Fundamental Concepts of Musculoskeletal Neoplasm: Radiographs

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Introduction of the Players: Bone Tumors

Tumors are classified by their pattern of differentiation. Tumors are graded on their degree of anaplasia.

Skeletal Components Derived From Embryonal Mesenchyme

- Bone and cartilage progenitor cells
- Periosteal cells
- Hematopoietic cells
- Lipocytes
- Nerve and Schwann cells
- Fibroblasts
- Osteoclasts and osteoclast-like cells
- Endothelial cells
- Perithelial cells
- Notochordal cells (rests)
- Histiocytic cells
- Epithelial cells (rests)

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Incidence of Bone Tumors  
*Figure 1*
- Approximately one individual in 75,000 develops a primary bone tumor that leads to biopsy
- About 4,000 new cases per year

Incidence of Bone Tumors  
*Figures 2 to 4*
- Of biopsied primary bone tumors: malignant tumors are 3 times more common as benign lesions
- Metastatic lesions are biopsied about 35 times more frequently than primary tumors

Important Factors in Diagnosis of Bone Tumors  
*Figures 5 & 6*
- Patient age and sex
- Bone involved
- Location of bone
- Lesion margin
- Matrix formation
- Periosteal reaction

These radiologic characteristics reflect the pathologic process and its biologic activity.
Primary Benign Bone Tumors:
Age Distribution by Decade  [Figure 5]

![Graph showing age distribution of primary benign bone tumors by decade.]

Figure 5  
Dahlin DC. Data on 8542 Cases. 1986

Primary Malignant Bone Tumors:
Age Distribution by Decade  [Figure 6]

![Graph showing age distribution of primary malignant bone tumors by decade.]

Figure 6  
Dahlin DC. Data on 8542 Cases. 1986

“The site frequency, peak age of incidence, and numerical frequency of bone tumor indicate that they are not completely autonomous, but are subject to the laws of field behavior and developmental anatomy of normal bone...”

Johnson L. 1953.

Location in Bone: Longitudinal  [Figures 7 & 8]
- Epiphysis
- Metaphysis
- Diaphysis

![Image showing location in bone: longitudinal.]

Figure 7  
Chondroblastoma with lytic lesion in the epiphysis.

Figure 8 A, B & C
Ewing sarcoma involving the femoral diaphysis on radiograph, T1-weighted MR, and gross specimen.

Location in Bone: Axial  [Figures 9 & 10]
- Central
- Eccentric
- Cortical
- Juxtacortical
- Soft tissue

![Image showing location in bone: axial.]

Figure 9  
Axial location in bone.

Figure 10  
Lesion location in bone.

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Pattern of Bone Destruction and Lesion Margin  

- **Type 1: Geographic**
  - A: Well-defined, sclerosis
  - B: Well-defined, no sclerosis
  - C: Ill-defined
- **Type 2: Motheaten**
- **Type 3: Permeative**
- Transition zone

**Figure 11**  
*Patterns of bone lysis.*

Margin Reflects Biologic Activity

**Aggressive vs Nonaggressive**

**Biologic Activity**

<table>
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<tr>
<th>Margin</th>
<th>Growth Rate</th>
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<tr>
<td>Geographic 1A</td>
<td>Slow</td>
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<tr>
<td>Geographic 1B</td>
<td>Slow to intermediate</td>
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<tr>
<td>Geographic 1C</td>
<td>Intermediate</td>
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<tr>
<td>Motheaten</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Permeative</td>
<td>Fast</td>
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**IA Margin**  

- Geographic
- Well-defined
- Sclerosis

**Figure 12**  
*Geographic 1A.*

**Geographic 1A: Differential Diagnosis**  

- Bone cyst
- Brodie abscess
- Cartilage lesions
  - Chondroblastoma
  - Chondromyxoid fibroma
  - Enchondroma
- Fibroblastoma
- Fibrous dysplasia

**Figure 13 A, B & C**  
*Nonossifying fibroma/fibroxanthoma with geographic 1A margin on radiograph, gross specimen, and macrosection.*

**Figure 14 A & B**  
*Brodie abscess with geographic 1A margin. Note the channel-like extension (arrow) representing a sinus tract inferiorly on the conventional tomogram (right image).*

**1B Margin**  

- Geographic
- Well-defined
- No sclerosis

**Figure 15**  
*Geographic 1B.*
Geographic 1B: Differential Diagnosis

- Giant cell tumor  
- Bone cyst  
- Cartilage lesions
  - Chondroblastoma  
  - Chondromyxoid fibroma  
  - Enchondroma  
- Fibrous dysplasia  
- Myeloma/metastasis

Figure 16 A & B
Giant cell tumor of the distal radius with geographic 1B margin on radiograph and macrosection extending to subchondral bone.

