The Role of Bone Scintigraphy in the Evaluation of Talar Dome Fractures

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We undertook a retrospective study of 122 patients with ankle pain to determine the accuracy of bone scintigraphy using ^{99m}Tc-methylene diphosphonate (MDP) for detection of osteochondral talar dome fractures (OCTDF). Plain radiographs, which were available in 97 patients, had not revealed any abnormality in the talar dome. Bone scintigraphy was followed by CT, which was considered to be the reference test in diagnosing OCTDF. Analysis of our data showed that when the bone scan findings in the two highest confidence categories (high and moderate probability) were accepted as abnormal, the sensitivity and the specificity of the test were 0.94 and 0.76, respectively. Although CT is mandatory to establish the stage of OCTDF, it cannot be used routinely due to its high cost. Bone scintigraphy appears to be a good screening procedure that will identify patients who are likely to benefit from further radiographic studies such as CT. These findings are subject to further confirmation in a prospective study.

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Osteochondral fractures of the talar dome usually result from injuries to the ankle. Early diagnosis and treatment of these fractures is associated with an improved outcome and in less late degenerative changes in the ankle joint (*1,2*). Due to the complex anatomy of this region, a definitive diagnosis of osteochondral talar dome fractures (OCTDF) in patients with ankle pain of acute or chronic onset may be difficult. Plain radiographs are of limited value, particularly soon after injury (*3*). Although CT accurately delineates the subarticular surfaces and the body of the talus, it cannot be performed as a routine procedure due to its high cost and delay.

Bone scintigraphy, which demonstrates bony abnormalities by revealing changes in metabolism and blood flow, is an effective diagnostic test that can be used to evaluate the talus and its articulations when the etiology of persistent ankle pain remains undiagnosed by plain radiography. When the presence of bony damage is revealed by scintigraphy, the abnormality can then be further assessed by conventional tomography or CT. Although it has been proposed as a screening method for detection of OCTDF, the sensitivity and specificity of bone scintigraphy has yet to be established in a large patient series (*4*).

The aim of this study was to determine the accuracy of ^{99m}Tc-methylene diphosphonate (MDP) bone scintigraphy in the detection of OCTDF in patients with post-traumatic persistent ankle pain.

PATIENTS AND METHODS

In a retrospective study we examined the records of 122 patients with acute or chronic ankle pain seen at University of British Columbia Sports Medicine Clinic between January 1986 and December 1989. The patient files were reviewed to identify the type of injury and the location of pain. Plain radiographs were available in 97 patients (80%), which were all negative for OCTDF. Patients who had evidence of OCTDF on plain radiographs were excluded from this study. All patients were evaluated by ^{99m}Tc-MDP and subsequently by CT. Bone scintigraphy was performed within 3 mo of injury in 36 (30%), within 6 mo of injury in 55 (45%), and within 12 mo of injury in 75 (61%) patients. The time interval between the injury and the bone scan was longer than 12 mo in 26 (21%) cases and could not be determined in 21 (18%).

Bone scintigraphy was performed following intravenous injection of 555–740 MBq of ^{99m}Tc-MDP. Dynamic images were acquired over the distal lower extremities every 2 sec for 1 min using a gamma camera. The blood flow was evaluated in the injured ankle region and was compared to the normal contralateral side. Flow was graded as 9 when normal, 1+ when slightly increased, 2+ when moderately increased and 3+ when markedly increased. A 250,000 count blood-pool image was obtained immediately after the radionuclide angiogram. Blood-pool images of the injured ankle were also evaluated, compared to the contralateral side, and graded from 0 to 3+. Delayed scintigraphy was performed 3 hr after injection and images were acquired for 5 min using a 256 × 256 matrix with a ¾-inch crystal in the anterior, lateral and medial projections. The images were evaluated for intensity of uptake adjacent to the ankle joint mortice and graded subjectively. Grade 0 indicated no increased uptake. Grade 1 images revealed minimal increased uptake compared to the contralateral side. Grade 2 and 3 images revealed moderate and markedly increased uptakes compared to the contralateral side, respectively.

