“Incidental” Bone Lesions
When to Refer to the Tumor Specialist

LT Suezie Kim, M.D., M.C., U.S.N., Catherine N. Laible, M.D., Leon D. Rybak, M.D., and Timothy B. Rapp, M.D.

Abstract
Incidental bone tumors are, by definition, asymptomatic lesions that are discovered through routine radiographs obtained for other reasons. Generally, these lesions are benign and latent, requiring no further intervention except observation. However, occasionally these radiographs will detect benign aggressive processes or even malignant lesions that do require further treatment and referral to a tumor specialist. Oftentimes, there are characteristic findings on radiographs that are pathognomonic. Knowledge of these findings can simplify the treatment algorithm for a practicing general orthopaedist. This article will describe radiographic characteristics of benign and malignant bone lesions and their typical presentations. It will then focus on the types of bone lesions that are often found incidentally by routine radiography. Specific recommendations, including recommendation for referrals to orthopaedic tumor specialists, will be noted for lesions described. Most malignant lesions will present with pain and a constellation of history and physical exam findings that will signal the patient to seek medical care; although they will be mentioned for the sake of comparison and completeness, they will not be the focus of this review.

Incidental bone tumors are asymptomatic lesions that are discovered by routine radiographs obtained for other reasons.1 An orthopaedic surgeon may encounter incidental lesions in their practice. The purpose of this review is to distinguish the classic radiographic findings of benign versus malignant lesions and their typical presentations. We will also provide a brief description of common incidental lesions that an orthopaedist may encounter and give recommendations for referral to a tumor specialist.

History and Physical Examination
The typical presentation of an incidental lesion found on radiograph is pain located near the site of the lesion. The lesion is not attributable to the source of pain for the patient. In contrast, a malignant lesion will typically present with pain at the site of the lesion and can be associated with a mass.

A thorough history and physical examination will also aid in differentiating benign and malignant lesions. The age of the patient can help to narrow down the diagnosis of bone lesions. Incidental lesions typically found in children include unicameral bone cyst, fibrous dysplasia, and non-ossifying fibroma. On the other hand, diagnoses specific to older patients include metastasis, multiple myeloma, enchondroma, and subchondral cysts. Usual questions about the quality, location, radiation, alleviation, and worsening of pain should be inquired. Information from the history that can help alert a physician to the possibility of a malignancy include night pain, constitutional symptoms (such as fever, chills, change in weight, change in sleep pattern), as well as a previous history of tumor or malignancy or a family history of tumor or malignancy.2 Thorough history of past treatment of tumors, surgical history of biopsy or excision, and pathology results should be addressed.

A comprehensive physical exam should be performed. The area of concern should be visually inspected, palpated, and the range of motion should be assessed. A motor and sensory exam should be performed and involved joint-specific tests done. Exam findings more worrisome for malignancy include tenderness over site of lesion, an associated mass,
tender lymph nodes, café au lait spots, and cutaneous hemangiomas. If a mass is found on exam, the size, consistency, mobility, temperature, and change in position should be assessed.

Imaging

Imaging is a standard diagnostic modality in many orthopaedic diagnoses. When an incidental bone lesion is found on standard radiograph, characterization of the lesion can be very helpful in determining if the lesion is benign or malignant. Miller provided an overview of the characterizations of bone lesions in his radiographic review. He specifies seven specific radiographic features of bone lesions.

The first is the location of the bone lesion. This can be described as the position of the lesion in the skeleton: axial or appendicular. It can also be specific to its longitudinal location: epiphysis, metaphysis, or diaphysis. Epiphyseal equivalents include apophysis, patella, small bones of the wrist, and hindfoot and midfoot.

The second is the margin of the lesion. “What is the tumor doing to the bone?” Benign lesions tend to be more geographic, focal, with discrete margins. In contrast, malignant lesions often have a “moth-eaten” or permeative appearance. The borders are ill-defined, mottled, and patchy in appearance with a broad zone of transition. Small round blue cell lesions that are malignant tend of have this type of appearance with ill-defined areas of lytic bone destruction and small holes.

