Depiction of Nidi and Fibrovascular Zones of Osteoid Osteomas Using Gamma-Correction Tc-99m HDP Pinhole Bone Scan and Conventional Radiograph, and Correlation with CT, MRI, and PVC Phantom Imaging

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Abstract

Purpose For the precise imaging diagnosis of osteoid osteoma (OO), the identification of the nidus and fibrovascular zone (FVZ) is essential. However, the latter sign has received little attention because it is difficult to demonstrate. We applied the recently introduced gamma correction (GC) to depict the FVZ on pinhole bone scan (PBS), conventional radiography (CR), and computed tomography (CT). Non-gamma correction MRI was also analyzed for reference.

Methods Ten patients with histologically proven diagnoses of OO were enrolled in this retrospective study. PBS, CR, and CT were processed by GC to demonstrate the nidi and FVZ as distinct yet integrating components of OO. PBS was performed using a 4-mm pinhole collimator 3 h after iv injection of 925 to 1,110 MBq (25 to 30 mCi) of Tc-99m HDP, and anteroposterior and mediolateral CR and transverse CT were taken according to the standard technique. MRI sequences included T1- and T2-weighted images. For gamma correction, we utilized the Photo Correction Wizard program of ACD Photo Editor v3.1. A team of three qualified nuclear physician-radiologists, two nuclear physicians, and one MRI specialist read bone scans, radiographs, and MRIs of OO according to each specialty, and orthopaedic aspects and histology were reviewed by one qualified orthopedic surgeon and two qualified pathologists, respectively. Each observer first read the images separately with basic information about the aim of the study given and then in concert. Interpretive disagreement was settled by discussion and consensus.

Results On pinhole scan, nidi were presented as areas of intense tracer uptake in all cases, and, importantly after GC, a thin ring-like zone became visible in seven out of ten cases. GCCR also revealed a thin lucent zone...
that circumscribed the nidi in six out of ten cases and GCCT in two of four cases. MRI, without GC, presented nidi with high signal in the center and a thin ring-like zone with low signal in the periphery in five out of six cases. Ring-like zones were 1–2 mm in thickness and circumscribed the nidus as an integrated part and, hence, were morphologically interpreted as FVZ. Histologically, the presence of a variously mineralized FVZ was confirmed in four cases, but individual locus-by-locus image-histology correlation could not be accomplished because specimens were fragmentary. In the FVZ, tracer uptake was lower than in nidi, presumably reflecting that bone metabolism in the two parts differs as in their histology. Statistically, no significant correlation existed between the duration of symptoms and imaging demonstrability of the FVZ (Spearman’s test \( r = -0.057, p = 0.877 \)), but parallelism existed in the demonstrability of the FVZ among GC PBS, CR, and CT, and non-correction MRI. Conclusions GC was useful to enhance the resolution of PBS, CR, and CT in OO so that both the nidi and FVZ were separately imaged. The use of CG PBS and CR in combination is recommended for the specific diagnosis of OO with information about bone metabolism and anatomical characteristics. PBS and CR are economical and widely available.

Keywords Osteoid osteoma · Pinhole bone scan · Gamma correction

Introduction

Gamma correction (GC) of Tc-99m hydroxydiphosphonate (HDP) pinhole bone scan (PBS) has recently been shown to be a useful means of precise piecemeal diagnosis of six different types of occult fractures at the knee [1]. The rationales for such a diagnostic performance of GCPBS were that PBS could create images with higher resolution through optical magnification with increased photon acquisition and GC could distinguish occult fractures with higher tracer uptake from edema or bleeding with lower uptake. PBS is simple, and GC is an easily performed algorithm on any personal computer provided with a photographic management program.