Independent evaluation of the bone scans was carried out by

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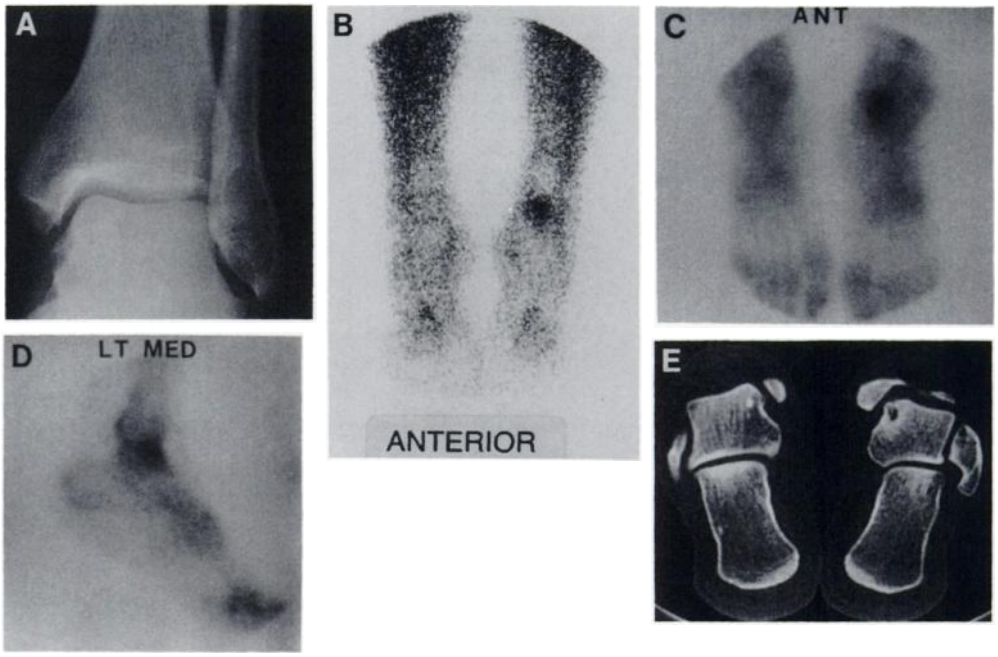

FIGURE 1. (A) Normal plain radiograph of the left ankle in a patient with persistent post-traumatic left ankle pain. (B–D) Blood-pool and delayed bone scan images of the feet taken from anterior and medial aspect of the left ankle demonstrates markedly increased activity in the talus. This pattern is compatible with OCTDF. (E) Coronal CT confirmed the presence of osteochondral cyst in the medial aspect of the left talus (Stage IIA).

two observers according to the above criteria and the readings were made without knowledge of the CT findings.

Final analysis of the bone scans included categorizing patients into probability groups based on the degree and pattern of radiotracer activity. High probability was defined as the presence of definite abnormalities involving the talar dome both on anterior and lateral projections (Fig. 1). Moderate probability consisted of examinations where focal abnormality was noted either in the medial or lateral ankle mortice but, with uncertain exact localization (talar dome or malleolus). Diffuse activity involving the ankle or focal abnormalities clearly visualized in the lateral or medial malleolus were defined as low probability. Bone scintigraphy was defined as negative when no abnormality was demonstrated in the talar dome or ankle mortice. Patients with lesions elsewhere in the ankle, hindfoot and midfoot were also categorized as having negative bone scans for OCTDF.

All patients were subsequently evaluated by CT. For 71 patients (58.2%), CT scans were performed within 4 wk of the bone scan and for 104 patients (84.4%) within 8 wk of the bone scan. CT (Siemens Somatom DR2 Ehrlanger, Germany) was performed in semicoronal and tangential planes and adjacent 2-mm slices were obtained. CT was regarded as the reference test by which the final diagnosis was established. The lesions were categorized using the five-stage classification system described by Anderson et al. (*5*), in which Stage 1 is subchondral trabecular compression; Stage 2 is incomplete separation of the cartilaginous fragment, Stage 2A is formation of a subchondral cyst; Stage 3 is an unattached, undisplaced fragment, and Stage 4 is displaced fracture fragment.

