Skeletal Radiol (2012) 41:725–731
DOI 10.1007/s00256-012-1371-z

CASE REPORT

Entrapped intralesional marrow: a hitherto undescribed imaging feature of benign notochordal cell tumour

Radhesh Lalam · Victor N. Cassar-Pullicino · John McClure · Jaspreet Singh

Received: 23 November 2011 / Revised: 18 January 2012 / Accepted: 24 January 2012 / Published online: 14 March 2012
© ISS 2012

Abstract We report two cases of histologically proven benign notochordal cell tumour (BNCT) with imaging evidence of entrapped intralesional marrow and discuss the relevance of previously undescribed imaging feature.

Keywords Bone marrow · Notochord · Magnetic resonance imaging · Tumor

Introduction

The presence of entrapped marrow in benign notochordal cell tumour (BNCT) has in passing been previously noted by pathologists and is suggested to be a differentiating feature between BNCT and chordoma [1, 2]. BNCT has to date been thought to produce fairly consistent and reproducible imaging appearances that do not include evidence of entrapped intralesional marrow. We report two cases of histologically proven BNCT that demonstrate intralesional marrow entrapment and discuss its relevance.

R. Lalam · V. N. Cassar-Pullicino (✉) · J. Singh
Department of Diagnostic imaging, Robert Jones and Agnes Hunt Orthopaedic Hospital,
Oswestry, England SY10 7AG, UK
e-mail: Victor.Pullicino@rjah.nhs.uk

J. McClure
Department of Musculoskeletal Pathology, Robert Jones and Agnes Hunt Orthopaedic Hospital,
Oswestry, England SY10 7AG, UK

Case report

Case1

A 59-year-old man presented with severe back and leg pain, from which he had suffered for 3 months. Seven years earlier he had been diagnosed with bladder carcinoma and had a cystectomy. On examination, he had a left leg radiculopathy. MRI studies demonstrated degenerative disease causing compression of the left L4 and S1 nerve roots, explaining the origin of the patient's symptoms.

The MRI study also demonstrated an incidental solitary 2.5 x 2.3 x 2.1-cm lesion (Fig. 1) entirely confined within the posterior aspect of the L1 vertebral body. The lesion showed heterogeneous signal characteristics on all sequences. The left side of the lesion demonstrated low signal on T1-weighted and high signal on T2-weighted images (Fig. 2) . The right side of the lesion demonstrated a heterogeneous appearance with scattered foci of relatively high signal on T1-weighted images, which were completely suppressed on the STIR sequence and demonstrated intermediate signal on T2-weighted images (Figs. 1, 2). There was no enhancement after intravenous gadolinium injection. There was no abnormality on scintigraphy. Computed tomography (CT) demonstrated a significantly sclerotic lesion in the midline along the posterior aspect of the L1 vertebra (Fig. 3). Within the lesion, there were a number of scattered "bubbly areas" of low CT density with intact trabecular architecture, particularly in the right side of the lesion. Density measurement in these areas of lucency varied

