Osteoid Osteoma—The Role of Bone Scans in Diagnosis and Surgery

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Osteoid osteoma is a benign bone tumor which is most often seen in young males. Several imaging techniques have been used for the detection of osteoid osteoma lesions. Conventional x-ray was found to detect only two-thirds of lesions. Computerized tomography has been used to determine the extent of the osteoid osteoma's progress, particularly the soft tissue involvement. In this study, the radionuclide three-phase bone scan was positive in all six patients with surgically proven osteoid osteoma. In addition, nuclear medicine scans of bone specimens may be used to predict whether all of the tumor has been removed. Incomplete excision will likely result in recurrence. Since ^{99m}Tc-MDP (methylene diphosphonate) is blood borne, it reflects blood flow to the tumor site. It also adsorbs onto the hydroxyapatite crystal. Its concentration is proportional to osteoblastic activity. A study was undertaken to evaluate the use of the three-phase bone scan in patient's referred with possible osteoid osteoma. In addition, scans of bone samples were used during the surgical procedures to evaluate complete tumor renewal.

Osteoid osteoma is a solitary benign bone tumor which appears as a tightly woven mass of tissue usually less than 1 cm in diameter with a good vascular supply (*1–3*) and accounts for 10% of benign osseous neoplasia (*4*). It is mainly seen in young males with up to 4:1 male:female prevalence reported (*1,5*). The patients' ages usually range from 10–25 yr old, although the condition may extend to 5–35 yr.

The most common sites of the osteoid osteoma are in the long bones, especially the femur and the tibia (65%). Ten percent have been reported in the vertebral column, and the rest are found in the carpals, tarsals, ribs, scapulae, patellae, calvarium, and the mandible (*2,6*).

The tumor is associated with pain, which may be mild at first, but progresses to severe. It is a continuous aching pain which is worse at night. It is thought that the pain is related to the tumor's high density of vascular and nerve fiber tissue (*4*). A localized palpable swelling may occur. The overlying skin is not reddened or warm to the touch. The patient's temperature and white cell count are normal.

If this lesion is in the lower extremities, the patient may experience limping, weakness, muscle atrophy, and depressed tendon reflexes. In the thoracic and lumbar vertebrae, it can produce a rigid painful scoliosis. In the cervical spine, torticollis may occur (*1*).

Pain may be referred from the tumor site. An osteoid osteoma in the lumbar spine, for example, may present itself as sciatica down the patient's leg. All possible sites should be examined.

Treatment is by complete excision of the nidus, or recurrence is likely (*2,5*). With incomplete excision, the patient will continue to have pain and will require a second operation to remove the tumor (*7*). Malignancy has not been reported after surgery (*3*).

The differential diagnosis for osteoid osteoma includes osteoblastoma, chrondroblastoma, Brodie's abscess, and eosinophillic granuloma. For diagnosing osteoid osteoma, conventional x-ray has a varying degree of sensitivity. Fifty-five to ninety-three percent of lesions have been reported (*4*). Conventional tomography may be useful to localize or to better distinguish the osteoid osteoma. A dense cortical thickening may mask the tumor on the plain x-ray, and a tomogram can accurately locate the nidus within these areas. The computerized tomogram will also accurately locate the nidus and determine its extent, especially the soft tissue involvement (*7*).

The three-phase bone scan has a sensitivity approaching 100% in detecting osteoid osteoma. A negative scan can virtually exclude the diagnosis (*8*). If necessary, a ^{67}Ga-citrate scan can further help distinguish an osteoid osteoma from small fractures or from osteomyelitis (Brodie's abscess) (*9*).

The accumulation of bone-seeking radionuclides in bone lesions is primarily dependent upon blood flow and on nonmetabolic exchange processes between normal constituents of the hydroxyapatite-crystalline structure and the radionuclides (*10*). The osteoid osteoma has a large vascular supply and a higher than normal number of osteoblasts. The tumor avidly takes up the commonly used bone agents.

