Craniotomy flap osteomyelitis: a diagnostic approach


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Nine cases of suspected craniotomy flap osteomyelitis evaluated by combined bone and gallium scanning are presented. In six cases, the clinical data were inconclusive and evaluation by radionuclide imaging provided an accurate negative diagnosis. The other three cases considered positive by this technique were proven infected at subsequent exploration and flap removal. The use of radionuclide bone and gallium imaging should be considered in cases of possible cranioic flap osteomyelitis.

**Key Words** • osteomyelitis • infection • diagnostic imaging

**POSTOPERATIVE wound infections remain a major complication of craniotomy.** A combined incidence of 3% to 5% has been reported,\(^1,5,7,8,16\) with increased rates in certain high-risk groups.\(^10,20,22\) Bone-flap osteomyelitis has represented approximately one-third of these postoperative infections,\(^1,20\) necessitating flap removal and delayed cranioplasty in 1% to 2% of craniotomy patients. The ability to rule out osteomyelitis in the presence of soft-tissue healing and/or inflammation would minimize unnecessary surgical intervention and its potential medical and cosmetic complications.

The use of combined technetium-99m methylene diphosphonate (\(^{99m}\)Tc MDP) bone and gallium-67 citrate (\(^{67}\)Ga) radionuclide scans has been well described in the evaluation of long-bone and vertebral osteomyelitis.\(^2,6,12-14,18,21\) We have recently treated cases using this diagnostic technique, and our results suggest the value of these studies in assessing possible cranial flap osteomyelitis.

**Clinical Material and Methods**

Each patient examined was given a standard intravenous injection of 6.0 mCi \(^{67}\)Ga citrate and on the following day an injection of 20.0 mCi \(^{99m}\)Tc MDP. Imaging commenced 4 hours after the second injection using a gamma camera with a large field of view.* Two

\* Searle LFOV gamma camera manufactured by Siemens Medical Systems, Inc., Iselin, New Jersey.


\(\uparrow\) Imaging computer, Model MDS-A² manufactured by Medical Data Systems A², Ann Arbor, Michigan.
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**Fig. 1.** Studies in Case 2. A: The 24-hour gallium-67 citrate scan, posterior vertex view, showing a small area of increased activity around the posterior margin of the craniotomy (arrows). B: The corresponding 4-hour technetium-99m methylene diphosphonate bone scan showing a bright rim of activity around the entire circumference of the flap. C: The Ga:Tc ratio image (which is normalized so that normal bone of a geometry similar to the flap is blue) indicates that high ratio values expected in soft tissues are pink and red while low ratio values around the rim of the flap are yellow and white. A preponderance of osteoblastic activity relative to inflammatory activity around the flap is thus mapped by the Ga:Tc ratio image.

sequent ratio image were then set to zero and the cranioplasty site appears as a black void.

Table 2 presents a summary of the clinical course of the nine patients in this series. Representative cases are described in more detail below.

**Illustrative Case Reports**

**Case 2**

This 65-year-old man presented 6 weeks after excision of a left parietal parasagittal meningioma. He noted erythema, tenderness, and occasional swelling in the region of the craniotomy flap, and gave a history of a fever of 104°F. On examination, the suture line appeared healthy and well healed. There was tenderness on deep palpation of the flap. The patient was afebrile.

Complete blood count at the time of evaluation was normal, and Westergren sedimentation rate was 28 mm/hour. Combined 99mTc MDP and 67Ga scanning was interpreted as negative for osteomyelitis (Fig. 1). A

**TABLE 1**

<table>
<thead>
<tr>
<th>Ga:Tc Ratio</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1:2</td>
<td>white</td>
</tr>
<tr>
<td>1:2-2:3</td>
<td>yellow</td>
</tr>
<tr>
<td>2:3-9:10</td>
<td>green</td>
</tr>
<tr>
<td>9:10-11:10</td>
<td>blue</td>
</tr>
<tr>
<td>11:10-3:2</td>
<td>pink</td>
</tr>
<tr>
<td>3:2-2+:1</td>
<td>red</td>
</tr>
</tbody>
</table>