Osteoid osteoma (OO) is a painful benign bone tumor with an incidence of 11% of all benign tumors and tumorous conditions of the bone [2]. It can occur in any bone, but has a strong proclivity to the femur and tibia. OO is characterized by the presence of the nidus circumscribed by a fibrovascular zone (FVZ) and reactive sclerosis in the surrounding host bone. Histologically, the nidus consists of a core meshwork of osteoid trabeculae, woven bones, and osteoblastic rim, and the FVZ consists of loose fibrovascular tissue that measures 1 to 2 mm in thickness. The FVZ is uniquely furnished with nerve fibers that are related to the pain of OO [3, 4].

For the diagnosis of OO, conventional radiography (CR) [5], computed tomography (CT) [6, 7], magnetic resonance imaging (MRI) [7–9], and bone scanning (BS) [10, 11] are used. However, the diagnostic target of these modalities is limited to the detection of the nidus and sclerosis, but not the FVZ, which is more typical of OO. Indeed, the diagnosis of BS is made by finding just “hot” uptake, and CR and CT diagnosis relies upon finding a lucent or mineralized nidus. As is well known, however, such a sign may also occur in the sequestrum of osteomyelitis [12], abscess, osteogenic sarcoma and hemangiomia [13], and even malignant metastasis [14]. Thus, detection of the FVZ is considered to be essential for more precise diagnosis of OO. To our knowledge, however, the importance of the FVZ has received little attention in imaging diagnosis.

In an endeavor to establish a piecemeal diagnosis of the nidus and FVZ, we applied GC to PBS, CR, and CT to depict the two pathognomonic signs in ten patients with histologically proven diagnoses of OO. Non-gamma correction MRI was also analyzed. In addition, a polyvinyl chloride capsule phantom study was performed to substantiate the imaging findings of GCPBS. We will present and discuss the results.

Materials and Methods

Patients

The study was carried out retrospectively and required no informed consent. Ten patients with OO (histological diagnosis in nine cases and clinical-surgical diagnosis in one) undergoing PBS were enrolled in this study (Table 1). Patients were pooled from four Catholic University of Korea Hospitals. There were seven males and three females with an age range from 5 to 26 years, median 16.9 years.

Imaging Techniques

Imaging studies performed were Tc-99m HDP PBS, CR, CT, and MRI. A pinhole scan was performed using a 4-mm pinhole collimator 2.5 h after intravenous injection of 925 to 1,110 MBq (25 to 30 mCi) of Tc-99m HDP. Gamma cameras used were Orbiter Siemens (Seoul St. Mary’s Hospital), DST Sophy (Euijongboo St. Mary’s Hospital), Millenium VG GE (St. Vincent Hospital), and E.CAM Siemens (St. Mary’s Hospital). Photon acquisition ranged from 150 to 300 Kcounts, and acquisition time was 10 min on average. Anterior-posterior and medial-lateral CR and transverse CT were taken according to the standard technique under quality control plan. When the penetration was inadequate, CR and CT were treated by gamma correction to properly expose nidi
as in Figs. 1, 2, and 4. The MRI machine used was a 1.5-T Magnetom Avanto (Siemens, Erlangen Germany) in all hospitals except in one where a 0.5-T Gyro (Philips, Einthoven, The Netherlands) was used. Image sequences of the 1.5-T machine included spin-echo T1-weighted (TR: 480, TE: 11) images, turbo spin-echo proton density (TR: 3,000, TE: 13) images, and turbo spin echo T2-weighted (TR: 4300, TE: 70) images; those of the 0.5-T machine included T1-weighted images (TR: 430, TE: 29), T2-weighted images (TR: 3,800, TE: 92), and fat suppression gradient echo (TR: 400, TE: 17.10, FA: 30) images.

