
Small Calvarial Bone Scan Foci—Normal Variations

John Harbert and Robert Desai

Department of Radiology, Georgetown University Hospital, Washington, DC

In a series of 3,000 bone scans reviewed retrospectively 21 (0.7%) small calvarial foci were observed. Seventeen of these lesions were found along skull suture lines. No evidence for metastatic disease could be found. Skull radiographs were normal and follow-up bone scans demonstrated no change in the size or location of the lesion. These intense calvarial foci are thought to represent normal variations; among the possibilities are subradiographic cartilaginous rests, sutural foramina, or enlarged Pacchionian granulations.

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An analysis of 3,000 serial bone scans between January, 1982, and June, 1983, was initiated to determine the efficacy of bone scanning in malignant diseases (Harbert, 1982; Arnstein et al., 1984). Among these scans, 17 cases of small, solitary, intense foci of calvarial uptake located along the suture lines were observed. In each case the suspicion of an early solitary calvarial metastasis was raised and skull radiographs or follow-up bone scans were obtained. This report describes the findings. These lesions are thought to represent normal bone scan variations. We offer some speculation as to their nature, and suggest how they might be differentiated from skull metastases.

METHODS AND RESULTS

The scan protocol in all cases was the same. Patients were scanned 2 to 3 hr following i.v. administration of 20 mCi (740 MBq) of technetium-99m methylenediphosphonate (^{99m}Tc]MDP). Anterior, posterior, and both lateral views of the skull were taken with wide field-of-view scintillation cameras. Images were integrated for the time required to obtain 500,000 counts over the anterior thorax. This usually results in >250,000 counts from the skull in all views. Examples of the scan findings are shown in Fig. 1. All the lesions were located along suture lines. The distribution is shown in Fig. 2. Skull radiographs were obtained in eight of the 17 patients. The interval between initial

bone scan and skull radiographs ranged from 1 wk to 22 mo. Serial skull radiographs were obtained in only one patient. All radiographs were interpreted as normal. Follow-up bone scans ($M = 15.3$ mo) were obtained in all 17 patients. In each case the size and location of the lesion was unchanged and there was no evidence of skeletal metastases in other locations. Dynamic blood-flow studies demonstrated no increased vascularity.

In the same series of bone scans, four similar small, solitary skull lesions were found that were located outside of suture lines. All four lesions became more intense or multiple on follow-up bone scans (Fig. 3). All four of these developed evidence of disseminated cancer. Skull films were obtained in two of these patients; both were interpreted as normal. However both patients had relatively small calvarial lesions that would not be expected to be visible roentgenographically. Because of definite lesion progression observed by bone scanning, these four lesions are believed to represent skull metastases.

DISCUSSION

The differential diagnosis of focal calvarial bone scan lesions includes metastases, calvarial meningioma, dermoid cyst, osteoma, enchondroma, fibrous dysplasia, and calvarial hemangioma. The most important distinction to be made is between malignancy and some benign process. All of the patients reported had solitary foci. About one-half of all solitary bone scan lesions outside of periarticular bone are found to be metastases and 6–8% of all bone metastases are solitary (1–3). In fact, four of 21 (20%) solitary calvarial foci we observed

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For reprints contact: John Harbert, MD, Dept. of Radiology, Georgetown University Hospital, Washington, DC.