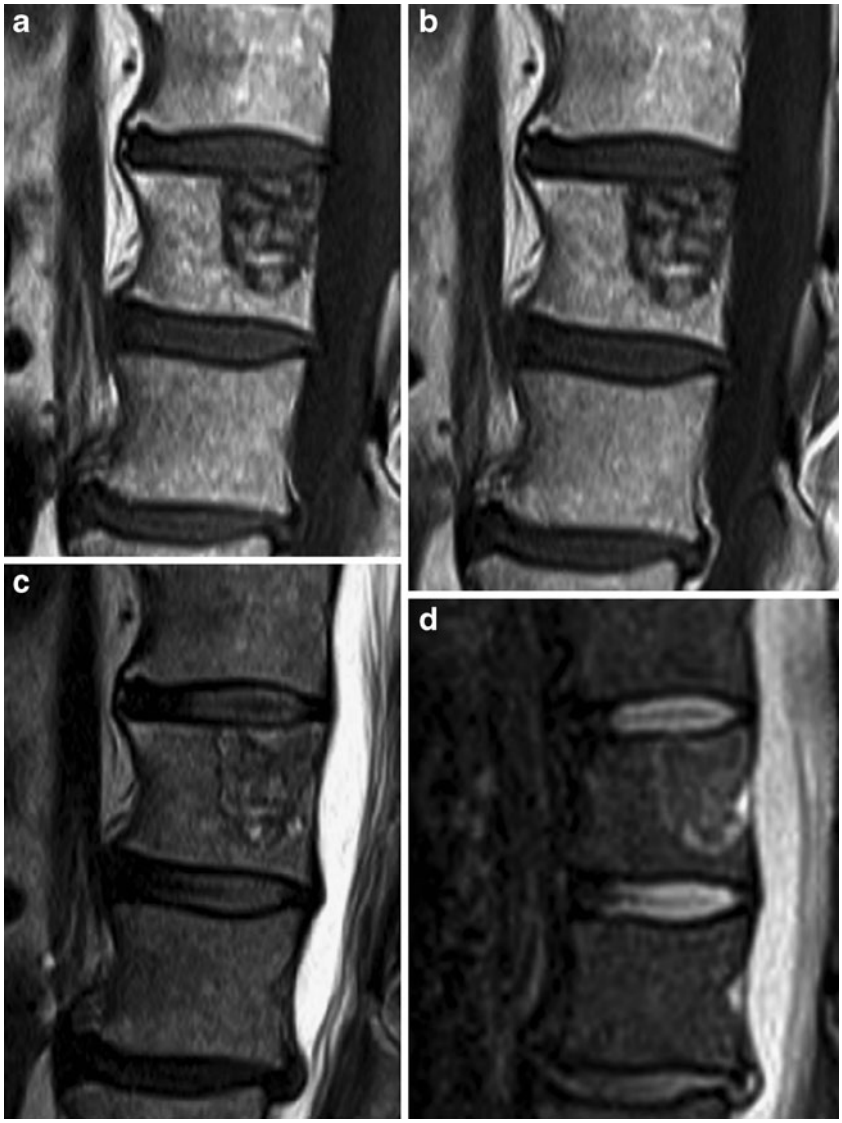

Fig. 1 Case1. **a** Sagittal T1W, **b** post-contrast T1W, **c** T2W and **d** STIR images, demonstrate a lesion in the posterior aspect of the L1 vertebra with multiple intralesional high signal foci on T1W images with complete suppression on STIR sequence in keeping with intralesional fat content. No enhancement is seen after gadolinium administration

between −110 and +133 with a mean of 22 Hounsfield units (HU).

Because of the rather heterogeneous appearance of the lesion and the background medical history, a CT-guided biopsy was performed.

The biopsy tissue showed a tumour that was consistent with BNCT (Fig. 4). The cells were generally large, but with size variability and variable vacuolation. These cells showed eosinophilic cytoplasm and were arranged in sheets. The nuclei were uniform with no significant atypia. The cells stained positively for S100 protein, pan-cytokeratin and epithelial membrane antigen, which are all features of BNCT. The tumour replaced most of the marrow with a sharp margin between tumour and uninvolved marrow. The bone trabeculae were thickened with no destruction. Within the lesion, there were a number of islands of haematopoietic marrow with adipocytes partially or completely surrounded by tumour cells (Fig. 4).

Case 2

In view of these observations in Case 1, we reviewed the histological sections of a previous vertebrectomy specimen diagnosed as BNCT along with the radiological images. This case had previously been presented at the International Skeletal Society meeting in 1996 and subsequently published in 1999 [3, 4]. The original histology report at the time of the vertebrectomy noted "The tumour is seen replacing the marrow, except for a few small foci of marrow which survive in the midst of the tumour."

Review of the macroscopic cut section of the vertebra clearly shows distinct intralesional macroscopic areas of preserved marrow (Fig. 5). Microscopically, within the tumour, there were a number of islands of preserved haematopoietic tissue and adipocytes surrounded partially or completely by sclerotic trabeculae and tumour tissue (Fig. 5).

