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IMAGING FEATURES OF GIANT CELL TUMOR AND ANEURYSMAL BONE CYST: A RETROSPECTIVE CASE SERIES

Radio-Diagnosis

Dr. Mihir P. Patel* Resident doctor, Department of Radiodiagnosis, GCRI (Gujarat cancer and Research institute), B.J Medical college, Ahmedabad*Corresponding Author

Dr. Drasty Y. Rathod Associate Professor, Department of Radiodiagnosis, GCRI (Gujarat cancer and Research institute), B.J Medical college, Ahmedabad

ABSTRACT

This retrospective case series analyzes 25 biopsy-proven lesions—6 Aneurysmal Bone Cysts (ABC) and 19 Giant Cell Tumors (GCT)—to evaluate differentiating radiological features. Case analysis revealed that ABCs primarily occur in the metaphysis of long or flat bones, presenting as expansile lytic lesions with characteristic fluid-fluid levels on MRI. In contrast, GCTs typically involve the epi-metaphyseal region, often extending to subchondral bone. While fluid-fluid levels are hallmark features of ABC, they were also observed as secondary components in several GCT cases, potentially complicating initial diagnosis. Results indicate that while internal architecture on MRI provides significant diagnostic clues, the lesion's location relative to the growth plate remains a critical factor in differentiating primary ABC from GCT. Accurate radiological identification is essential for guiding surgical intervention and management.

KEYWORDS

Aneurysmal Bone Cyst, Giant Cell Tumor, Mri, Fluid-fluid Levels, Bone Oncology.

INTRODUCTION

Primary bone tumors in the pediatric and young adult populations present diagnostic challenges due to overlapping clinical and radiological features. Among these, Giant Cell Tumor (GCT) of bone and Aneurysmal Bone Cyst (ABC) are two distinct entities that frequently mimic one another on conventional imaging[1].

GCT is a benign but locally aggressive neoplasm characterized by the presence of multinucleated giant cells, typically occurring in the epi-metaphyseal regions of long bones after skeletal maturity[2]. Conversely, ABC is a benign, expansile osteolytic lesion consisting of blood-filled spaces separated by connective tissue septa[1]. While ABCs can occur as primary lesions, they are also known to arise secondarily within other bone tumors, most notably GCT[3].

The hallmark of ABC on Magnetic Resonance Imaging (MRI) is the presence of multiple fluid-fluid levels, reflecting the sedimentation of blood products[4]. However, this finding is not pathognomonic and is frequently documented in GCTs with secondary ABC components, leading to potential diagnostic pitfalls[5]. Differentiating these lesions is critical, as management strategies—ranging from simple curettage to aggressive surgical resection or medical therapies like denosumab—differ significantly based on the risk of local recurrence[2]. This retrospective case series analyzes the imaging spectrum of 25 biopsy-proven cases of GCT and ABC. By evaluating location, cortical involvement, and internal architecture across X-ray, CT, and MRI, this study seeks to identify key radiological indicators for preoperative differentiation.

Material and Methods

Study Design and Patient Population

A retrospective, single-center case series evaluated 25 patients with biopsy-proven primary Giant Cell Tumor (GCT, n=19) or Aneurysmal Bone Cyst (ABC, n=6). Inclusion criteria required a histopathologically confirmed diagnosis and adequate preoperative imaging. Cases lacking definitive biopsies or complete imaging were excluded.

Imaging Techniques

Preoperative imaging adhered to institutional musculoskeletal oncology protocols. Conventional radiographs (Carestream DRX Evolution) assessed initial bone architecture and transition zones. Multi-detector CT scans (Siemens SOMATOM Emotion 16-slice or GE Revolution Maxima 128-slice) evaluated fine osseous details, cortical thinning, and focal breaks. Thoracic CT was used to screen for pulmonary metastases in suspected GCTs. Advanced MRI was conducted on a 3-Tesla Siemens Magnetom Skyra scanner, utilizing multi-planar T1-weighted, T2-weighted, STIR/TRIM, Diffusion-Weighted Imaging, and post-contrast T1-weighted sequences to characterize solid components and cystic septations.

