



Is Fluid- Fluid Level in Osseous Lesions- A Diagnostic Clue?

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Citation: Patnaik S, Kakarla S (2018) Is Fluid- Fluid Level in Osseous Lesions- A Diagnostic Clue?. Int J Musculoskelet Disord: IJMD-102. DOI: 10.29011/IJMD-102.000002

Received Date: 19 March, 2018; **Accepted Date:** 29 March, 2018; **Published Date:** 09 April, 2018

Abstract

Fluid-Fluid Level (FFL) is a non-specific cross-sectional imaging finding described in de novo and secondary Aneurysmal Bone Cysts (ABC) and in a variety of conditions including benign and malignant tumours. This is a review of osseous lesions showing FFL and the relative diagnostic value of the sign based on our experience and the relevant literature. We studied 35 cases of tumours and tumour like lesions having FFL. The imaging features were analysed with respect to single or multiple, occupancy percentage, uniformity, septae and the ratio of the largest FFL to the total tumour length. The percentage of occupancy of FFLs is an important clue to differentiate benign from malignant lesion with only exception of TOS. Uniformity of FFLs and irregularity/ nodularity in septum should also be studied which add to the diagnostic value. Additionally, signal intensity of FFLs in T1W, T2W/STIR sequences can enhance diagnostic accuracy.

Keywords: Aneurysmal Bone Cyst; Fluid-Fluid Level; Telangiectatic Osteosarcoma

Introduction

Fluid-Fluid Level (FFL) is a well-described feature of Aneurysmal Bone Cyst (ABC) on cross-sectional imaging; but can also be seen in a variety of conditions including benign and malignant tumours. Aneurysmal Bone Cyst is a benign intraosseous solitary lesion that consists of blood filled cavities. It is a consequence of increased venous pressure and resultant dilatation and rupture of local vascular network resulting in arterio-venous fistula within the bone. It may arise de novo or arise within pre-existing Chondroblastoma(CB), Chondromyxoid Fibroma(CMF), Osteoblastoma(OB), Giant cell tumour(GCT) or Fibrous Dysplasia(FD) [1]. FFL can occur whenever different fluid densities are contained within a cystic or compartmentalised structure, usually related to haemorrhage or necrosis. It develops in tumours, because of haemorrhage with a subsequent breakdown of blood product extracellular meth-haemoglobin or due to tumour necrosis with sedimentation of tumour cells as in Telangiectasia Osteosarcoma (TOS). Tissue fluid or separation of blood and

serum in large blood filled cavernous spaces like ABC can be studied on CT/MRI. Image acquisition near perpendicular to plane of FFL is required to demonstrate optimally [2]. It is considered a nonspecific sign, but sometimes helps to narrow down the differential diagnosis. This following is a review of osseous lesions showing FFL and the relative diagnostic value of the sign based on our experience and the relevant literature.

Our Observation

We studied 35 cases of tumours and tumour like lesions having FFL. The imaging features were analysed with respect to single or multiple, occupancy percentage, uniformity, septae and the ratio of the largest FFL to the total tumour length and correlated with the histological diagnosis. There were 23 males and rest were females with the youngest being 3 years and the oldest 45 years. Maximum were 10-20 years (n=20) followed by 20-30 years (n=8). The different lesions that were showing FFT are depicted in the (Figure 1). There were 8 cases of de novo- ABC, 13 cases of secondary ABC (GCT- 10, CB- 2, OB-1), TOS- 9, Simple Bone Cysts(SBC)-2 and Ewing's Sarcoma(EWS)- 3. Hence, benign to malignant ratio was 1.9:1.

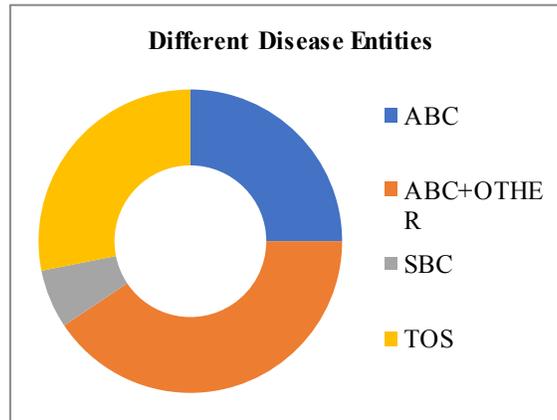


Figure 1: The different disease entities showing FFL in our observation.

The imaging characteristics like the number of FFL, occupancy of FFL, ratio of largest FFL to total occupancy, uniformity and septae are detailed in the (Table 1) with respect to each tumour type.