Patients are injected with ^{99m}Tc-MDP (methylene diphosphonate). Since the agent is blood borne, it reflects blood flow to the tumor site. It also adsorbs onto the hydroxyapatite crystal. Its concentration is proportional to osteoblastic activity.

MATERIALS AND METHODS

Eleven patients, ages 4–16, with suspected osteoid osteoma were referred for bone scans. Patients were positioned on the imaging table, with the scintillation camera over the suspected area. A butterfly needle, attached to a 4-way stopcock is inserted into the patient's vein. Technetium-99m-MDP was then rapidly injected, and the line was flushed with saline. Flow images were recorded on film and acquired on a computer

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TABLE 1. Summary of Results of ^{99m}Tc-MDP Three-Phase Bone Scan Compared to Radiologic Findings

Age	Suspected Area	Plain X-rays	Nuclear Medicine Scans			CT Scan	^{99m}Tc-MDP Bone Tracing?
			Bone Flow	Blood Pool	Bone Delay		
13	left knee, femoral epiphysis	showed soft tissue swelling possible sclerosis	+	+	+	+	yes
4	left calcaneous	mild demineralization	+	+	+	+	not done
16	right femoral neck	questionable right femoral neck	+	+	+	+	yes
16	right proximal tibia	not done	+	+	+	+	yes
14	left mid-tibia	probable osteoid osteoma	+	+	+	+	yes
5	right femoral head	possible sclerosis with irregularity and thickening osteoid osteoma	+	+	+	+	yes
14	negative	right great toe	—	—	—	not done	not done
10	negative	left 6th rib at costo-chondral junction	—	—	—	not done	not done
16	negative	lumbar spine	—	—	—	not done	not done
10	negative	right knee	—	—	—	not done	not done
9	negative	left knee	—	—	—	not done	not done

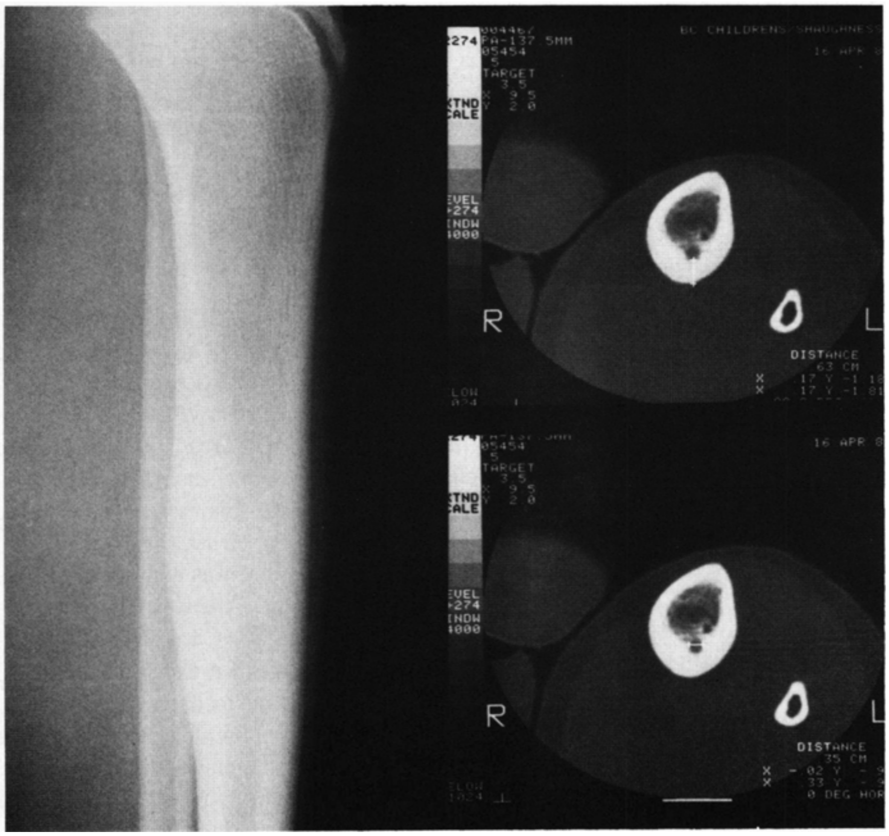

FIG. 1. Radiograph (left) in a 14-yr-old male showing cortical thickening in the left mid-tibia with a suggestion of a central lucent area. The CT scan (right) demonstrated a 3-mm nidus located at the junction between the medulla and cortex.

at a fast-framing rate of 2–5 sec/frame for 90 sec. Two-minute images are then taken of the area from different angles. In addition, adjacent areas are imaged since they are possible sites of involvement referring pain to the suspected area. The images may also reveal stress on the opposite limb. At 2 hr post injection, the images are repeated.