1C MARGIN  
[Figures 17 & 18]

- Geographic
- Ill-defined

Figure 17
Geographic 1C.

Geographic 1C: Differential Diagnosis

- Chondrosarcoma  
- Enchondroma (active)
- Malignant fibrous histiocytoma (MFH)/Fibrosarcoma  
  [Figure 18]  
- Giant cell tumor/aneurysmal bone cyst/chondromyxoid fibroma  
- Osteosarcoma  
- Metastasis/myeloma

Figure 18 A & B
Fibrosarcoma with geographic 1C margins, particularly laterally (arrowheads) on both the radiograph and macrosection.

Tumor Margin  
[Figures 19 to 22]

- Motheaten  
- Permeative

Figure 19 A & B

Figure 20
Permeative.

Lytic Bone Lesion Margin

- Type 1: Geographic
  - A: Well-defined, sclerosis  
  - B: Well-defined, no sclerosis  
  - C: Ill-defined  
- Type 2: Motheaten  
- Type 3: Permeative
Motheaten: Differential Diagnosis

[Figures 21 & 22]
- Ewing sarcoma
- Round cell tumors
- MFH/fibrosarcoma
- Osteomyelitis
- Osteosarcoma
- Langerhans cell histiocytosis (LCH)
- Metastasis/myeloma

Permeative: Differential Diagnosis

[Figures 21 & 22]
- Ewing sarcoma
- Round cell tumors
- MFH/fibrosarcoma
- Metabolic disorders
- Osteomyelitis
- Osteosarcoma
- LCH
- Myeloma/metastasis

Lytic Patterns

[Figure 23]

Invisible Margin

[Figure 24]

Changing Margin

[Figures 25 to 28]
- Increased biologic activity

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Hyperparathyroidism with variation of the permeative pattern of bone lysis in the cortex on radiograph and macrosection (multiple areas of resorption along haversian canals – arrows).
Matrix Formation

- I. Mineralized
  - Chondroid: rings, arcs, honeycomb [Figures 29 & 30]
  - Osteoid: ivory or cloudlike [Figures 31 & 32]

- II. Nonmineralized
  - Fluid
  - Soft tissue
  - Fat

Figure 26

Osteonecrosis (*) with malignant transformation to malignant fibrous histiocytoma showing new lysis (arrow) at periphery on specimen radiograph representing the changing margin.

Figure 27 A & B

Osteonecrosis (*) with malignant transformation to malignant fibrous histiocytoma on CT (same patient as previous radiograph) with new cortical destruction laterally and soft tissue mass (arrow).

Figure 28 A & B

Coronally sectioned gross specimen and macrosection showing osteonecrosis (*) and malignant fibrous histiocytoma arising at periphery (arrows) (same patient as previous radiograph and CT).

Figure 29 A, B & C

Pictorial representation of chondroid matrix.

Figure 30

Chondrosarcoma of the fibula on specimen radiograph and gross specimen showing “ring-and-arc” matrix mineralization (arrows).

Figure 31 A & B

Pictorial representation of ivory or cloud-like osteoid matrix.
Periosteal Reaction: Nonaggressive
[Figure 33]
- Solid (A)
- Buttressing (B)
- Expansion (C)
- Septation (D)

Periosteal Reaction: Aggressive
[Figures 34 & 35]
- Codman triangle (A)
- Sunburst (B)
- Hair-on-end (C)
- Laminated (D)

Figure 32 A & B
Osteosarcoma of the tibia with dense cloud-like matrix mineralization (arrows).

Figure 33
A, B, C & D

Figure 34
A, B, C & D

Figure 35
Osteosarcoma with aggressive "hair-on-end" periosteal reaction (arrows).
Polyostotic vs Monostotic Holes in Bone

Polyostotic Lesions: Benign
- LCH  [Figure 36]
- Enchondromatosis
- Fibrous dysplasia
- Hereditary multiple exostoses
- Osteomyelitis
- Paget disease
- Neurofibromatosis (type 1)
- Angiomaticous lesions

Polyostotic Lesions: Malignant
- Metastasis
- Multiple myeloma  [Figure 37]
- Hemangioendothelioma

![Figure 36](image)

*Langerhans cell histiocytosis with areas of calvarial lysis in the frontal and occipital areas (arrows).*

![Figure 37](image)

*Multiple myeloma on lateral skull radiograph with multiple areas of bone lysis.*

References