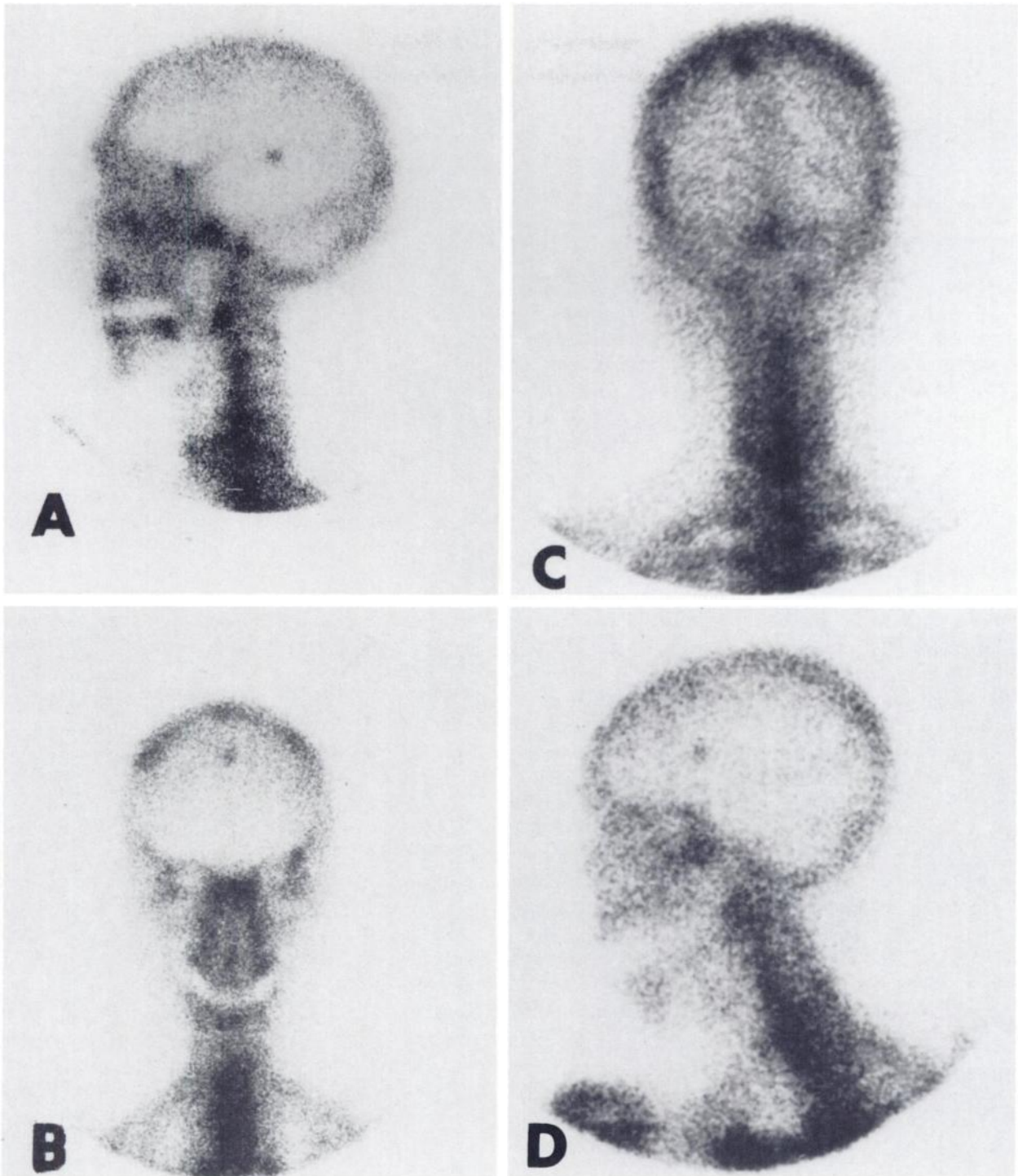
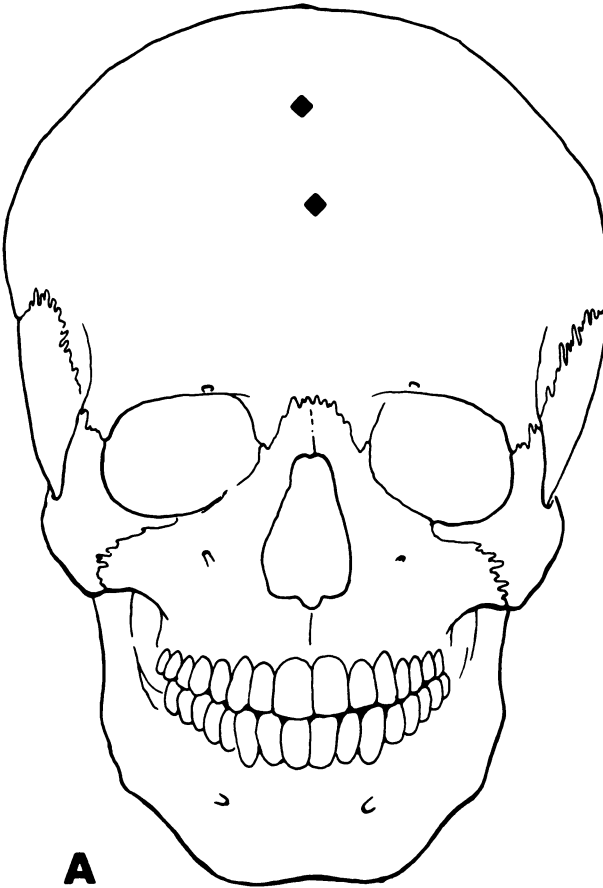


FIGURE 1
 Examples of solitary calvarial densities located in A: squamosal suture, B: metopic suture, C: sagittal suture (parietal foramen?), D: coronal suture. None of these foci changed in size or intensity in follow-up scans more than 1 yr later

did progress in size over 3–12 mo and were thought to represent metastases. It is the remainder that requires explanation.