Diagnosis	Occupancy of FFL	Ratio of largest FFL to Occupancy of the tumour	Uniformity	Septae	Remarks
ABC	>75%	38%	uniform	smooth	
Secondary ABC	50-75%	43%	uniform mostly	smooth	27% are nonuniform
Malignancy	less than 25% to more than 75%	26%	nonuniform	irregular	in TOS, the FFL occupancy is more than 75% which are nonuniform

Table 1: The characteristics of 35 FFL lesions in our study.

In a study that included 700 consecutive bone tumours, van Dyck et al found that 2.7% of the cases contained FFL [3]. But incidence of FFL was reported as 11.2% of bone tumours in a study by O Donnell, et al. [4]. Our observations are somewhat like the findings by Hong Yu who analysed 47 cases with benign to malignant ratio of 1.6:1. OS was 21.3%, ABC 21.3%, GCT 19.1% and metastases 14.9% in their study. The rest were CB, SBC, Nerve sheath tumour, Cystic fibrous dysplasia and Brown tumour [5]. FFLs also can be observed in plasmacytoma, chondrosarcoma and tumour like conditions (Brown tumour, Brodies abscess, haemophilic pseudotumour). Various studies have shown that MRI can distinguish benign from malignant tumours. The FFLs originating from multiple necrosis in malignant tumour are usually small in size, whereas primary cavities in benign tumour typically have large FFLs [6]. According to O Donnell P, et al. higher the percentage of fluid-fluid level volume within a bone tumour, the greater the chance of tumour being benign on MRI imaging [4]. Similarly, Hong et al analysed 47 cases of lesions containing FFL. They demonstrated that the ratio of maximum length of largest fluid-fluid level to maximum length of tumour in sagittal plane was significantly higher in benign than that of malignant bone tumours. If the ratio is >41.5%, the tumours were considered

benign (Sensitivity-73%, and specificity-83%) [4].

Aneurysmal Bone Cysts (ABC)

ABC represent 6% of bone tumours and predominantly occur in metaphysis. About 80% are found in age group of 5-20 years. Long bones are affected in 70-80%, pelvis 5-10%, spine 15% and hands 10-15%. Primary ABC accounts for 70% and secondary 30% of ABC in conjunction with GCT, OB, CB, FD, OS [7]. In secondary ABC, the site depends on the site of bone tumours: for example, CB in epimetaphyseal region, FD in diaphysis. Primary ABC arises de novo in bones without any pre-existing lesions whereas secondary ABC arises in pre-existing lesions in one third cases and in areas of previous fracture. In a study by Sasaki et al, 11 cases of ABC accompanying lesions were GCT 2, CB 3, FD 2, and NOF 2. GCT (Figure 1) was the most common as observed in our series (our study: 10 out of 13) [8]. FFL here represents sediments of RBCs and serum within cavities. On imaging, ABC appear eccentric expansile lesion with well-defined sclerotic margin. Cortex will be blown out with thin periosteal reaction and bony trabeculae within the lesion. On CT Scan the thin intact cortex, FFL are well demonstrated. There is no enhancement of cystic component. FFL are best seen in MRI (Figure 2). In

secondary ABC the radiological features reflect the primary bone tumour associated .10-14% of GCT,10-15% of CB are associated with ABC. We had primary ABC 8 cases and secondary 13. GCT were most common followed by CB and OB. Long and flat bones were equally affected in ABC (primary and secondary) [9].

Fig 1 ABC with OB,CB in 13/M,15/M,GCT in 20/M,M28/F
Note: size of FFLs are almost uniform with smooth septations

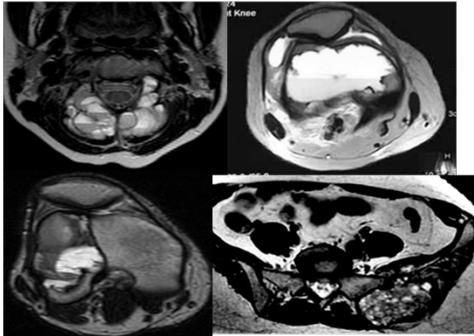
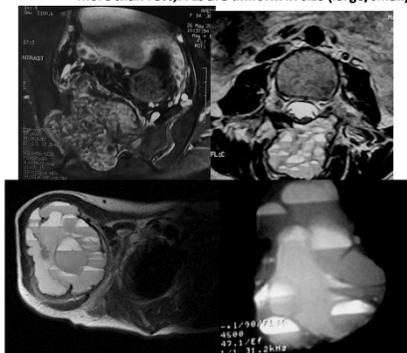