Gamma Correction Process

Gamma correction was performed to extract the nidi and FVZ using the Photo Correction Wizard program of an ACD Photo Editor v3.1 (Adobe Photoshop v7.0 produced similar results) [1]. The gamma value of the individual Tc-99m HDP pinhole scan was manually adjusted so that both the nidi and FVZ were made visible. The correction was processed by clicking the tool bars on the personal computer screen in the following order: exposure → auto-exposure to maximize uptake intensity → done and save with a new name → exposure → image-brightness control by increasing gamma value to best visualize fracture → done and save the finished image with another new name. Starting from 50 (the default value in Photo Editor), the gamma value was gradually increased until the nidus with higher uptake stood out from an amorphous admixture of high, intermediate, and low uptake of the nidi, FVZ, and reactive sclerosis, respectively. In the present series, the correction gamma values for an ideal result ranged from 62 to 90, which depended upon the quality of the original scan. In general, pinhole scans with a lower photon acquisition required a lower gamma value increment and vice versa. For reference, the default gamma value in Photoshop was 1.0, and optimum values ranged from 2.0 to 4.0. The use of original digital information and communications in medicine (DICOM) scans without modification was a mandate. Unlike in bone scans, the gamma correction was processed in CR and CT by decreasing the gamma value to zero or below with the gamma value ranging from 44 to −15 after 0.

Interpretation of Bone Scan, CR, CT, and MRI

A team of three qualified nuclear physician-radiologists (SKC, SHK, YWB), two nuclear physicians (WHC, YAC), and one MRI specialist (JMP) interpreted bone scan, radiographs and whole-sequence MRIs of OO according to each specialty, and the histology was reviewed by two qualified pathologists (YMK, BKK). Images were first read separately with basic information about the aim of the study

<table>
<thead>
<tr>
<th>Case</th>
<th>Age(years)/sex (show case)</th>
<th>Symptoms and duration</th>
<th>Nidal site</th>
<th>Nidal size (mm)</th>
<th>Nidal shape</th>
<th>Nidal mineralization</th>
<th>FVZ definition</th>
<th>Reactive sclerosis</th>
<th>Histology</th>
<th>Imaging performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>23/F</td>
<td>Hip pain for 6 months</td>
<td>Femoral neck/IC</td>
<td>12×8</td>
<td>Oval</td>
<td>Marked</td>
<td>MWD</td>
<td>Moderate</td>
<td>OO</td>
<td>CR+, CT+, MRI+</td>
</tr>
<tr>
<td>2</td>
<td>14/M</td>
<td>Limping gait for 9 months</td>
<td>Femoral neck/IC</td>
<td>13×9</td>
<td>Round</td>
<td>V</td>
<td>SD</td>
<td>Surgery only</td>
<td>CR, CT, MRI⁵</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>15/M</td>
<td>Crossed leg pain for 3 years</td>
<td>Femoral neck/IC</td>
<td>14×14</td>
<td>Oval</td>
<td>Moderate</td>
<td>MWD</td>
<td>Moderate</td>
<td>OO</td>
<td>CR, CT, MRI⁵</td>
</tr>
<tr>
<td>4</td>
<td>05/M</td>
<td>Knee pain for 2 years</td>
<td>Femoral neck/IC</td>
<td>7×3</td>
<td>Oval</td>
<td>PD</td>
<td>MWD</td>
<td>Moderate</td>
<td>OO</td>
<td>CR, CT, MRI⁵</td>
</tr>
<tr>
<td>5</td>
<td>12/M (Fig. 3)</td>
<td>Painful mass for 6 months</td>
<td>Femoral neck/IC</td>
<td>7×2</td>
<td>Oval</td>
<td>PD</td>
<td>MWD</td>
<td>Moderate</td>
<td>OO</td>
<td>CR, CT, MRI⁵</td>
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<tr>
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<td>11/M (Fig. 4)</td>
<td>Shoulder pain for 2 months</td>
<td>Femoral neck/IC</td>
<td>8×7</td>
<td>Oval</td>
<td>PD</td>
<td>MWD</td>
<td>Moderate</td>
<td>OO</td>
<td>CR, CT, MRI⁵</td>
</tr>
<tr>
<td>7</td>
<td>25/M</td>
<td>Back pain for 2 years</td>
<td>Femoral shaft/IC</td>
<td>3×2</td>
<td>Oval</td>
<td>PD</td>
<td>MWD</td>
<td>Moderate</td>
<td>OO</td>
<td>CR, CT, MRI⁵</td>
</tr>
<tr>
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<td>20/M</td>
<td>Leg pain for 2 months</td>
<td>Femoral shaft/IC</td>
<td>3×2</td>
<td>Oval</td>
<td>PD</td>
<td>MWD</td>
<td>Moderate</td>
<td>OO</td>
<td>CR, CT, MRI⁵</td>
</tr>
<tr>
<td>9</td>
<td>11/M</td>
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<td>Femoral shaft/IC</td>
<td>2×15</td>
<td>Oval</td>
<td>PD</td>
<td>MWD</td>
<td>Moderate</td>
<td>OO</td>
<td>CR, CT, MRI⁵</td>
</tr>
<tr>
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<td>26/M (Fig. 5)</td>
<td>Back pain for 2 years</td>
<td>Femoral shaft/IC</td>
<td>11×9</td>
<td>Oval</td>
<td>PD</td>
<td>MWD</td>
<td>Moderate</td>
<td>OO</td>
<td>CR, CT, MRI⁵</td>
</tr>
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</table>