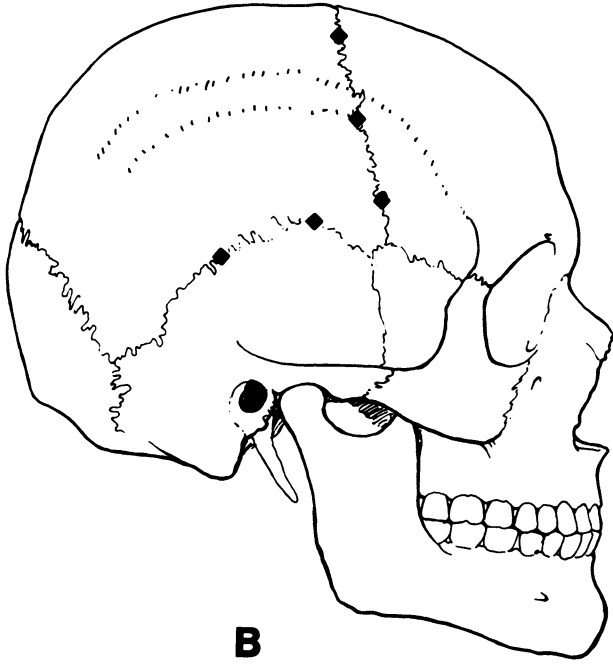
Bone hemangiomas are benign primary tumors composed of formed blood vessels. Radiographically they

are characterized by an outgrowth from the outer table of the skull, with prominent trabeculations in a honeycomb or sunburst pattern. The only bone scan we could find in the literature shows a coinlike skull lesion with raised projection from the outer table of the skull

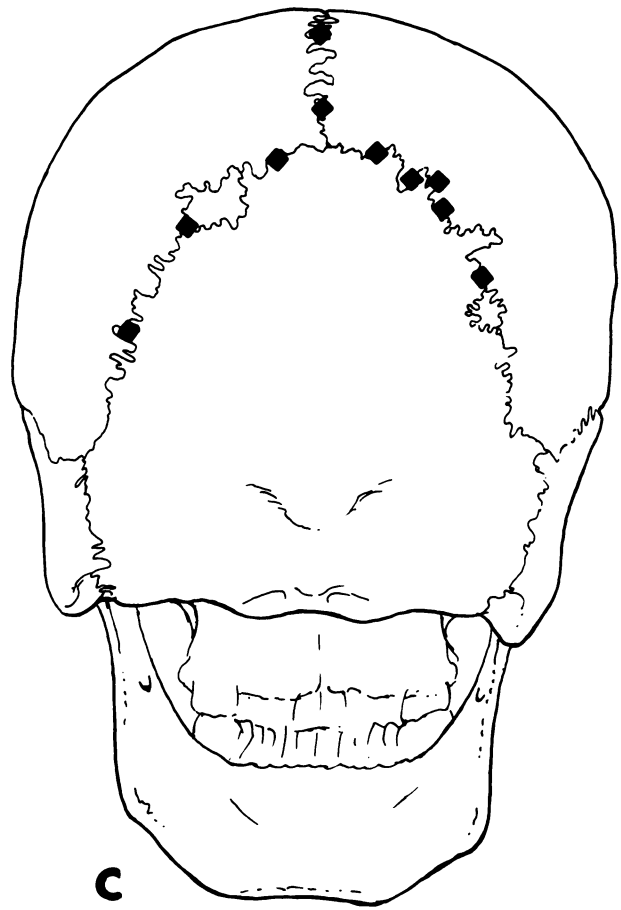


A

FIGURE 2
Distribution of discrete calvarial foci as seen from A: anterior, B: lateral, and C: posterior projections