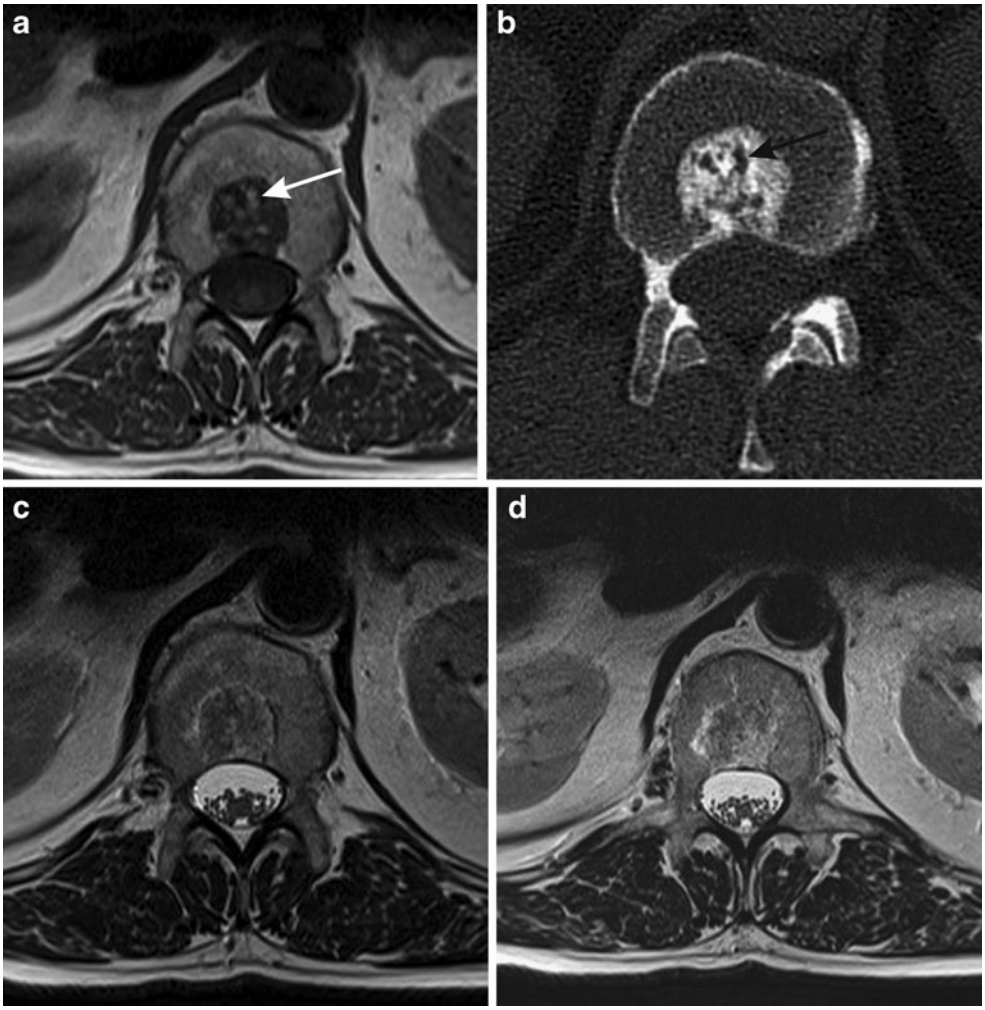

Fig. 2 Case 1. **a** Axial T1W and **b** corresponding axial CT image demonstrate high signal foci on T1W images corresponding to bubbly areas of low CT density (*arrows*). Axial T2W images **c** at and **d** immediately below the corresponding level of **a** demonstrate intermediate low signal on the right side and high signal on the left side of the lesion

Retrospective inspection of the MRI showed tiny focal areas of relatively high T1-weighted signal scattered throughout the lesion (Fig. 6). These relatively high signal areas were, however, less confluent than those seen in Case 1. CT in this case showed minimal sclerosis and did not demonstrate the "bubbly" lucent appearances seen in Case 1.