Another feature to observe is the periosteal reaction around the lesion. “What is the bone doing to the tumor?” Benign lesions are typically slow-growing and therefore have a solid or unilamellated periosteal reaction. A pathologic fracture associated with a benign lesion would also have a periosteal new bone or callus formation. On the other hand, malignant lesions are fast growing; therefore, the surrounding bone has difficulty containing the lesion. This produces a multilamellated or “onion skin” appearance as seen with Ewing’s sarcoma. A spiculated appearance, also called “hair-on-end” or “sunburst,” occurs when new bone is laid down perpendicular to the cortex along Sharpey’s fibers. A codman triangle can also be seen, which forms due to elevated periosteum. These features are common in aggressive and malignant lesions such as osteosarcoma. Occasionally malignant lesions can cause erosion of the inner surface of the cortex and produce endosteal scalloping. When the malignant tumor gets large, it can cause cortical expansion and disruption.

The matrix can further classify the lesion. Specific matrices do not indicate malignancy. However, it is helpful to narrow down the lesion into general categories depending on the matrix it produces. Osteoid matrix appears amorphous and fluffy with solid mineralization. This is seen in bone-producing lesions such as osteoid osteoma, osteoblastoma, and osteosarcoma. The appearance of cartilage producing lesions consists of punctate opacities, with rings and arches, and “popcorn” densities. This is seen in lesions such as enchondroma and chondrosarcomas. Fibrous matrix is commonly described as “ground glass” or hazy in appearance, as seen in fibrous dysplasia. Some lesions, such as cysts, have no mineralization.

The size and number of lesions can also aid in differentiating between bone lesions. For instance the size of the nidus is important in the diagnosis of an osteoid osteoma versus an osteoblastoma (less than 1 cm compared with more than 2 cm respectively). The number of lesions can be indicative of specific tumors as well. Most primary bone lesions are solitary. Examples of tumors that can have multiple lesions are metastasis, myeloma, lymphoma, brown tumors, multiple enchondromatosis, and fibrous dysplasia.

On radiographs, it is hard to detect the presence of soft tissue masses. However, if one is seen, it may contribute to a specific diagnosis.

Overall, all of these features and characteristics viewed separately cannot differentiate between benign and malignant lesions consistently. However, certain combinations of these findings may help to narrow down the differential. Additionally, other imaging modalities can be obtained if a lesion is worrisome for a malignancy. Computed tomography (CT) is recommended to further assess lesions with osteoid matrix. This modality can better delineate the size of a nidus in osteoid osteoma or osteoblastoma, cortical thinning in an aneurysmal bone cyst, or to look for lung metastasis. Magnetic resonance imaging (MRI) can be helpful for additional visualization of bone and soft tissue lesions. Bone scan uptake levels can help to differentiate some lesions. For example, myeloma and renal cell carcinoma can appear cold on bone scan. It will also show skip

Figure 1 Lateral radiograph of the distal femur demonstrating intramedullary popcorn-like calcifications with no associated soft tissue mass or periosteal reaction around the lesion. This radiograph is typical of the appearance of an enchondroma.
lesions as well as metastasis.

**Bone Producing Incidental Lesions**

Enostoses are also known as bone islands. These lesions are a focus of cortical bone within cancellous bone. They are asymptomatic lesions that can occur in any bone but are more commonly found in the pelvis and long bones. They are also more common in adults. On radiographs, they appear as homogenous, round, or oval-shaped lesions and radiopaque in cancellous bone. Sometimes radiating bone streaks that appear as “thorny radiation” or “pseudopodia” may be present. On bone scan, there is usually mild or no uptake. If high uptake is found, it is unlikely enostosis but rather a more aggressive lesion. The treatment of these benign lesions is to observe with serial x-rays. If the lesion becomes painful or increase in size, a biopsy may need to be done.