B



C

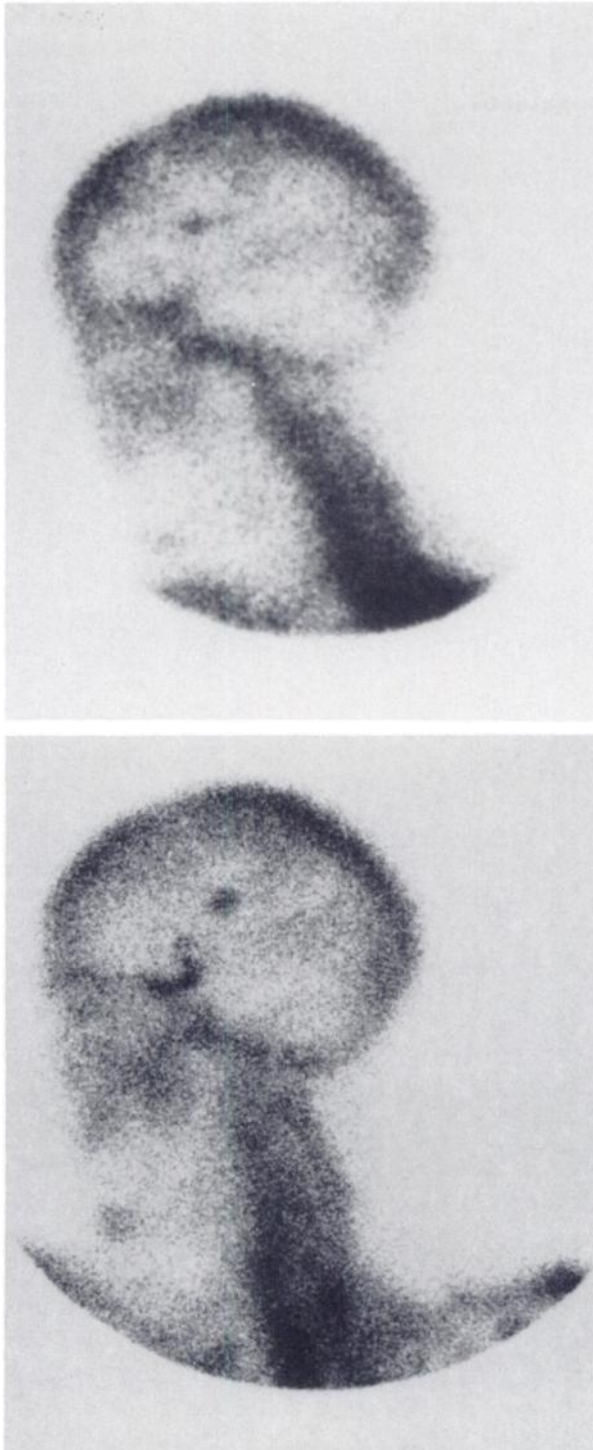


FIGURE 3

Upper: Small intense focus in left superior temporal line posterior to coronal suture. Lower: Same patient 5 mo later showing definite evolution of metastatic lesion

(4). The scan appearance in that patient bears no resemblance to the features shown in Fig. 1.

Enchondromas are hamartomatous proliferations of masses of cartilage within bone. When sufficiently large, they are roentgenographically visible, but one

might speculate that small cartilaginous rests might persist along the suture lines, giving rise to the metabolically active foci we have described.

Osteoid osteomas are known to concentrate [^{99m}Tc]MDP (5,6), but they are rarely encountered in the skull and are usually roentgenographically apparent (5). Fibrous dysplasia, on the other hand, is commonly found in the skull and may be localized or diffuse. Lesions are characterized by fibrous replacement containing scattered islands of immature bone. Uptake of radiophosphates is usually intense (7-9). If the phenomena we have described are small foci of fibrous dysplasia, it is not surprising that they would not be radiographically visible.

The bones of the cranial vault develop from mesenchyme that forms a connective tissue capsule for the forebrain (10). These bones ossify from centers that appear in the connective tissue membrane and spread rapidly, undergoing varying degrees of fusion. The frontal, temporal, parietal, and occipital bones unite along the suture lines. However fusion may not always be complete with the result that small clefts may persist (11). Occasionally small *os incae* may be left that never ossify and may or may not be radiographically apparent.

Parietal foramina are paired perforations on either side of the sagittal suture and observed in the postero-mesial aspect of the parietal bones. They extend from the inner to the outer tables and their margins are lined with periosteum (12). They are conduits for transosseous emissary veins that connect the intracranial with the extracranial venous system. The focus shown in Fig. 1B may be an example of an enlarged parietal foramen, although skull films were unremarkable.

Pacchionian granulations are arachnoid extensions into the lumen of the dural sinuses. Large granulations reach the inner table and produce local elevations and erosions. Occasionally they erode through the diploe and into the outer table (12). These erosions are usually visible only on exceptionally well-made radiographs. On the other hand they could account for the bone scan findings.

In summary, we find no single explanation for the observed phenomenon. The fact that these foci lie within calvarial suture lines suggests the presence of cartilaginous rest bodies which appear to have relatively long lives. Recognition of the apparent benignity of these foci is important to avoid the misdiagnosis of malignancy. When we encounter these foci, we continue to recommend repeat scans in 6 to 12 mo. If no change is observed in that time, we conclude that the process is a normal variation of calvarial architecture. We believe that skull roentgenograms are not likely to delineate lesions as small as we have described. Only when serial scans demonstrate lesion progression are roentgenograms likely to be of value.

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