Both cases showed similar histological features in relation to these marrow islands. All haematopoietic cell lines were represented in the marrow islands. Mature adipocytes were present within, and more commonly, at the periphery of these islands abutting the trabecular surface and creating a palisade of fat cells. The haematopoietic islands and adipocytes were readily distinguishable from tumour cells on H/E stains and by immunomarker stains.

There was an interesting observation regarding the trabeculae around these haematopoietic islands in both cases. On the side where the haematopoietic islands abut the trabeculae, the trabecular structure was normal. On the contralateral aspect of the encasing trabeculae (viz. on the surface in contact with tumour cells), there was trabecular thickening with woven bone deposited on unresorbed surfaces (Fig. 5).

Discussion

The first case from which the concept of a benign variant of the classic "malignant" chordoma evolved was presented at the closed meeting of the International Skeletal Society in 1996 [3] and published in 1999 with the title "*Vertebral intra-osseous chordoma or giant notochordal rest?"* [4]. Since 1996, the relatively consistent pathological and imaging features of this entity have been mainly described in a number of case reports. Different descriptive terms have been used to describe this entity including "giant notochordal hamartoma", "benign notochordal cell lesion(BNCL)", notochordal remnant, notochordal vestige and "giant vertebral notochordal rest" [1, 5–8]. We favour the term "benign notochordal cell tumour (BNCT)", which was coined by Yamaguchi et al., but other authors use these various terms interchangeably for these lesions [2].

The imaging features of BNCT have now been widely accepted and are thought to be consistently reproducible [1, 9]. Roentgenographically, the affected bone may appear normal or mildly sclerotic. On computed tomography, the lesion usually demonstrates a variable degree of sclerosis,

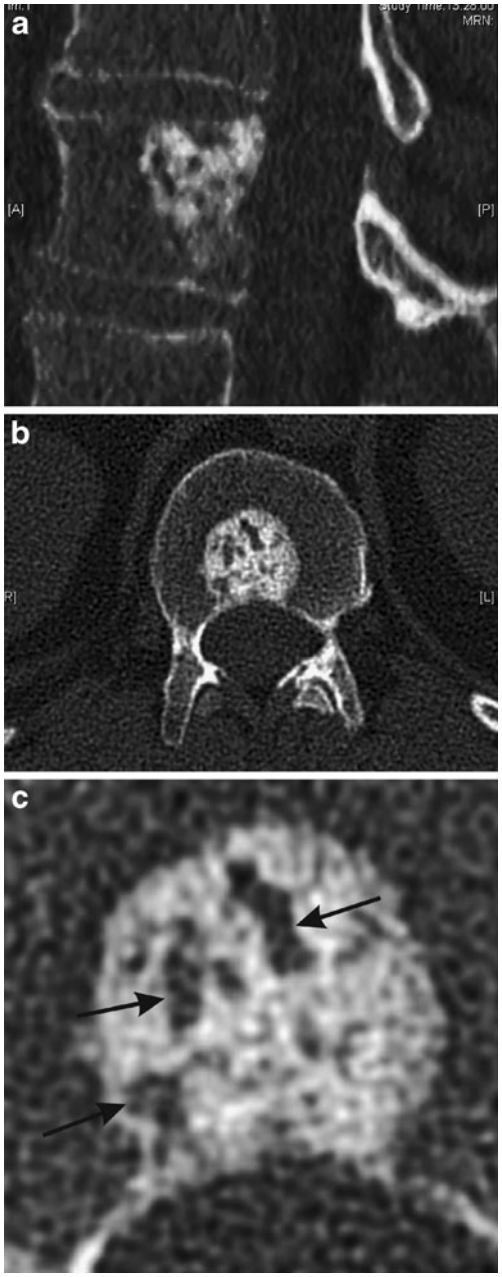

Fig. 3 Case1. **a** Sagittal reconstruction, **b** axial demonstrate multiple bubbly low CT density foci within the lesion. **c** Magnified view of **b** shows preserved trabecular architecture (*arrows*) in these areas of low CT density

which is the result of trabecular thickening. On magnetic resonance imaging, the lesion is seen as a well-defined abnormality with sharp demarcation from surrounding normal marrow. BNCTs are reported to consistently return low signal on T1W images and high signal on T2W images, with no enhancement after contrast medium administration. There is no cortical destruction or soft tissue extension. The lesions do not demonstrate increased uptake on scintigraphy. Both our cases demonstrate most of the imaging features previously described in the literature. They demonstrate