Surgical ^{99m}Tc-MDP tracing was done on the day of surgery. The patients were injected with ^{99m}Tc-MDP ~ 2 hr before surgery. When the tumor is excised, the nidus and the surrounding removed bone are brought to the nuclear medicine

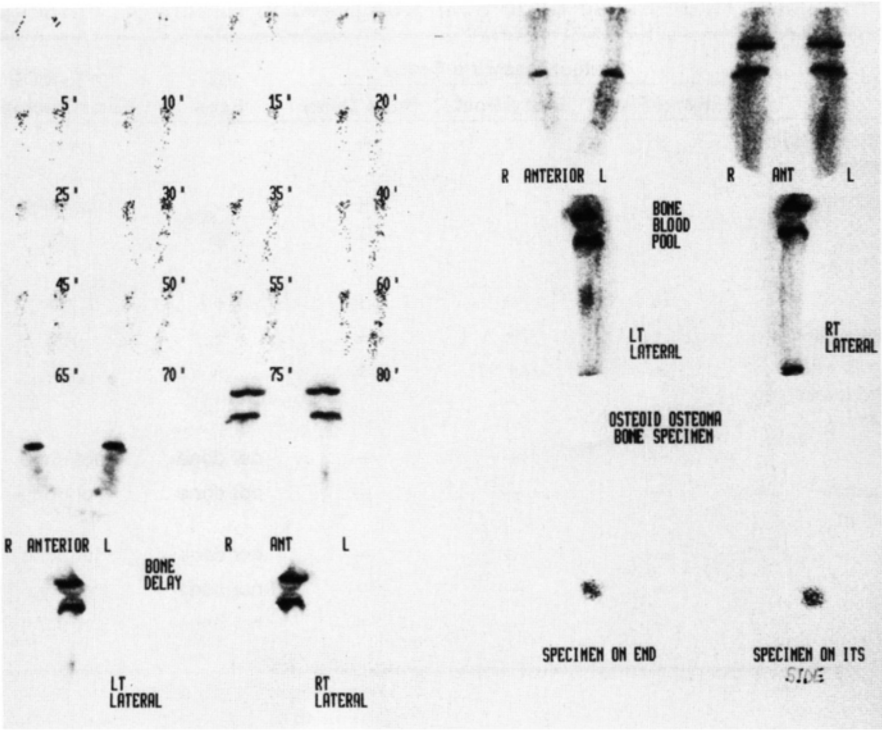

FIG. 2. Three-phase bone scan in a 14-yr-old male shows increased blood flow to the left tibia (upper left), which is also seen on the blood-pool images (upper right). The delayed images show a focal area of increased activity in the left tibia (lower left) in surgical specimens.

department and imaged. If the specimen of surrounding bone has comparable activity to the nidus, the surgeon is guided to remove more of the surrounding bone since the bone-surrounding specimens have much less ^{99m}Tc-MDP uptake than the nidus.

RESULTS

Table 1 summarizes the study findings. The three-phase bone scan detected an osteoid osteoma in six patients. Conventional tomograms were not performed on these patients. Computed tomography scans were found to be positive in all six cases. On the plain x-rays, one was probable, one was not done and the rest had nonspecific findings of soft tissue swelling, sclerosis, and mild demineralization and bone thickening.

In the remaining five patients, the nuclear medicine bone scan was negative. These patients also had negative plain x-rays. None of these patients were referred for CT scans. Diagnostic studies were terminated in these patients.