Image Analysis and Histopathology

Image analyzed for anatomical location, margins, and internal architecture, specifically noting fluid-fluid levels on T2W/STIR sequences and aggressive features like cortical destruction. Definitive diagnoses were established via core needle or open incisional biopsy, serving as the reference standard. Histopathology identified bland fibroblastic cells with blood-filled spaces for ABCs, and uniformly distributed multinucleated giant cells for GCTs.

DATA ANALYSIS AND RESULTS

Table 1: Patient Demographics (N=25)

Demographic Variable	Aneurysmal Bone Cyst (n=6)	Giant Cell Tumor (n=19)	Overall (N=25)
Age (Years)			
Mean ± SD	11.3 ± 6.3	30.6 ± 8.2	26.0 ± 11.1
Range	3 – 30	17 – 53	3 – 53
Age Group Distribution			
< 20 years	5 (83.3%)	3 (15.8%)	8 (32.0%)
20 – 30 years	1 (16.7%)	8 (42.1%)	9 (36.0%)
> 30 years	0 (0.0%)	8 (42.1%)	8 (32.0%)
Gender			
Male	3 (50.0%)	10 (52.6%)	13 (52.0%)
Female	3 (50.0%)	9 (47.4%)	12 (48.0%)

Table 1 summarizes the demographic profile of the study cohort. Patients with Aneurysmal Bone Cysts presented at a significantly younger age (mean 11.3 ± 6.3 years) compared to those with Giant Cell Tumors (mean 30.6 ± 8.2 years), with a notable pediatric predominance in the ABC group starting from age 3. Gender distribution across the total cohort was nearly equal, with 13 males and 12 females.

Table 2: Anatomical Distribution of Lesions

Anatomical Location	ABC (n=6)	GCT (n=19)	Total Cases
Proximal Humerus	1	3	4
Distal Humerus	0	1	1
Proximal Ulna	0	1	1
Distal Ulna	1	0	1
Proximal Radius	0	2	2
Distal Radius	0	4	4
Proximal Tibia	0	3	3
Distal Tibia	1	0	1
Distal Fibula	1	1	2
Tarsal Bones	0	3	3
Metatarsal	1	0	1
Metacarpal	0	1	1
Scapula	1	0	1

The anatomical distribution of the lesions is detailed in Table 2. While ABCs were found across a variety of sites including flat bones and small bones, GCTs demonstrated a strong predilection for the major

long bones of the upper and lower extremities, particularly around the knee (proximal tibia) and wrist (distal radius).

Table 3: Radiographic and Computed Tomography (CT) Characteristics

Imaging Feature	Aneurysmal Bone Cyst (n=6)	Giant Cell Tumor (n=19)
Location within Bone		
Metaphyseal / Diaphyseal	6 (100.0%)	0 (0.0%)
Epi-metaphyseal	0 (0.0%)	19 (100.0%)
Zone of Transition		
Narrow, well-defined	6 (100.0%)	19 (100.0%)
Wide, ill-defined	0 (0.0%)	0 (0.0%)
Articular Surface Involvement		
Spared (Does not abut joint)	5 (83.3%)	0 (0.0%)
Reaches Subchondral/Articular Margin	1 (16.7%)	19 (100.0%)
Cortical Involvement		
Cortical Thinning / Expansion	6 (100.0%)	19 (100.0%)
Focal Cortical Breach	2 (33.3%)	11 (57.9%)
Internal Architecture (X-ray/CT)		
Visible Internal Septations	6 (100.0%)	5 (26.3%)
Purely Lytic (No visible septa)	0 (0.0%)	14 (73.7%)
Other Features		
Matrix Calcification / Mineralization	0 (0.0%)	0 (0.0%)
Periosteal Reaction	0 (0.0%)	0 (0.0%)

Table 3 outlines the primary features observed on conventional radiography and CT. The most significant differentiating factor was the lesion's location within the bone; 100% of GCTs exhibited epi-metaphyseal involvement reaching the subchondral articular margin, whereas all primary ABCs were confined to the metaphyseal or diaphyseal regions.