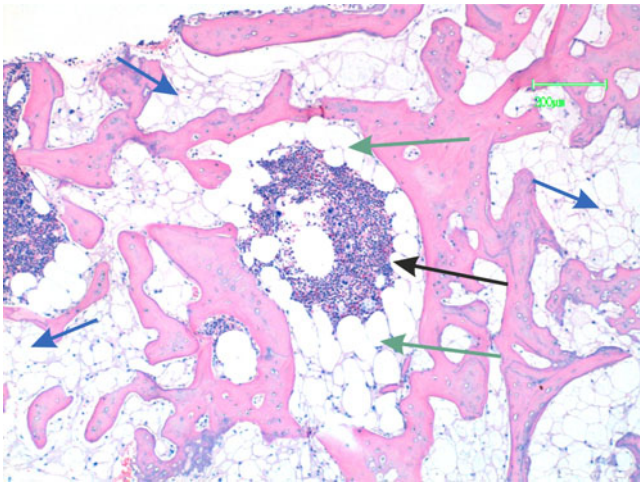

Fig. 4 Case 1. Photomicrograph of biopsy core demonstrates an island of haematopoietic marrow (*black arrows*) and adipocytes (*green arrows*) completely surrounded by benign notochordal cell tumour (BNCT) tissue (*blue arrows*). Note that the adipocytes are arranged in a palisade around the haematopoietic cells and abut the trabeculae

sclerotic areas on CT, low signal on T1W images and high signal on T2W images. There was no enhancement after contrast medium administration and there was no uptake on scintigraphy.

Both our cases demonstrate intralesional, relatively high-signal foci on unenhanced T1W images. High signal on T1W images could be due to haemorrhage or fat. These foci of high T1W signal suppress on fat-saturated sequences, indicating fat content. These foci of relatively high signal on T1W imaging also correspond to large "bubbly areas" of low CT density in our first case. The Hounsfield density measurements in these areas on CT are supportive of fat content. In fact, histological examination of our biopsy specimens demonstrate multiple scattered foci of preserved intralesional haematopoietic tissue and marrow fat. In the second case where there was a vertebrectomy, even the macroscopic specimen demonstrates multiple macroscopic foci of preserved intralesional marrow scattered throughout the lesion.

All haematopoietic cell lines were represented in these islands on histological examination of our cases. Mature adipocytes were present within and, more commonly, at the periphery, in contact with the trabecular surface, creating a palisade of fat cells. The simple explanation for their occurrence in BNCT, especially with the presence of all haematopoietic cell lines and adipocytes, is that they represent residual islands of marrow surviving alongside tumour proliferation. The tumour cells encase small islands of normal marrow rather than destroying and replacing it in these areas. However, the observed degree of architectural complexity could suggest that more specific mechanisms may be operating.

Benign notochordal cell tumour is associated with a uniform but variable degree of sclerosis, but not lysis on CT [9]. This sclerosis is primarily due to trabecular thickening

