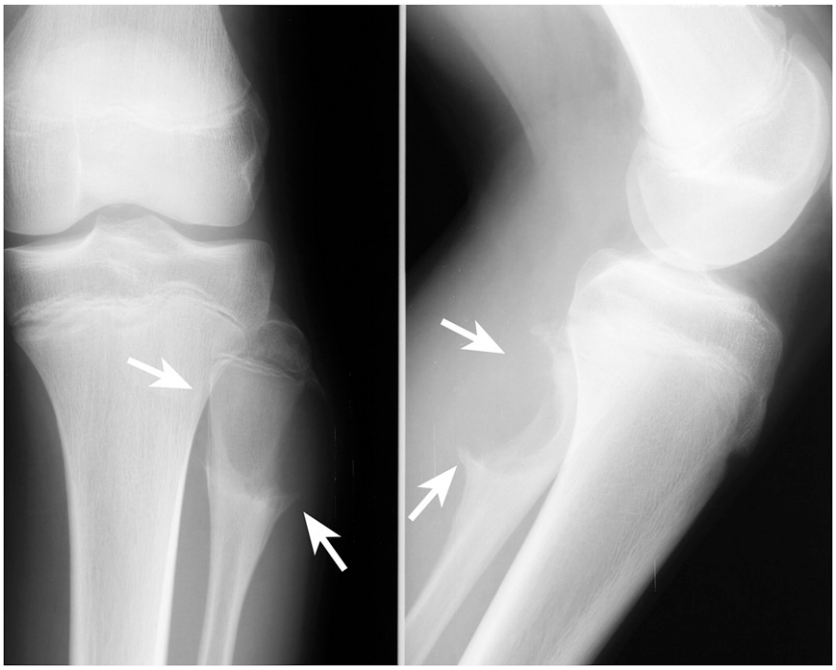
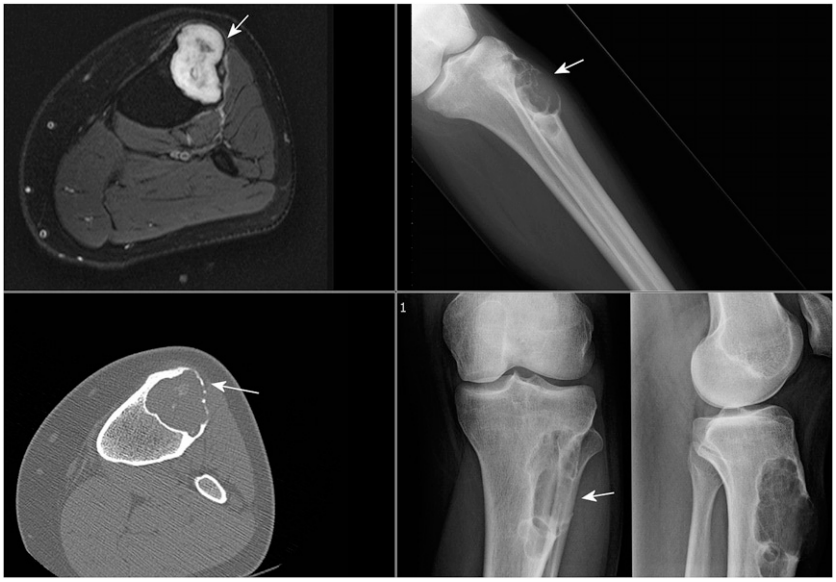


Figure 3. Chondromyxoid fibroma of tibia metadiaphysis. Plain radiography shows a lobulated, expansile, eccentric osteolytic lesion with internal trabeculation, cortical breakthrough and destruction (arrows right panel). On CT, internal mineralization is easily visualized (arrow lower left). The internal mineralization is seen on T_2 short tau inversion recovery images (arrow upper left) as foci with a low signal intensity centrally.



between chondroblastoma and CMF. Because of the clinical behaviour and benign aspect of the lesions, differentiation is not important. In these cases, we simply speak of a chondroblastoma if the lesion is epiphyseal and of a CMF if it is located in the metaphysis.[3]

Clinically, patients with CMF can present with progressive pain, often long standing and/or with bony swelling and restricted range of movement in the affected limb. This clinical presentation is also found in patients with chondrosarcoma.

A differential diagnostic list contains aneurysmal bone cyst, GCT, non-ossifying fibroma, enchondroma, chondroblastoma and chondrosarcoma. Imaging features are summarized in Tables 4 and 5.

Figure 4. Chondromyxoid fibroma of the right iliac wing (arrows). (a, c) T_1 weighted images before and after contrast administration: the lesion is homogeneous isointense to muscle tissue with a low signal intensity rim before contrast administration. The lesion showed a linear peripheral enhancement with foci of low signal intensity centrally. (b, d) Corresponding CT images.