Table 4: Magnetic Resonance Imaging (MRI) Characteristics

MRI Parameter	Aneurysmal Bone Cyst (n=6)	Giant Cell Tumor (n=19)
T1-Weighted (T1W) Signal		
Predominantly Hypointense	6 (100.0%)	0 (0.0%)
Isointense to muscle / Heterogeneous	0 (0.0%)	19 (100.0%)
T2-Weighted (T2W) / STIR Signal		
Uniformly/Multilocular Hyperintense (Cystic)	6 (100.0%)	0 (0.0%)
Heterogeneously Hyperintense (Solid-Cystic)	0 (0.0%)	19 (100.0%)
Internal Architecture		
Exclusively Multicystic / Lobulated	6 (100.0%)	0 (0.0%)
Predominantly Solid	0 (0.0%)	19 (100.0%)
Fluid-Fluid Levels		
Present	6 (100.0%)	2 (10.5%)
Absent	0 (0.0%)	17 (89.5%)
Solid Soft-Tissue Enhancing Component		
Absent (Peripheral/Septal enhancement only)	6 (100.0%)	0 (0.0%)
Present (Marked, heterogeneous enhancement)	0 (0.0%)	19 (100.0%)

The comparative MRI characteristics are presented in Table 4. MRI effectively differentiated the exclusively multilocular, cystic architecture of primary ABCs from the predominantly solid nature of GCTs. Notably, while characteristic fluid-fluid levels were present in 100% of primary ABCs, they were also observed as a secondary finding in 10.5% of GCT cases.

DISCUSSION

Differentiating Giant Cell Tumor (GCT) and Aneurysmal Bone Cyst (ABC) is crucial due to divergent surgical management strategies[2]. Our series of 25 cases reinforces that anatomical location is the most reliable initial differentiator: all GCTs exhibited hallmark epi-metaphyseal involvement extending to the subchondral bone, while primary ABCs were restricted to metaphyseal or diaphyseal regions[1].

While MRI is invaluable for mapping internal architecture, our findings highlight a significant diagnostic pitfall. Although multilocular cystic spaces with fluid-fluid levels were present in 100% of primary ABCs[4], identical secondary aneurysmal changes were observed in 10.5% of our GCT cohort[3]. Therefore, fluid-fluid levels are not pathognomonic for primary ABC[5]. The definitive radiological feature remains the presence of a solid, enhancing soft-tissue matrix on post-contrast MRI, which is invariably present in GCTs but absent in primary ABCs. Recognizing these specific patterns prevents misdiagnosis and optimizes patient-specific surgical planning.

CONCLUSION

While MRI fluid-fluid levels strongly suggest primary Aneurysmal Bone Cysts, they also occur secondarily in Giant Cell Tumors. Therefore, the combination of epi-metaphyseal location, subchondral extension, and a solid enhancing matrix on MRI remains definitive for GCT. Accurate radiological differentiation is essential for guiding appropriate patient-specific surgical management.

IMAGE PLATES

Case 1: Primary Aneurysmal Bone Cyst of right distal ulna

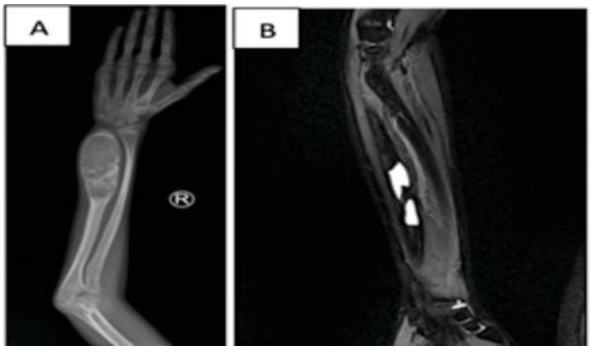

Figure 1 (A-B): A 7-year-old female with a primary ABC of the right distal ulna. Note the purely cystic architecture and sedimentation of blood degradation products on MRI.

Case 2: Primary Aneurysmal Bone Cyst of right distal fibula

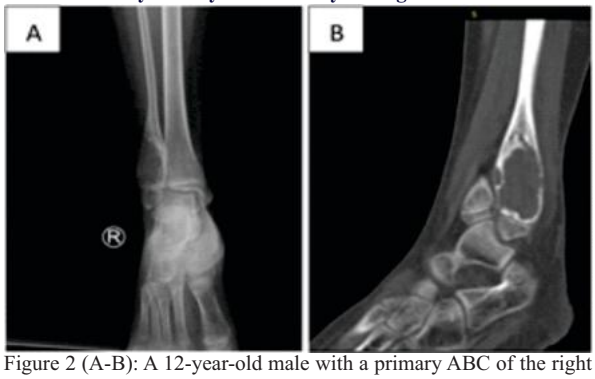

Figure 2 (A-B): A 12-year-old male with a primary ABC of the right distal fibula. Radiography reveals a characteristic expansile "blow-out" lytic lesion. CT imaging provides superior detail of the thin osseous margins and internal septations.