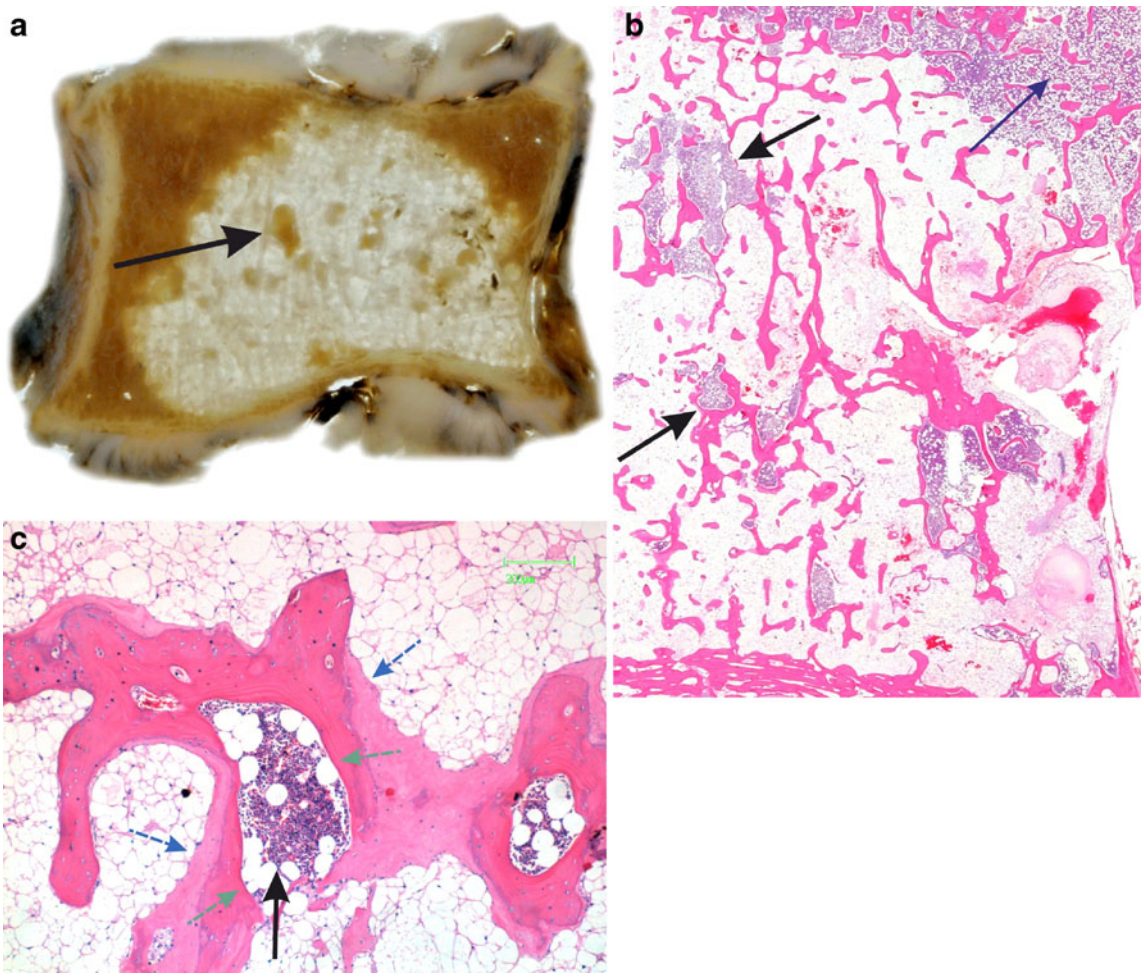

Fig. 5 Case2. Mounted sagittal section of L5 vertebrectomy specimen of BNCT (**a**) and photomacrograph (**b**) demonstrate entrapped intralesional islands of marrow (black arrows). High power photomicrograph (**c**) demonstrates entrapped marrow island (*black arrows*) surrounded by BNCT tissue. There is trabecular thickening and woven bone deposition on the trabecular surface where tumour tissue abuts trabeculae (*blue dashed arrows*). Normal trabecular architecture where entrapped marrow abuts trabecular surface (*green dashed arrows*). Normal marrow surrounding BNCT at the subchondral region (*blue arrows*)