Five of the six patients who were positive for osteoid osteoma had ^{99m}Tc-MDP tracings done during surgery. The specimens were imaged with a scintillation camera. In each instance, a high uptake was shown in the nidus whereas the surrounding bone specimen showed much less (normal) uptake.

DISCUSSION

Osteoid osteoma is a solitary benign bone tumor with symptoms of mild to severe pain which may be controlled with salicylates. Because the tumor has a large vascular supply and high osteoblastic activity, it avidly takes up the bone scan radiopharmaceuticals. The three-phase bone scan has ~ 100% sensitivity in detecting these lesions. Our results show the osteoid osteoma with increased uptake and blood flow. The results correlate well with the positive CT scan findings. The plain x-rays, however, are not very helpful for diagnosing the tumor.

The following cases show the usual evident increased blood flow and uptake in osteoid osteoma.

Case 1:

A 14 yr-old-male with no history of injury. His complaint was constant night pain in his left ankle. The pain was relieved with aspirin. Plain x-rays of his left tibia and ankle (Fig. 1) showed cortical thickening in the left mid-tibia. There was also a suggestion of a central lucent area. The x-rays were otherwise normal. A three-phase bone scan (Fig. 2) showed an increased blood flow to the left tibia as compared to the right. The suspected area also showed focal hyperemia and increased uptake of the tracer. There was also some diffuse ^{99m}Tc-MDP uptake in the left ankle. This was felt to be a result of undue stress on the left foot. The CT scan (Fig. 1) demonstrated a 3-mm nidus. It was located 6 mm below the cortical surface and at the junction between the medulla and the cortex.

The patient went to surgery for complete excision of the osteoid osteoma. The surgical specimen showed high uptake of the ^{99m}Tc-MDP. There was a surrounding rim of decreased activity compared to the center. These findings predicted complete removal of the nidus. Plain x-rays at 4 mo post-surgery revealed healing of the left tibia which was covered by a well formed callous.

Case 2:

A 16-yr-old male with no history of injury. His complaint was a 7-mo history of pain in his anterior right thigh. He also

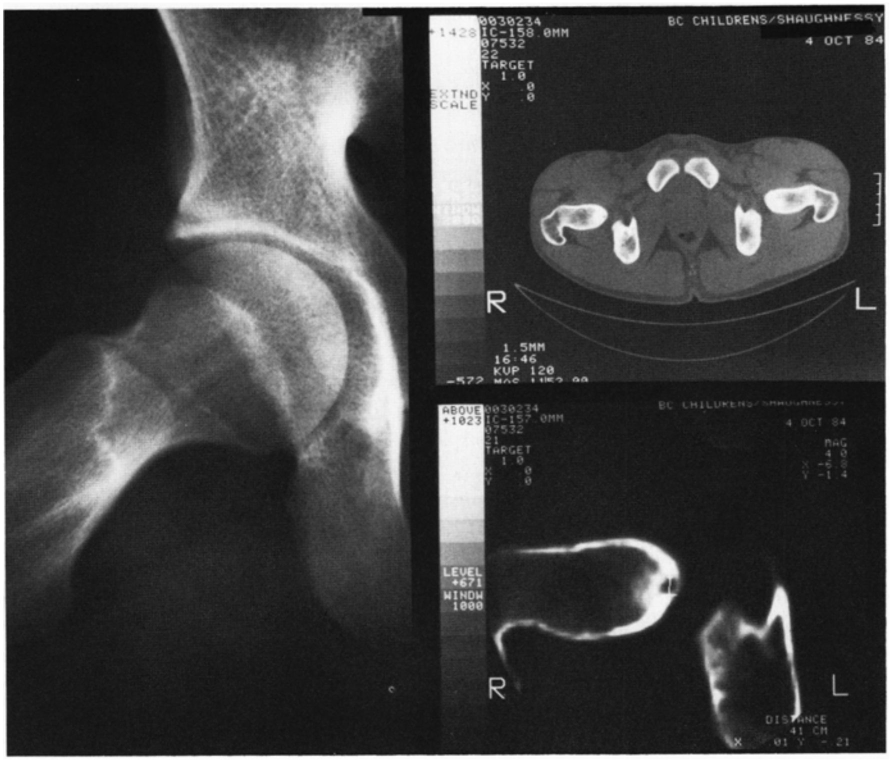

FIG. 3. Radiograph (left) in a 16-yr-old male showing a small radiolucent area with no surrounding sclerosis. The CT scan (right) demonstrated a small area of necrosis in the proximal medial portion of the right femoral neck.