**TABLE 2**

Clinical summary of nine patients with suspected craniotomy flap osteomyelitis*

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Operative Diagnosis</th>
<th>Findings Suggesting Bone-Flap Osteomyelitis</th>
<th>Final Diagnosis</th>
<th>Follow-Up Period (mos)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>36, F</td>
<td>rt parietal meningioma</td>
<td>wound drainage; incision-line granulation tissue; radiographs suggestive of osteomyelitis</td>
<td>granulomatous reaction to methyl methacrylate cranio-plasty</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>65, M</td>
<td>lt parietal meningioma</td>
<td>scalp flap tenderness; history of scalp flap swelling, erythema, &amp; 104°F fever</td>
<td>soft-tissue inflammation</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>48, F</td>
<td>lt pterional meningioma</td>
<td>scalp fluctuate, tenderness, &amp; erythema</td>
<td>subgaleal CSF collection</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>37, F</td>
<td>lt frontal glioblastoma</td>
<td>100.3°F fever; scalp erythema &amp; tenderness; radiographs suggestive of sinusitis</td>
<td>influenza syndrome</td>
<td>10.5</td>
</tr>
<tr>
<td>5</td>
<td>46, F</td>
<td>rt MCA aneurysm ligation</td>
<td>100.2°F fever; scalp tenderness &amp; (?) fullness; chronic hemodialysis</td>
<td>urinary tract infection</td>
<td>11</td>
</tr>
<tr>
<td>6</td>
<td>62, F</td>
<td>ACoA aneurysm ligation</td>
<td>scalp flap erythema &amp; induration; radiographs suggestive of osteomyelitis</td>
<td>infarcted cortical bone with chronic cellulitis of periosteal tissue</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>17, M</td>
<td>cranioplasty after brain abscess &amp; VP shunt</td>
<td>purulent drainage from scalp sinus tract</td>
<td>infected cranioplasty &amp; skull osteomyelitis</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>28, M</td>
<td>rt frontal parietal AVM</td>
<td>purulent drainage from scalp</td>
<td>staphylococcus aureus scalp infection; skull osteomyelitis</td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td>49, M</td>
<td>temporal lobe hematomata</td>
<td>incision-line erythema; purulent drainage; 102.4°F fever</td>
<td>Staphylococcus aureus scalp infection; skull osteomyelitis</td>
<td>1</td>
</tr>
</tbody>
</table>

*CSF = cerebrospinal fluid; MCA = middle cerebral artery; ACoA = anterior communicating artery; VP = ventriculoperitoneal; AVM = arteriovenous malformation.
FIG. 2. Studies in Case 5. A: The 24-hour gallium-67 citrate scan, right lateral view, showing no abnormal activity. B: The 4-hour technetium-99m methylene diphosphonate bone scan showing a rim around the craniotomy site. C: The Ga:Tc ratio (which is normalized to uninvolved bone over the occipital region) indicates the expected yellow and white rim characteristic of osteoblastic repair which far outstrips inflammatory processes.

wound aspirate was sterile. The patient has remained well, and the bone flap remained in place 14 months after surgery.

Case 5

This 46-year-old woman presented 2 months after right pterional craniotomy for clip ligation of a right middle cerebral artery aneurysm. She had a history of polycystic kidney disease with chronic renal failure requiring hemodialysis twice weekly. She developed a low-grade fever, headache, and a small bulging area underlying the skull flap. On examination, there was mild tenderness at the operative site. A region of fullness seemed associated with an underlying burr hole. The patient's temperature was 100.2°F. Combined 99mTc MDP and 67Ga scanning was unremarkable for osteomyelitis (Fig. 2). Further outpatient evaluation revealed a urinary tract infection. At her 11-month follow-up visit, the patient remained well.

Case 6

This 62-year-old woman presented 3 years after clip ligation of an anterior communicating artery aneurysm. Her immediate postoperative course was complicated by a retroperitoneal hemorrhage requiring surgical evacuation and arterial repair. She subsequently under-

FIG. 3. Skull radiographs in Case 6, anteroposterior (left) and lateral (right) views, showing a lucent area in the middle of the portion of bone affixed to the craniotomy site. This appearance was highly suggestive of osteomyelitis.
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An exploratory craniotomy at that time revealed a fragment of wood causing the infection. Thereafter, he developed postmeningeal hydrocephalus requiring ventriculoperitoneal shunting and underwent a number of shunt revisions, the last of which was performed approximately 8 months prior to the current admission. There was a chronic draining wound in the right frontal region at the site of the previous cranioplasty, as well as drainage from the right parieto-occipital region; both of these conditions were followed in the outpatient clinic.