Statistical analysis of the results was performed using the Statistical Package for the Social Sciences (SPSS 4.0, Chicago, IL, 1990) software package. Positive results were based on lesion characterization at the two highest confidence levels (moderate and high probability). Sensitivity was defined as the number of OCTDFs correctly diagnosed in patients with talar dome fractures who were evaluated. Specificity was defined as the proportion of patients without an OCTDF who had negative or low probability bone scan. Accuracy was defined as the fraction of lesions correctly characterized in all patients and the positive predictive value was defined as the probability of OCTDF in a patient with a moderate or high probability bone scintigraphy. Negative predictive values were defined as the absence of OCTDF in a patient with negative or low probability bone scintigraphy. Pearson correlation coefficients were calculated to determine the association between variables. Patients who were found to have lesions elsewhere on CT were not included in the statistical analysis.

RESULTS

The mean age of the patients in the study was 31.2 ± 10.7 (mean ± s.d.) with a range of 15 to 74 yr. Of the 122 patients, 61 (50.0%) had inversion injuries, 24 (19.6%) had direct trauma to the ankle, 13 (10.7%) had recurrent ankle sprain, and 13 (10.7%) had miscellaneous injuries. Eleven (9%) patients were not able to recall a history of trauma to the ankle. Plain radiographs of the injured ankle were available in 97 patients who were all negative for OCTDF.

Both observers classified 115 of the 122 patients identically; after a review, consensus was obtained for 7 patients regarding image interpretation and diagnostic impression.

No significant correlation was observed between the time interval following injury and delayed bone scintigraphic findings ($p > 0.05$) (Fig. 2). Blood-pool images revealed hyperemia in all patients with OCTDF, except one patient who had an ankle injury two years prior to the bone scintigraphy. No statistically significant correlation was found between the time of injury and the blood-pool images. There was a negative correlation between the time of injury and the flow study ($r = -0.45$, $p < 0.05$). When the time interval between the injury and the bone scintigraphy was less than 12 mo, all patients showed hyperemia

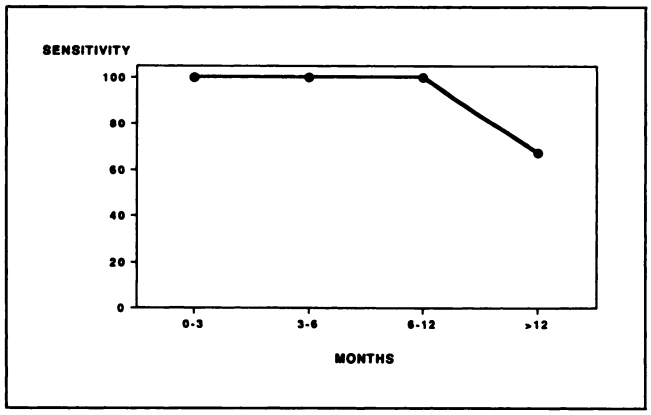

FIGURE 2. Changes in sensitivity of bone scintigraphy related to elapsed time since injury.

on the angiogram phase. However, hyperemia was noted in only 7 of 11 patients (64%) when the time interval between injury and the bone scintigraphy was longer than 12 mo.

Eighteen patients had negative bone scans; none had OCTDF on CT, but CT showed evidence of degenerative disease in the ankle in two. Only 2 (5%) of 39 patients with low probability bone scans had OCTDF on CT. CT was negative for 17 patients and showed lesions elsewhere in the ankle in 20. Therefore the negative predictive value of a negative or low probability bone scan was 94%. The two patients with low probability bone scintigraphy had Stage 1 fractures on CT. One of these patients, who underwent bone scintigraphy two years earlier that indicated moderate probability relative to diagnosis of OCTDF, showed a focus of increased activity involving the ankle mortice. The change in findings was due most probably to the healing of the lesion during the interval between the two bone scans. The second patient, who had a distal fibular fracture four years ago, had lateral ankle pain and tenderness at the time of the bone scan, which showed increased radiotracer uptake involving the lateral malleolus. The bone scan was reported as fibular stress fracture and low probability for OCTDF. CT revealed new bone formation at the site of the previous fibular fracture along with an osteochondral lesion (Stage 1) in the medial dome. Since this patient did not have any medial ankle pain, we assumed that this lesion in the medial talar dome was old and not the cause of the patient's symptoms.