**Cartilage Producing Incidental Lesions**

Enchondromas are hyaline cartilage tumors in the medullary canal. They typically are asymptomatic; however, lesions in the hands or feet may be painful. The radiographic appearance of these lesions is a central medullary location, well circumscribed with punctuated (stippled or popcorn-like) appearance (Fig. 1). Cortical thinning may be present in enchondromas of the hand and may lack the typical rings and arc or punctuate calcifications (Fig. 2). The treatment for this benign lesion is observation with serial x-rays. If the lesion becomes symptomatic or has an increase in growth, curettage and bone graft may be indicated. Maffucci syndrome and Ollier disease is associated with multiple enchondromas with increased risk of malignant transformation (Fig. 3). In patients with these conditions, operative treatment may be indicated for treatment of deformities and malignant transformation.

**Fibrous Incidental Lesions**

Fibrous dysplasia is a lesion that is a developmental abnormality where there is a replacement of bone with fibrous tissue. It is typically seen in children and young adults. However, it can occur at any age. Fibrous dysplasia is usually asymptomatic but can be associated with a pathologic fracture. The appearance on x-ray images is a central, geographic lesion that looks like “ground glass or shower door glass” with a sclerotic rim. It occurs in the metaphysis or diaphysis and can be associated with a bowing deformity (shepherd’s crook deformity, Fig. 5). This benign lesion can be observed with serial radiographs. If symptomatic or associated with a pathologic fracture, curettage and bone graft...
with or without fixation is the treatment. Bisphosphonates have also been shown to provide pain relief.\textsuperscript{7,9}

Non-ossifying fibroma (fibrous cortical defect or metaphyseal fibrous defect) is also a lesion that is a developmental abnormality where there is a defect in ossification. This benign lesion is usually asymptomatic and can be associated with a pathologic fracture. These lesions are seen in children and adolescents. They can regress or ossify with skeletal maturity. On x-rays, the lesion is eccentric, geographic, and mostly radiolucent with multiloculations (Fig. 6). It can have a sclerotic rim and have cortical expansion and thinning. It is a metaphyseal lesion but can appear to be diaphyseal with growth. Treatment for this benign lesion is observation with serial x-rays. Curettage, bone graft, with or without fixation is the treatment for symptomatic lesions or pathologic fracture.

\textbf{Incidental Tumor-like Conditions of Bone}

Unicameral bone cysts (UBC) are filled with serous fluid. These bone lesions are asymptomatic but can be seen in association with a pathologic fracture. Patients typically present in the first two decades of life. On radiographic examination, the lesion is radiolucent, centrally located, well circumscribed, and metaphyseal (near the growth plate, Fig. 4).
It can appear to be in the diaphysis with growth. There is a pathognomonic sign called "the fallen leaf sign," which is a thin cortical fragment that falls into the cyst. Some of the more common locations of UBCs include the proximal humerus, proximal femur, pelvis, and calcaneus. Observation is the usual treatment for these incidental lesions; however, they are worrisome for fracture. Another treatment option is to inject the cyst with steroid. If the cyst is associated with a pathologic fracture, the healing process will typically fill in the cyst. Large, symptomatic lesions can be curettaged and bone grafted.

Intraosseous ganglions are an extension of soft tissue ganglia. These lesions are commonly seen in middle-aged men and can be asymptomatic. On radiographs they are well circumscribed, radiolucent, typically subchondral in location and with a sclerotic rim. They can also be multiloculated. If the lesion is asymptomatic, treatment is observation with serial x-rays. Symptomatic lesions are treated with soft tissue excision and bone lesion curettage.

Bone infarcts can also be found incidentally. They are usually associated with other underlying diseases such as Gaucher’s disease, alcoholism, sickle cell, systemic lupus erythematosus, and history of steroid use. The appearance on x-rays is a well circumscribed metaphyseal lesion with irregular borders. There is peripheral calcification, unlike cartilage lesions which may have calcification throughout. Asymptomatic lesions can be observed with serial radiographs. If symptomatic, a workup needs to be done to determine the etiology.