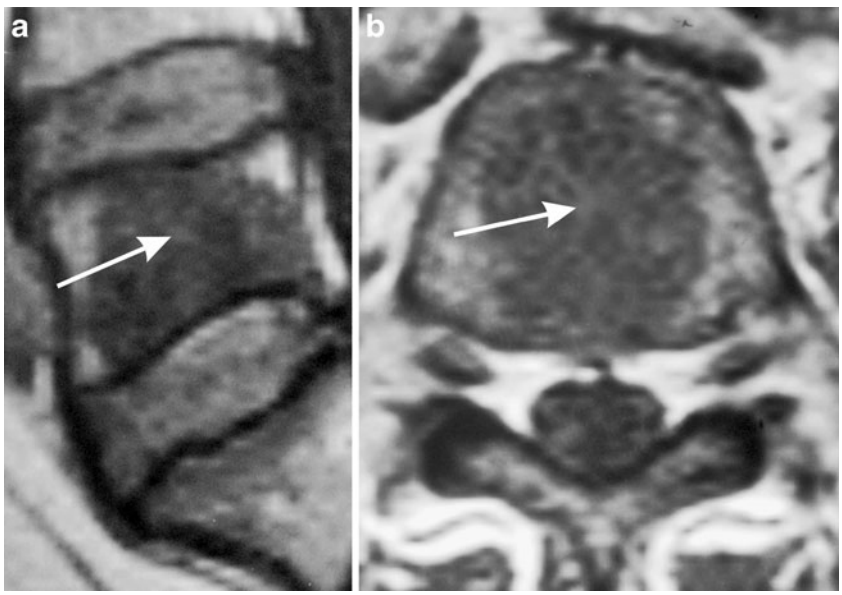

Fig. 6 Case 2. **a** Sagittal and **b** axial T1W images of the L5 vertebra demonstrate small foci of high T1W signal (*arrows*) that are discernible on these magnified images, but are less conspicuous than in Case 1

induced by the tumour, but not produced by the tumour itself. This osteoinductive nature of the tumour is clearly seen in our cases where tumour tissue and haematopoietic islands abut trabeculae on opposite sides. On the surface where the tumour tissue abuts the trabeculae, there is evidence of trabecular thickening, with woven bone deposited on unresorbed surfaces. On the contralateral surface where the haematopoietic islands abut the trabecular surface, there is no evidence of trabecular reaction. This in turn means that, contrary to existing literature, the CT density of this lesion can be non-uniform and heterogeneous. If there are large areas of entrapped marrow surrounded by significant osteoinduction caused by tumour tissue, CT can show bubbly areas of apparent reduced density contrasting with surrounding sclerosis. On the other hand, if there are tiny areas of haematopoietic islands in the lesion and there is minimal osteoinduction by the tumour, the lesion may be seen as a relatively homogeneous CT density owing to the low contrast between these areas. The combination of sclerosis and entrapped marrow causes heterogenous MR signal characteristics of the BNCT which is usually high T2 and low T1 in appearance.

The presence of lytic/lucent areas on CT has been suggested as a useful discriminating feature between BNCT and chordoma [7]. The presence of bubbly areas of relative lucency, as seen in one of our cases, may inadvertently be interpreted as confluent areas of osteolysis usually ascribed to malignant lesions including chordoma. It is therefore important to measure the density of these areas on CT, look for intact trabecular architecture in these areas of low density, and correlate with the high T1W signal characteristics on MRI before attributing these lucent areas to malignant destruction. This is especially important in the follow-up of BNCT, which is recommended to detect any possible malignant transformation to chordoma, if indeed this ever actually occurs.

Detection of these intralesional marrow islands on MR imaging also depends on the relative size and composition of these islands. Larger confluent areas of fatty marrow as seen in our cases may be easy to recognise because of their obvious contrasting imaging features compared with adjacent lesional BNCT tissue—high signal on T1W and intermediate signal on T2W images in the case of fat compared with low signal on T1W images and high signal on T2W images in the case of BNCT. It may be difficult to identify islands of red marrow as the contrast between lesional BNCT tissue and red marrow (intermediate signal on T1W and T2W images) is poorer than it is for fat. However, the possibility should be borne in mind in the interpretation of these lesions.

It is not known if entrapped marrow is a consistent feature of BNCT. However, some of the cases previously published do suggest the presence of areas of high signal on T1-weighted images [10]. Reference to its presence is found in the pathological description of these cases, but not in the imaging description.