M, male; F, female; trans, transverse; IC, intracortical; IM, intramedullary; SD, sharply defined; MWD, moderately well defined; PD, poorly defined; sclerosis, reactive host-bone sclerosis; FVZ, the presence of fibrovascular zone confirmed; OO, osteoid osteoma; CR, conventional radiography; CT, computed tomography; MRI, magnetic resonance imaging; +, FVZ visible; −, FVZ invisible.

Table 1 Demographics, symptoms, nidal site, size, and mineralization, FVZ definition, reactive sclerosis, histology, and imaging performed.
and then in concert. Interpretive disagreement was settled by open discussion and consensus.

Analysis of Categorical Findings of the Nidi and FVZ on Gamma Correction PBS, CR, and CT, and Non-Correction MRI

Image findings of nidi were assessed on GC PBS, CR, and CT, and non-GC MRI in terms of: (1) the site, size, shape, and the degree of mineralization; (2) the depiction and definition of the FVZ; and (3) the degree of reactive host-bone sclerosis. Mineralization extent was arbitrarily graded as mild (less than 1/3), moderate (2/3), and marked (more than 2/3) as seen on CR and/or CT; the sclerosis was graded as mild (less than 1 cm in thickness), moderate (1–2 cm), and marked (more than 2 cm) on CR; the definition of the FVZ was assessed in terms of sharp, moderate, and poor on GCPBS, GCCR, GCCT, and/or MRI.

Statistical Analysis

The statistical significance was assessed between the duration of symptoms and (1) the nidal size, (2) the nidal mineralization, (3) the definition of the FVZ, (4) the degree of reactive sclerosis using Spearman’s test, and (5) between the nidal mineralization and sclerosis using Kendall’s tau test (SPSS version 13.0 Chicago, IL).

Phantom Experiment for Validation of the FVZ

For an indirect validation of the GCPBS demonstration of the nidus and FVZ, we performed an experiment using

![Fig. 1 Markedly mineralized nidus with moderate reactive sclerosis in the right femoral neck in a 23-year-old female with hip pain of 6-month duration.](image1)

(a) Anterior pinhole scan shows a bean-shaped lesion with intense tracer uptake. The outline is blurred (arrow). (b) GCPBS ($\gamma$=75) shows the nidus with prominent tracer uptake and circumscribing the thin FVZ with lower stippled uptake (arrows). (c) GCCR ($\gamma$=20) shows the nidus and FVZ (arrows). Inset is original CR showing the nidus only dimly. (d) GCCT ($\gamma$=05) shows the nidus and lucent FVZ (arrows). Inset is original CT showing no detail. (e) Coronal T2-weighted MRI (3,590/90) shows the nidus with intermediate signal and the FVZ as a low-signal ring-like zone (arrows). (f) Microscopic study shows markedly mineralized osteoid osteoma. H&E, ×100