Case 3: Primary Aneurysmal Bone Cyst of the left scapula

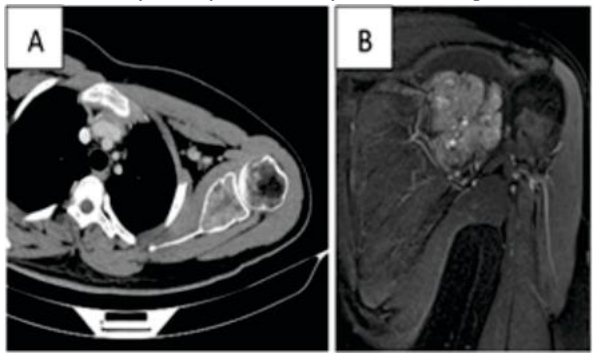

Figure 3 (A-B): A 17-year-old male with a primary ABC of the left scapula, demonstrating characteristic multilocular expansion and

fluid-fluid levels in an atypical flat bone location.

Case 4: Primary Aneurysmal Bone Cyst of left 2nd metatarsal

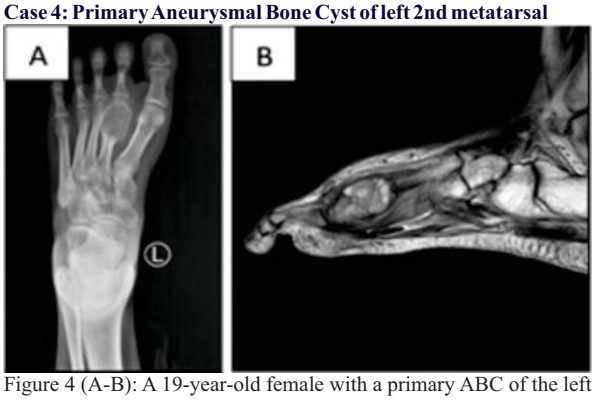

Figure 4 (A-B): A 19-year-old female with a primary ABC of the left 2nd metatarsal. The lesion remains strictly metaphyseal/diaphyseal without articular surface involvement.

Case 5: Primary Aneurysmal Bone Cyst of left distal tibia

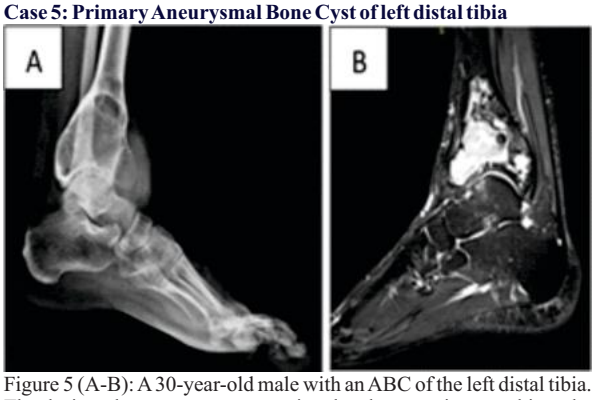

Figure 5 (A-B): A 30-year-old male with an ABC of the left distal tibia. The lesion demonstrates aggressive local expansion reaching the subchondral bone, mimicking GCT, but retains a purely multicystic architecture on MRI.

Case 6: Giant Cell Tumor of left proximal ulna (olecranon).

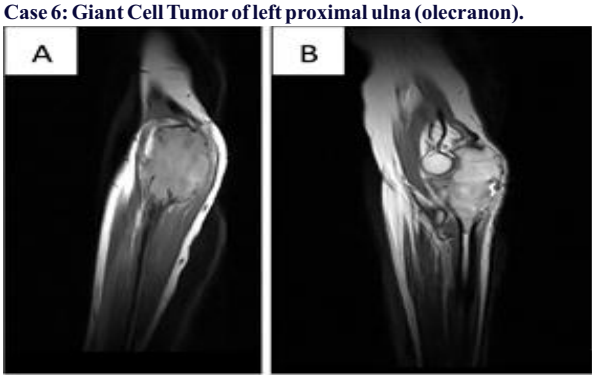

Figure 6 (A-B): A 25-year-old female with a GCT of the left proximal ulna. Radiography demonstrates the hallmark epi-metaphyseal location extending to abut the subchondral articular surface. MRI confirms a highly vascular, solid tumor.