On admission, the patient appeared acutely ill with a temperature of 100.4°F. Neck examination showed definite rigidity. Scalp examination showed purulent drainage in the right frontoparietal region over the cranioplasty plate. He was lethargic but arousable and would follow commands; he also exhibited a left hemiparesis. On the day of admission, cultures of the scalp were obtained that grew coagulase-positive Staphylococcus aureus and light Pseudomonas aeruginosa. Lumbar puncture was performed and the cerebrospinal fluid (CSF) obtained had a glucose concentration below detectable limits and a protein level of 777 mg%. The peripheral white blood count was 18,900/cu mm and the CSF white blood count was 10,400/cu mm with 85% polymorphonuclear cells. A course of parenteral antibiotic therapy was initiated. Combined 99mTc MDP and 67Ga scanning was performed, and a second ratio image was generated to discount the region of the cranioplasty plate (see Clinical Material and Methods). This study was interpreted as showing infection along the inferior margin of the cranioplasty plate and at a focus in the posterior parietal region (Fig. 5).

The previous scalp flap incisions were incised and the methyl methacrylate cranioplasty plate was removed. The bone along the inferior margin of the cranioplasty in the frontotemporal region appeared grossly infected and was removed with a rongeur. Attention was also directed to the parietal region at the site of a previous burr hole. There was evidence of subgaleal purulence at the site of the ventricular drainage catheter. Subsequent culture of the operative specimens revealed Pseudomonas aeruginosa, coagulase-positive Staphylococcus aureus, and Serratia marcescens in the cranial wound and S. marcescens from the shunt catheter tip. Pathological examination revealed foci of necrotic bone and acute and chronic inflammation in the skin and subcutis. The patient was managed postoperatively with a course of parenteral antibiotics; his fever abated and he was discharged on the 20th hospital day. At 2 months after surgery he appeared well.

**Discussion**

The 99mTc MDP bone scan is one of the most frequently performed studies in nuclear medicine. Radiation exposure is minimal and the study is very sensitive for areas of increased osteoblastic activity in the skele-
FIG. 5. Studies in Case 7. A: The 24-hour gallium-67 citrate scan, lateral view, showing increased activity in the posterior parietal region. B: Corresponding 4-hour technetium-99m methylene diphosphonate bone scan showing markedly decreased activity over the cranioplasty plate. C: The mean count over the cranioplasty plate was then corrected to zero (see Clinical Material and Methods). D: The Ga:Tc ratio reveals intense inflammatory activity in the posterior parietal region (shunt catheter abscess) and along the margin of the calvarial defect (arrow).

ton. Thus, areas of bone repair such as craniotomy sites demonstrate increased activity on the bone scan; however, areas involved with osteomyelitis also demonstrate increased activity. The specificity of the bone scan for infection can be increased through the simultaneous or sequential use of gallium scanning.

Gallium-67 citrate is routinely used for detection of occult infection and in the evaluation of tumors and inflammatory processes; this agent also localizes in bone, particularly in areas of increased osteoblastic activity. However, its avidity for bone is far less than that of $^{99m}$Tc MDP used in bone scanning. The bone scan activity can be qualitatively, or with computer-aided techniques quantitatively, compared with gallium activity in an area of suspected osteomyelitis (Table 1). This helps differentiate the increased activity seen with normal bone repair and tissue inflammation from that associated with infection. An animal model osteomyelitis studied by this technique (Fig. 6) is provided for comparison with the clinical cases presented here.

The technique of combined $^{99m}$Tc MDP and $^{67}$Ga scanning has proven very helpful in the management of our patients. In the initial five cases, an alternative explanation to bone flap infection was sought and found following the negative radionuclide studies (Table 2). In Cases 6, 7, and 9, a positive study was confirmed at operative exploration. Thus, this small series suggests that this imaging modality may have excellent specificity and sensitivity. An alternative radioisotope study for use in osteomyelitis evaluation is the indium-111-labeled leukocyte technique. This involves hours of complex manipulations to separate and label the patient's polymorphonuclear leukocytes prior to reinjection. The combined $^{67}$Ga and $^{99m}$Tc MDP technique is simpler and more widely available. This combined scanning should be considered when evaluating possible craniotomy flap osteomyelitis.

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References


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