![Fig. 2 Markedly mineralized nidus with moderate reactive sclerosis in the right femoral neck in a 14-year-old male with limping gait of 9-month duration.](image2)

(a) Anterior pinhole scan shows an oval lesion with intense tracer uptake (arrow). The outline is blurred. (b) GCPBS ($\gamma$=70) depicts the lesion as consisting of two different parts as a well-defined central nidus with higher tracer uptake and a circumscribing FVZ with lower uptake (arrows). (c) Original CR shows a barely discernible lucent lesion buried in sclerosis (arrow). (d) GCCR ($\gamma$=12) shows a markedly calcified nidus and lucent FVZ (arrows). (e) Coronal T2-weighted MRI (3,000/99) shows nidus consisting of low and intermediate signals surrounded by the FVZ with low signal intensity (arrows). The nidus was confirmed by the surgeon and removed by radiofrequency ablation using a 14-gauge drill under C-arm guidance. A surgical specimen was unavailable in this case.
a rugby-football-shaped polyvinyl chloride (PVC) capsule (size=15×20 mm) with a 2-mm-thick wall as a phantom of OO. The phantom consisted of the nidus-equivalent interior and FVZ-equivalent wall (Fig. 6a). The interior was stuffed with absorbent cotton soaked with 18.5 MBq (0.5 mCi) of Tc-99m pertechnetate diluted in 3 ml of normal saline solution. The capsule was stood on the long axis and scanned using a gamma camera with a 4-mm pinhole collimator. The nidus with FVZ was simulated by decreasing the gamma value below default value.

**Results**

**Characteristics of Patients, Symptoms, and Osteoid Osteomas**

Patients included seven males and three females with ages ranging from 5 to 26 years (median=16.9 years). The symptom was pain in eight patients and limping gait in two. Duration of symptoms ranged from 2 months to 3 years. The femur and tibia were affected in five and three patients, respectively, and the transverse process of the T4 vertebra and the coracoid process were affected in one patient each. The cortical bone was affected in seven patients and the marrow bone in three (Table 1). Our series included two cases of elliptical nidi (cases 5 and 8; Fig. 3).

**Nidal Size and Duration of Symptoms**

The sizes of nidi ranged from 3×2 mm² to 20×15 mm²; the smallest nidus occurred in the tibial shaft and the largest nidus in the coracoid process (case 9). There was no significant correlation between the nidal size and the duration of clinical symptoms (Spearman’s test r=0.337, p=0.340).

**Nidal Mineralization and Duration of Symptoms**

Nidal mineralization on CR and/or CT was mild in three cases, moderate in two, and marked in five. There was significant correlation between the nidal mineralization and the duration of symptoms (Spearman’s test r=0.686, p=0.028).

![Fig. 3](image)

**Fig. 3** Minimally mineralized elliptical nidus in the cortex of the right distal femoral metaphysis in a 15-year-old male with knee pain of 3-month duration. (a) Lateral pinhole scan shows intense homogenous tracer uptake in a small ovoid lesion. (b) GCPBS (γ=62) depicts nidus with higher tracer uptake and surrounding FVZ with lower uptake (arrows). (c) Lateral CR shows faintly visible sclerosis (arrows). (d) Sagittal T1-weighted MRI (403/29) shows an ovoid lesion with intermediate signal (arrows) of minimally mineralized osteoid osteoma. (e) T1-weighted coronal MRI (403/29) identifies a small, thin, elliptical nidus with intermediate signal and the surrounding FVZ with low signal (arrow). (f) Microscopic study shows mineralized osteoid tissue. H&E, ×100
Depiction and Definition of the Nidi and FVZ by Gamma Correction PBS, CR, and CT, and Non-Correction MRI

On pinhole scan, nidi were presented as areas of intense tracer uptake in all cases and, importantly after GC, a thin (1–2 mm) ring-like zone with lower tracer uptake was depicted in seven out of ten cases. The zone was sharply defined in two cases (Figs. 2b and 3b), moderately defined in two cases (Fig. 1b), and poorly but discernibly defined in six cases (Fig. 4b). After GC, the nidus and thin circumscripting lucent zone also became distinctly defined in six out of ten cases on CR (Figs. 1c, 2d and 4d) and CT in two of four cases (Fig. 1d). MRI, without GC, presented the nidus with high intensity in the center and the circumscripting thin zone with low signal intensity in the periphery on T2-weighted images in five out of six cases (Figs. 1e, 2e and 4e). The ring-like zones measured 1–2 mm in thickness and circumscribed the nidus as a part of it and, hence, were considered to represent the FVZ.