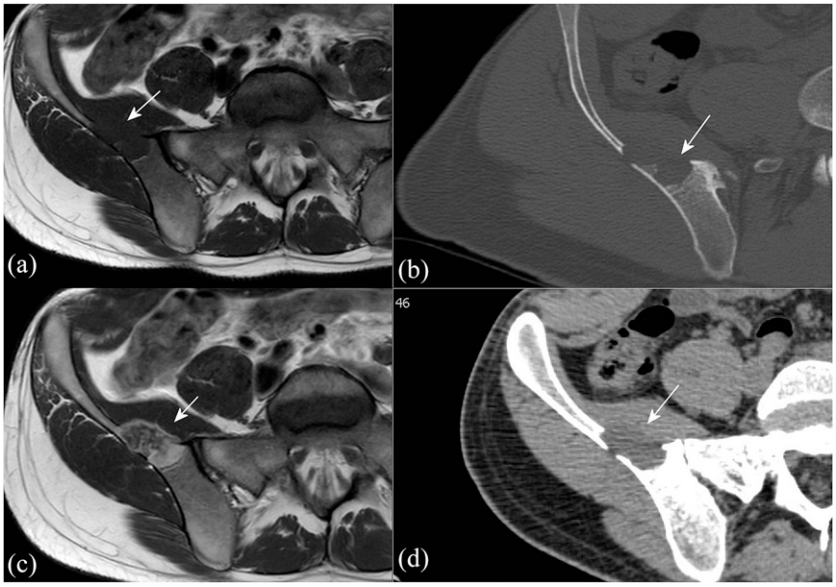


Table 4. Differential diagnostic imaging features[27–29]

Characteristics	ABC	GCT	NOF
Age (years)	All ages, preferably <20	20–40	<30
Localization within the skeleton	Tibia/femur/fibula/spine/humerus	Femur/tibia/fibula/humerus/ distal radius	Tibia/femur/fibula/humerus
Localization in bone	Diaphysis Centric in long bones	Epiphysis Eccentric in long bones	Metaphysis Eccentric in long bones
CR	Expansile well-defined osteolytic lesion	Well-defined or ill-defined osteolytic lesion	Well-defined osteolitic lesion
CT	Ballooning Soap bubble cortical expansion Trabeculations	No sclerotic margin No mineralization	Marked sclerotic margin Sometimes expansile
MRI	Fluid–fluid levels due to blood sedimentation	Low signal intensity on T2WI in 80% Secondary ABC possible	Diffuse hypointense on T2WI
Extra	Histologically: large blood-filled vascular spaces and vascular stroma		

ABC, aneurysmal bone cyst; CR, conventional radiography; GCT, giant cell tumour; NOF, non-ossifying fibroma; T2WI, T_2 weighted images.

The limitations of this case series exists in the small number of patients, its retrospective nature and the fact that the reviewers knew beforehand that they were screening histopathologically proven CMF. This could have influenced our detection for previous described characteristic features of CMF. An extra limitation of the comparison is the unavailability of all 3 imaging modalities (MR, CR and CT) in 4 out of the 15 patients.

CONCLUSION

CMF is a rare disease with only a few case reports and a few case series published in the literature. Most of them are atypical cases. Some debate exists regarding the characteristic radiological features which are needed to make the correct and important differential diagnosis between CMF and chondrosarcoma. A multidisciplinary approach is recommended to differentiate between CMF and chondrosarcoma. We tried to summarize some characteristic imaging features of CMF occurring in typical localizations to guide radiologists. CMF typically occurs in young patients who present with an oval or osteolytic, expansile lobulated lesion in long or flat bones. CMFs are isointense on T1WI and have an intermediate to high signal intensity on T2STIR/T2FS with a strong homogeneous or peripheral contrast enhancement. The conventional "bite" feature, low signal intensity rim on all MRI sequences and the lack off or minimal bone marrow or soft tissue oedema can be helpful features as well.

Table 5. Differential diagnostic imaging features[3,27–31]

Characteristics	Enchondroma	Chondroblastoma	Chondrosarcoma
Age (years)	All ages	<30, (±20)	>40
Localization within skeleton	Phalanges/femur/humerus/ metacarpals/rib	Femur/humerus/tibia/tarsal bone (calcaneus)/patella	Femur/rib/iliac bone/humerus/tibia
Localization in bone	Metaphysis/diaphysis Centric in long bones Eccentric in short bones	Epiphysis Eccentric in long bones	Metaphysis Centric in long bones
CR	Well-defined osteolytic lesion	Well-defined lobulated osteolytic lesion	Osteolytic lesion with endosteal scalloping
CT	Ring-and-arc mineralization (except in phalanges of hands and feet)	Sclerotic margin Regular benign periosteal reaction	Mineralization
MRI	Very bright on T2-FS Peripheral or septal-nodular enhancement No soft tissue oedema	Bone marrow oedema Soft tissue oedema	Ring-and-arc enhancement Soft-tissue mass Soft tissue oedema
Extra		Similar age range and histological features	Clinical differential diagnosis with CMF sometimes difficult

CMF, chondromyxoid fibroma; CR, conventional radiography; T2-FS, T_2 with fat suppression.

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