Fig 2 Cases of ABC showing FFLs in 14/F in sacrum, 22/F lumbar vertebra ,21/M calcaneum,3/M humerus ,21/M calcaneum, vertebra .Note: occupancy of FFL is more than 75%,FFLs are uniform in size (large/small)



Telangiectasia Osteosarcoma (TOS)

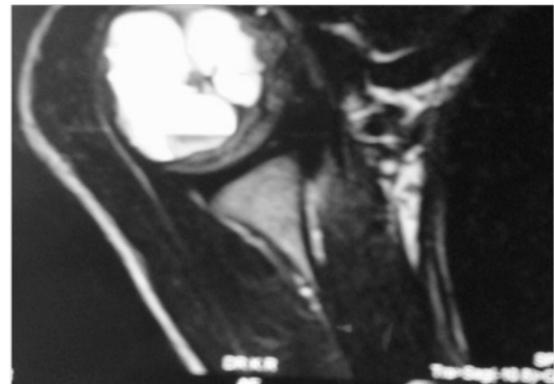
Telangiectasia osteosarcoma (TOS) accounts for 2.5-12% of all osteosarcomas. In 1903, Gay Lord used the term malignant bone aneurysm to refer to lesion which was described by Paget's in 1854. TOS is believed to originate from transformation from osteoblast or from stem cells that derive from mesenchymal tissue. Majority of tumour volume 90% or more consists of haemorrhage or necrotic cavity, an appearance like ABC. But the wall of septum is thickened, nodular and contain malignant cells that produce osteoid. They are metaphyseal in location of long bones.48% occur in distal femur. Geographic bone destruction, a wide zone of transition, endosteal scalloping with aneurysmal expansion of bone. Osteoid matrix mineralisation to seen 58% of cases. But it is subtle and not appreciated in radiograph. Matrix mineralisation is seen at periphery and in the trabeculae, which contain tumour cells. CT scan depicts the extent of soft tissue, bone destruction, fluid level in 49% cases. CT is the choice modality to demonstrate osteoid matrix. MRI demonstrates fluid -fluid level in 89% of cases [10].

Some malignant tumours other than osteosarcoma like Ewing's Sarcoma, chondrosarcoma, metastases, hemangioendothelioma have been associated with development of aneurysmal bone cyst and FFL [3,11].

Simple Bone Cysts

SBC are benign lesions occurring in 1st and 2nddecade. In active phase the lesion is close to growth plate and as lesion is inactive it migrates away from growth-plate. Proximal humerus is the most common site in 40-50% cases. It is central in location with sclerotic rim. Sometimes it expands the bone around with cortical thinning. Prominent ridges may appear as pseudo-trabeculations on X-ray. But SBC is a single cystic cavity and is rarely multiloculated. 'Fallen fragment sign' is pathognomonic of this entity and is observed when there is fracture. Usually there is no fluid level unless there is haemorrhage. In one of two cases of SBC in the series of 19 cases by Van Dyck, presented with FFL [3]. In a study by Margau, et al. 20 cases of SBC were retrospectively reviewed, and they found FFL in 11(55%) of them, like our observation (Figure 3) [12].

Fig 3 14/M ,SBC in humerus showing large FFL



Can FFL Provide Diagnostic Clue?

It is important to study whether there is a single or multiple FFL, the occupancy of FFLs in entire lesion, size of the largest FFL compared to tumour size, uniformity of the FFLs, septae and the signal intensity of fluids. These characteristics can help to reach a diagnosis of osseous lesion containing FFLs. The occupancy of FFL within the entire lesion in benign lesions is higher. The locules of FFL are more uniform with smooth outline of septum/septae. 27% of secondary ABC had non-uniform size of FFLs (Figure 4). On contrary the malignant lesions have smaller FFLs with irregular septae. An exception is occupancy of FFL in entire lesion is more than 75% in TOS (Figure 5), but in EWS it is less than 50% (Figure 6). Ratio of FFL to the tumour-occupancy is least in malignant lesion (excluding TOS) as compared to