The presence of these foci of intralesional marrow is also important for other diagnostic purposes. It has been well documented that the presence of intralesional fat signal on MR imaging is a very useful distinguishing feature of benign lesions compared with malignant lesions (23.3% compared with 3.6%) [11]. In another prior study involving review of MRI scans from 163 malignant bone tumours, the author reported no cases where islands of intralesional fat signal were seen in untreated malignant lesions. [12]. These studies concentrated on tumours of the peripheral skeleton and it is not known if the same conclusions could be extrapolated to axial skeletal lesions. The origin of this fat signal in benign lesions is not very clear from these studies. Our cases clearly show on histology that this fat signal in fact represents islands of normal marrow with varying proportions of fat and normal marrow lineage cells that are surrounded by tumour tissue. The demonstration of intralesional fatty marrow in our cases of BNCT further strengthens the assumption that intralesional fat MRI signal is a very useful, albeit not absolute, indicator of benignity of a vertebral lesion.

We would therefore recommend that the presence of high T1W signal areas in a vertebral lesion should not preclude a diagnosis of BNCT. Similarly, although the classic CT description of BNCT is of a diffusely variably sclerotic lesion of uniform density, the presence of bubbly focal lucent areas may be seen in BNCT because of intralesional fatty marrow islands. These should not be misinterpreted as areas of bone destruction suggestive of chordoma transformation.

Conclusion

We describe to our knowledge previously unreported imaging features of preserved intralesional marrow fat in two cases of histologically proven BNCT, which may be seen on MRI as relatively high T1W signal areas and on CT as areas of relatively low density.

References

1. Kyriakos M. Benign notochordal lesions of the axial skeleton: a review and current appraisal. Skeletal Radiol. 2011;40:1141–52.
2. Yamaguchi T, Suzuki S, Ishiiwa H, Ueda Y. Intraosseous benign notochordal cell tumors: overlooked precursors of classic chordomas? Histopathology. 2004;44:597–602.
3. Cassar-Pullicino VN, Darby AJ. Case 44. International Skeletal Society meeting; Paris 1996.
4. Darby AJ, Cassar-Pullicino VN, McCallI W, Jaffray DC. Vertebral intra-osseous chordoma or giant notochordal rest? Skeletal Radiol. 1999;28:342–6.
5. Mirra JM, Brien EW. Giant notochordal hamartoma of intra-osseous origin: a newly reported benign entity to be distinguished from

chordoma. Report of two cases. Skeletal Radiol. 2001;30:698–709.
6. Kyriakos M, Totty WG, Lenke LG. Giant vertebral notochordal rest: a lesion distinct from chordoma: discussion of an evolving concept. Am J Surg Pathol. 2003;27:396–406.
7. Chauvel A, Taillat F, Gille O, et al. Giant vertebral notochordal rest: a new entity distinct from chordoma. Histopathology. 2005;47:643–52.
8. Oner AY, Akpek S, Tali T, Ucar M. Giant vertebral notochordal rest: magnetic resonance and diffusion weighted imaging. Korean J Radiol. 2009;10:303–6.
9. Cassar-Pullicino V, Mangham DC. Notochordal tumours. In: Davies AM, Sundaram M, James SL eds. Imaging of bone tumors and tumor-like lesions. Techniques and applications; Heidelberg: Springer 2009; 375-393
10. Yamaguchi T, Iwata J, Sugihara S, et al. Distinguishing benign notochordal cell tumors from vertebral chordoma. Skeletal Radiol. 2008;37:291–9.
11. Simpfendorfer CS, Ilaslan H, Davies AM, James SL, et al. Does the presence of focal normal marrow fat signal within a tumor on MRI exclude malignancy? An analysis of 184 histologically proven tumors of the pelvic and appendicular skeleton. Skeletal Radiol. 2008;37:797–804.
12. Stacy GS. An analysis of malignant bone tumours for the presence of internal fat-signal intensity on magnetic resonance imaging examinations. Skeletal Radiol. 2007;36:355–75.