complained of pain in the lumbar spine. Plain x-rays (Fig. 3) were taken of his pelvis in the frog-leg position. The right femoral neck showed a small radiolucent area with no surrounding sclerosis. The three-phase bone scan (Fig. 4) revealed a small focus of activity in the right femoral neck. This was evident in the blood flow, blood pool, and delayed bone images. The CT scan (Fig. 3) showed a small area of necrosis with a central lucency seen in the proximal medial portion of the right femoral neck.

The patient went to surgery for complete excision of the osteoid osteoma. Surgical specimens were imaged. It was noted that the nidus appeared to be of equal mass to the sur-

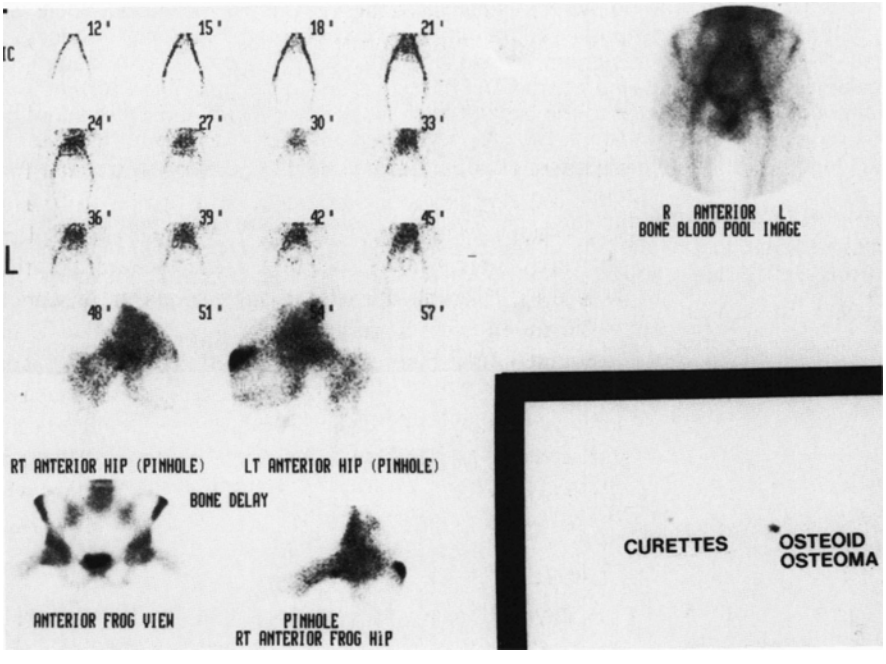

FIG. 4. Three-phase bone scan in a 16-yr-old male reveals a small focus of activity in the right femoral neck (upper left), which is also evident in blood-pool (upper right), and the delayed bone (lower left) images.

rounding bone specimen (curette). The nidus showed high uptake of the ^{99m}Tc-MDP whereas the curettes showed much less radioactivity.

CONCLUSION

The ^{99m}Tc-MDP bone tracing was helpful in predicting whether complete excision of the tumor was performed. Quantitative data may be attempted. Our results, however, did show a very significant difference in bone agent uptake between the tumor and nontumor specimen.

The bone scan proved to be very helpful in ruling out osteoid osteoma in five cases. The patients had also presented with pain. In each case the plain x-rays were normal. None of these patients had CT scans. Diagnostic workup for osteoid osteoma was terminated at this stage. Procedure cost and radiation exposure were minimized. Our limited study showed that the nuclear medicine three-phase bone scan and bone tracing proved to be very successful in diagnosing the osteoid osteoma and in guiding the surgeon in the tumor's excision.

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