primary and secondary ABC. FFLs are best appreciated on fluid-sensitive sequences. In a series of 83 patients with bone lesions containing FFL, it was found that the proportion of lesion filled with FFL was inversely related to likelihood of malignancy [4]. Our observation is the same, except TOS which have occupancy of FFL more than 75% though the uniformity of FFLs is highly un-uniform with varying sizes. Benign lesions have larger FFL and are mostly uniform in terms of size of FFLs. 27% of secondary ABC have non-uniform FFLs. In a retrospective analysis of 47 patients, the maximum length of largest FFL to maximum length of tumour in sagittal plane was significantly higher in benign than the malignant tumour. They found that when tumours with a ratio more than 41.5% were considered benign with sensitivity of 73% and specificity of 83% [5]. Similar observation was made by us in the present series. The largest FFL to largest diameter of lesion was least malignant lesion as compared to primary or secondary ABC and SBC (Fig 1,2,3,5). Van Dyck et al showed that multiple FFLs occupy at least one half of total volume in most of the cases. In their observation, diagnosis included ABC 10, FD 2, OB 1, SBC 1, LCH 1, TOS 1, Brown tumour 1, CB 1 and GCT 2 out of total 19 cases. In this study the occupancy of FFLs could not differentiate the benign or malignant etiology. Two other small studies have suggested that high signal intensity within superior layer on T1W images may be associated with malignant disease [6,3]. Also, these suggested that malignant lesions did not demonstrate low signal intensity superiorly on T1W images. Pathological and *in vivo* studies have postulated the FFL develop either separation of whole blood or separation of the by-product of haemorrhage at its various stages. Alyas F, et al. found significant difference in proportion visualised FFL with T2W/STIR compared with T1W images. They have concluded that the Low/High SI pattern on T1W images occur approximately five times more commonly in benign than malignant disease. However, if FFL in a lesion on T1W images contains High/Low SI pattern then it is 2.3 times more likely to be malignant; 1.4 times more likely benign if it shows Low/High SI pattern [13]. In our study, all FFLs are analysed on T2W, STIR and the above phenomenon was not observed by us.

FIG 4 Un-uniform sizes of FFLs in 28/M,21/M,25/F GCT with ABC in talus, tibia lower end and tibia upper end. Note:the occupancy of FFL is more than 50% of lesion,

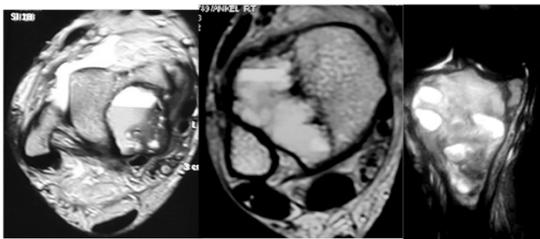


Fig 5 6 Different cases of HPE proven TOS in 16/M,25/F,19/M,13/M,14/M,19M. Lesions in Femur and tibia showing occupancy of FFL more than 75%,un uniform FFLs, ratio of largest to total occupancy was low

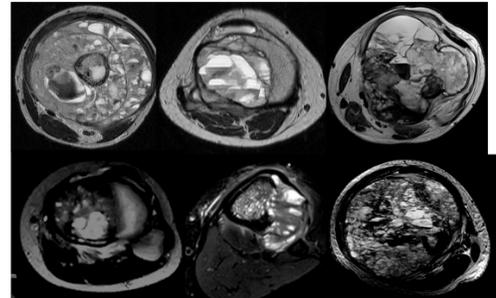
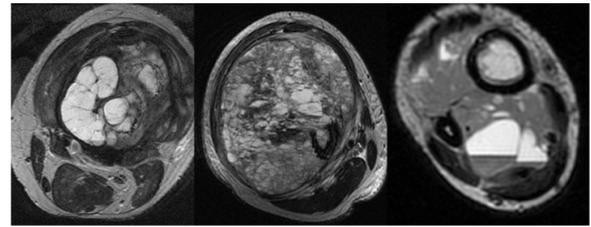


Fig 6 Cases of EWS in 20/M,14/M,25/M involving lower end of femur (two cases) and in upper end of tibia. Note:un-uniform sizes of FFLs and occupancy is also less. The tibial lesion is having FFL in soft tissue component.



Conclusion

Fluid-fluid level is an interesting imaging finding, seen in 2.7 to 11.2 % of bone tumours. The percentage of occupancy of FFLs is an important clue to differentiate benign from malignant lesion with only exception of TOS. Uniformity of FFLs is also a differentiating feature as benign lesions have more uniform FFLs. Smoothness of septae and irregularity/ nodularity in septum should also be studied which adds to the diagnostic value. Smooth septae indicate benign lesion whereas nodular/irregular septae indicate malignant lesion. Additionally, signal intensity of FFLs in T1W, T2W/STIR sequences can enhance diagnostic accuracy.

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