Heterotopic ossificans (HO) is defined as bone formation outside of skeletal tissue. This can be found incidentally or can cause decreased range of motion. HO is associated with traumatic brain injury, spinal cord injury, burns, and extremity trauma. X-rays demonstrate a soft tissue mass with mineralization that starts peripherally. This is in contrast to osteosarcoma which commonly has central mineralization. Non-operative treatment includes observation, nonsteroidal antiinflammatory drugs (NSAIDs), bisphosphonates, and...
physical therapy. Surgical excision can be done if the HO interferes with function.

Subchondral cysts can be seen as an incidental lesion frequently in association osteoarthritis. Patients present with symptoms attributable to arthritis. It generally affects middle-aged to elderly populations. A well circumscribed, periarticular, radiolucent lesion is seen on x-ray. It is also associated with other radiographic features of osteoarthritis including joint space narrowing, osteophytes, and subchondral sclerosis. The subchondral cyst is treated symptomatically with the osteoarthritis.

**Incidental Malignant Lesion**

It is uncommon to have malignancy present as an incidental lesion without associated constitutional symptoms; however, it can happen. Multiple myeloma is a neoplastic plasma cell proliferation that is ordinarily symptomatic but can be asymptomatic. These lesions can also be associated with pathologic fracture. The patients are typically older than 40 years of age and are more commonly seen in men. On radiographic evaluation, there are multiple radiolucent lesions with no surrounding sclerotic. The lytic lesions appear to be “punched out.” On bone scan these lesions usually have no increased uptake due to little osteoblastic activity. The treatment includes chemotherapy, bisphosphonates, radiation, and possible surgical stabilization for fractures.

Metastases can also present incidentally although they are more commonly painful. They can also be associated with a pathologic fracture. The patients are usually older than 40 years of age. In the history, there may be associated constitutional symptoms and possibly a known primary malignancy. On radiographs, the bony lesions do not tend to have associated soft tissue involvement. Prostate and bladder cancer metastasis are osteoblastic while lung, kidney, and thyroid cancer are osteolytic, and breast cancer is usually mixed. When a lesion suspicious for a metastasis is found, a work up, including bone scan, chest CT, and labs, such as complete blood count, basic metabolic panel, erythrocyte sedimentation rate, c-reactive protein, serum protein electrophoresis, urine protein electrophoresis, urinalysis, thyroid panel and liver panel, as well as possible bone marrow biopsy (if myeloma is considered), should be done. The specific treatment depends on the primary cancer. For management of pain, bisphosphonates, radiofrequency ablation, and radiation can be considered. If there is an impending fracture, prophylactic fixation could be a treatment option.

**Conclusion**

When an orthopaedic surgeon encounters an incidental bone lesion, a careful history and physical exam is the first step. The radiographic images should then be thoroughly evaluated using the features described in the section above. If the lesion has a benign appearance and the presenting pain or symptoms can easily be explained by a common orthopaedic diagnosis, then observation and serial radiographs are appropriate. If the bone lesion has an aggressive and or malignant appearance, a workup should be started as mentioned in the previous section. This includes bone scan, CT of the chest, and labs. An MRI may also be considered to further assess the lesion.

The general overview of the initial evaluation of an incidental lesion provided in this paper should help the orthopaedic surgeon determine if a lesion has benign or malignant characteristics. The brief descriptions of commonly seen incidental bone lesions should also aid in determining a diagnosis. However, the question of when to refer to a tumor specialist remains. If a bone lesion is not incidental and is the source of pain or symptoms that the patient is experiencing, a referral should be made. Most importantly, if there is any question or concern of any bone lesion, the tumor specialist should be contacted.

**Disclosure Statement**

None of the authors have a financial or proprietary interest in the subject matter or materials discussed, including, but not limited to, employment, consultancies, stock ownership, honoraria, and paid expert testimony.

**References**