Histologically, the presence of a variously mineralized FVZ was confirmed in cases 3, 6, 8, and 10 (Figs. 1f and 4f). Thus, GCPBS depicts only poorly in cases with advanced mineralization (Figs. 4 and 5). It is worth noting that tracer uptake was acutely diminished in the FVZ, suggesting that the bone metabolism in the nidus and FVZ would differ as their histology. There was no significant correlation between the duration of symptoms and the demonstration of the FVZ on imaging studies (Spearman’s test $r=−0.057$, $p=0.877$), but good parallelism was noted in the demonstrability of the FVZ on GC PBS, CR, and CT, and non-correction MRI (FVZ definition and imaging performed in Table 1).

Reactive Host-Bone Sclerosis and Duration of Symptoms

The reactive host-bone sclerosis shown on CR was mild in three cases, moderate in two, and marked in five, and a significant statistical correlation was noted between the duration of symptoms and the degree of reactive sclerosis (Spearman’s test $r=0.737$, $p=0.015$).

Mineralization of Nidi and Reactive Host-Bone Sclerosis

The mineralization of nidi on CR and/or CT was mild in three cases, moderate in two, and marked in five, and a significant statistical correlation was noted between the nidal mineralization and reactive host-bone sclerosis (Kendall’s tau test $τ=0.0820$, $p=0.005$).
Phantom Study

The pinhole scan of PVC phantom revealed that the nidus-equivalent interior was uniformly filled with intense radioactivity, and the FVZ-equivalent capsular wall was imaged as a ring-like zone with lower radioactivity (Fig. 6b). Such a finding on the pinhole scan image of the phantom resembled a GCPBS image of OO with higher tracer uptake in the nidus and lower uptake in the FVZ (Fig. 6c). Furthermore, we found that the GCPBS finding of case 1 of our series (Fig. 1b) closely matched with the gross macroscopic finding of a surgical specimen of OO published by Picci and Mirra (Fig. 7a) [5].

Discussion

OO is a painful benign bone tumor with an incidence of 11% of all benign tumors and tumorous conditions of bone [2]. Histologically, OO is characterized by the presence of the nidus and FVZ. The nidus consists of a core meshwork of osteoid trabeculae, woven bones, and an osteoblastic rim, and the FVZ consists of loose fibrovascular tissue and is 1–2 mm thick [2]. FVZ is innervated, relating to the pain that characterizes OO [3, 4]. For the diagnosis of OO, therefore, one must confirm the presence of the nidus and circumscribing the FVZ. Peculiarly, however, imaging studies have sought the nidus and reactive sclerosis, but not the FVZ. The reason has probably been that imaging of the FVZ is not as easy as that of the nidus. A review of the literature disclosed that some instances of OO in the small bones like the finger and the calcaneus were illustrated as OO in which the thin radiolucent FVZ was seen to circumscribe the nidus on CR [2]. In general, however, the imaging diagnosis of OO was made only on the basis of a spotty “hot” area on BS (Fig. 1a) and a lucent defect within diffuse sclerosis on CR (Fig. 1c inset) and CT (Fig. 1d inset). As mentioned above, such a sign is not specific, occurring in a number of other diseases including the sequestrum of osteomyelitis [12], chronic abscesses, osteogenic sarcoma and hemangioma [13], and malignant bone metastasis [14].