In the 46 patients with moderate probability bone scans, CT showed OCTDFs in 17 (37%). No abnormalities were demonstrated in 10 (22%), whereas 19 (41%) had lesions elsewhere in the ankle. Of the patients with lesions elsewhere in the ankle, six had distal tibial lesions, three had avulsion injuries, three had an os trigonum (the posterior tubercle of the talus with an accessory ossification center), two had degenerative changes in the ankle joint, one had a lateral malleolar fracture, one had a bone island, one had talocalcaneal fusion, and one had a subtalar cyst. The sensitivity and specificity of a moderate probability bone scan were 89% and 75%, respectively.

In 25 patients with high probability bone scans, CT showed OCTDF in 23 (92%). One of the remaining two patients had os trigonum and the other had a fracture involving the body of the talus. For high probability bone scans, the sensitivity was 89% and the specificity was 100%.

DISCUSSION

Forty-six of 48 OCTDFs were correctly diagnosed by using the three-phase bone scan at the two highest confidence levels (high or moderate probability), yielding an overall sensitivity of 0.94 and a specificity of 0.76. The accuracy of bone scintigraphy was 0.84. In two instances, the bone scan revealed low probability, whereas CT revealed osteochondral lesions. In these instances, the history and the patients' symptoms helped to determine the nature of these lesions. We believe that old and metabolically inactive lesions account for these "false-negative" results. Sensitivity was 1.0 when a low probability bone scan was considered to be positive. However, this was at the expense of specificity, which dropped to 0.27.

The definitive diagnosis of OCTDF in a patient with a painful ankle may be difficult. Early diagnosis and treatment is associated with improved clinical outcome (*6,7*). Partially detached fragments and small compression fractures may be missed on plain films. This is particularly true if the radiographs are taken within the first few days after an acute injury. The radiographic appearance of an early osteochondral fracture consists of radiolucency within the talar dome. Subchondral sclerosis and bony resorption require time to develop due to a devascularized fracture fragment and nonunion (*8*). For these reasons, radiographs are of limited value. Location of an OCTDF can be accomplished using conventional tomography. However, with this diagnostic method, scattered radiation limits contrast resolution. CT is a valuable method by which to improve diagnostic accuracy in the foot and ankle (*9*) since it provides a cross-sectional picture of a lesion such as an OCTDF and multiple images can be obtained in either the axial or coronal planes. The drawback of imaging every sore ankle with CT is cost. However, being as precise as possible in localizing the area to be scanned will reduce both the examination cost and radiation exposure to the patient. On the other hand, bone scanning is an effective diagnostic test that can be used in evaluating the talus and its articulations. It can localize the injury which can then be evaluated by conventional tomography or CT.

In our series, 122 patients with ankle pain were evaluated with bone scintigraphy and CT. All had remained undiagnosed despite plain radiographs of the ankle, which were performed in 97 patients. Bone scans were catego-

rized as negative, or low, moderate and high probability for OCTDF based on the degree and pattern of radiotracer uptake. When two abnormal categories (high and moderate probability) were combined into one, the sensitivity and specificity of bone scintigraphy for detection of OCTDFs was 0.94 and 0.76, respectively, with an accuracy of 0.84. It should be noted that two patients who did not show any definite evidence of OCTDF on bone scintigraphy had previous lesions. Nineteen patients (41%) with moderate probability bone scans in this study had lesions elsewhere in the ankle, including distal tibial lesions, os trigonum, subtalar cyst or degenerative disease. In these instances, the bone scan may localize the disease site and direct the radiologists' attention to this area for further evaluation with CT. For this reason, we believe that bone scanning is the method of choice in the initial evaluation of OCTDF when plain radiographs fail to show the lesion.

In this study, CT did not demonstrate any abnormality in 10 (22%) patients with moderate probability bone scans. These patients might have had soft-tissue or ligamentous injuries that yielded false-positive results, which confirms an earlier observations that soft-tissue injuries alone may cause increased radiotracer uptake (*10,11*). Another hypothesis is that these patients had small avulsion injuries, cartilagenous lesions of the talar dome (*12*), compression injuries of the talar dome without structural disruption or malleolar stress fractures that were not visualized on CT.

In conclusion, bone scanning appears to be a good screening test for OCTDF with a sensitivity of 0.96 that establishes the presence and location of the lesion which can then be followed up by more extensive radiographic examinations. On the other hand, a negative bone scan implies the absence of active bony disease and obviates the need for further tests.

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