Case 7: Giant Cell Tumor (with secondary ABC) of right proximal tibia

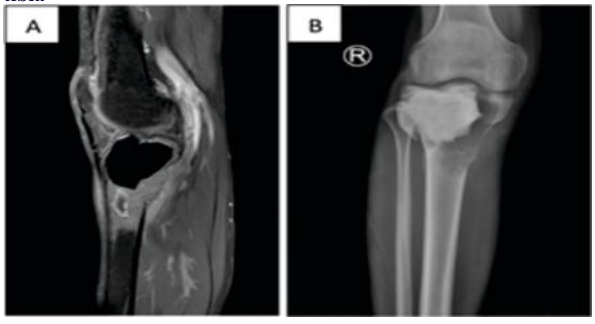

Figure 7 (A-B): A 30-year-old male, Post bone cementing status for GCT of the right proximal tibia. The MRI illustrates an altered marrow signal intensity. Plain radiograph shows cortical breaks, suggestive of recurrence.

Case 8: Giant Cell Tumor of the right proximal tibia

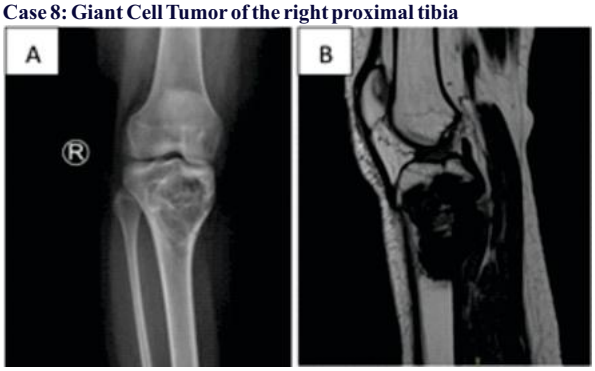

Figure 8 (A-B): A 19-year-old female with GCT of the right proximal tibia. The coronal MRI clearly depicts the subchondral extension and solid nature characteristic of uncomplicated GCTs.

Case 9: Giant Cell Tumor of left proximal humerus

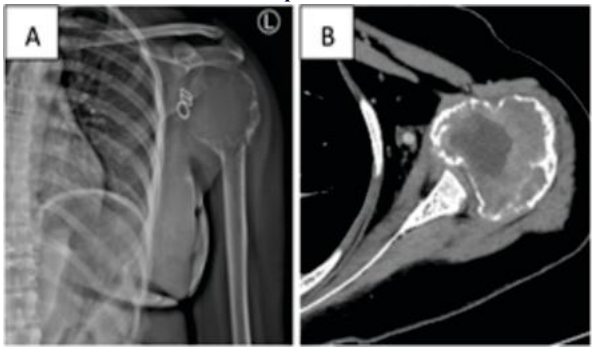

Figure 9 (A-B): A 23-year-old female presenting with an aggressive GCT of the left proximal humerus, complicated by a pathological fracture and significant soft tissue extension.

Case 10: Giant Cell Tumor (with secondary ABC) right distal humerus

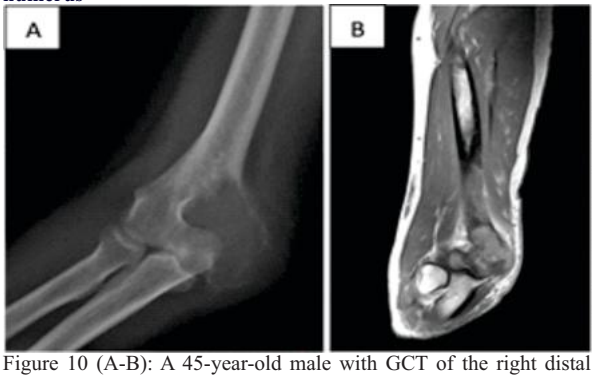

Figure 10 (A-B): A 45-year-old male with GCT of the right distal humerus. Advanced MRI sequences highlight the juxta articular position of highly cellular solid tumor and secondary aneurysmal cystic spaces.

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