GCPBS has lately been introduced as an efficient means of depicting six different types of occult fractures at the knees [1]. The rationales were that PBS produces a scan image with higher resolution through optical magnification.
and GC distinguishes the occult fractures with higher tracer uptake from the edema and hemorrhage of the bone bruise with lower uptake.

We applied GC to PBS, CR, and CT, and found that the nidus and FVZ were depicted as integrated but different elements of OO. Nidi manifested as an oval or round area of intense tracer uptake in all ten cases. The outline of nidi was sharp in two cases (Figs. 2 and 3), moderately well defined in two cases (Fig. 1), and poorly defined in six (Fig. 4). In addition to the nidus, GCPBS depicted a thin (1–2 mm) ring-like zone with lower tracer uptake in seven of ten cases. The zone was sharply defined in two cases (Figs. 2b and 3b), moderately well defined in two (Fig. 1b), and poorly yet discernibly defined in six (Fig. 4b). On the other hand, nidi were depicted along with a thin circumscribing lucent zone in six of ten cases on GCCR (Figs. 1c, 2d and 4d) and two of four cases on GCCT (Fig. 1d).

MRI, without GC, presented the nidus with high signal intensity in the middle and the ring with low signal intensity in the circumference on T2-weighted images (Figs. 1e, 2e and 4e). Ring-like zones were 1–2 mm thick and surrounded the nidus as an integrated part of it; and, hence, was considered to represent the FVZ. Histologically, the presence of a mineralized FVZ was confirmed in cases 3, 6, 8, and 10 (Figs. 1f and 4f), but, technically, individual locus-by-locus image-histology correlation could not be done because the specimens were fragmentary. In our series, the nidal sizes ranged from 3×2 mm² to 20×15 mm², with the smallest nidus occurring in the tibial shaft and the largest one in the coracoid process. Statistically, no significant correlation was noted between the nidal size and symptom duration.

On the other hand, the degree of nidal mineralization assessed semi-quantitatively on CR and/or CT varied from mild to marked and was positively correlated with the...
nidal age as estimated by symptom duration. The older the symptom, the more advanced was the mineralization. The reactive host-bone sclerosis shown on CR was mild in three cases, moderate in two, and marked in five. The degree of reactive sclerosis paralleled symptom duration. Thus, the most extensive sclerosis was observed in the patient with the longest history of 3 years (case 3). The nidus in this particular case could not be depicted on either CR or CT even after GC since the sclerosis was too intense.

Because whole-block OO specimens were no longer available due to the popular use of radiofrequency ablation and curettage surgery, we made an attempt to experimentally create the nidus and FVZ using an oval polyvinyl chloride (PVC) capsule with a 2-mm-thick wall as a phantom (Fig. 6a). The experiment showed the nidus-equivalent interior was scanned like a nidus with high tracer uptake and the FVZ-equivalent wall like a ring with low tracer uptake (Figs. 6b, c). Of interest, we noted that the GCPBS image of case 1 (Fig. 7a) closely matched with the macroscopic finding of an intact surgical specimen of OO published by Picci and Mirra [5] (Fig. 7b). In their specimen, the nidus was presented as a round tumor with a cobbled surface and the FVZ as a circumscribing furrow with cobblestone appearance. Such an appearance was scintigraphically well reproduced on the GCPBS of case 1 of our series, which presented the nidus as a round tumor with a higher tracer uptake and FVZ as a cobbled coronal-like zone with low uptake (Fig. 7b).

This study was limited because of the small pool of subjects and not being able to compare with the control disease. Also, an appropriate gamma correction parameter from OO could not be suggested. In future study, it will be necessary to increase the number of subjects and therefore present an appropriate parameter of the gamma correction from images of various diseases.

Conclusion

For the precise diagnosis of OO, the demonstration of the nidus and FVZ is essential, and GC PBS, CR, and CT can separately depict the nidus and FVZ. PBS and CR are inexpensive and simple to perform, and GC is an easily performed algorithm on any personal computer provided with a photographic management program. MRI can also detect the FVZ, but it is costly and not widely available.

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