Comparison of High-Resolution MRI and SPECT Bone Scintigraphy for Noninvasive Imaging of the Temporomandibular Joint

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Prospective evaluation by magnetic resonance imaging (MRI) and both single photon emission computed tomography (SPECT) and planar bone scintigraphy was undertaken in 31 temporomandibular joints (TMJs) of 21 symptomatic patients. When compared with the results of subsequent arthrography, MRI (0.88) was more sensitive than SPECT (0.76) or planar (0.56) scintigraphy for detection of internal derangement of the TMJ. A diagnostic sensitivity of 0.96 was achieved when the results of either MRI or SPECT was considered evidence of internal joint derangement. Five symptomatic TMJs, clinically thought to be abnormal, were positive on SPECT but showed no evidence of anterior disk displacement at the time of arthrography. In such instances, SPECT may be detecting functionally significant altered joint mechanics that are not evident on anatomic imaging of the TMJ.

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Symptomatic internal derangement of the temporomandibular joint (TMJ) may affect as much as 25% of the adult population with a smaller, but nonetheless significant, percentage of adults suffering serious disability due to this disorder (*1,2*). Although some individuals with internal derangement of the TMJ experience only minimal, intermittent symptoms, others experience pain, crepitus, opening snap, and/or limited opening for which they seek professional advice. History and physical examination often will implicate internal derangement of the TMJ as the cause for these symptoms. However, even the most experienced clinician frequently cannot distinguish with confidence between the various possible etiologies for facial pain (*2–8*). Therefore, important therapeutic judgements—such as the decision to continue nonsurgical therapy or advance to surgical intervention—should be based on a clinical evaluation with radiographic confirmation (*9*).

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Anterior displacement of the disk within the TMJ frequently is cited as the earliest detectable anatomic change associated with internal joint derangement (*10–12*). The desire of clinicians to detect such anterior displacement of the disk and thereby confirm the diagnosis of internal joint derangement provided the impetus for development of TMJ arthrography (*13,14*). It is now generally accepted that arthrography performed by an experienced skeletal radiologist is proof of morbid anatomic change within the TMJ (*15–18*).

More recently the noninvasive imaging techniques of computed tomography (CT) (*19–24*) and magnetic resonance imaging (MRI) (*25–30*) have been used to clarify the anatomy of the TMJ. Although experience with MRI is more recent and preliminary, reports to date suggest that the anteriorly displaced disk can be easily imaged using this technique. Both planar and single photon emission computed tomography (SPECT) bone scintigraphy also have been used to detect the functionally abnormal TMJ (*31–33*). SPECT bone scintigraphy, in particular, has been shown to be a highly sensitive screening test when used to detect internal derangement of the TMJ (*31,33*). To date, the

clinician seeking to confirm the diagnosis of internal joint derangement by means of a noninvasive imaging test has had no scientific basis for choosing between MRI and SPECT bone scintigraphy. Therefore, a prospective study comparing these two techniques was undertaken in a series of symptomatic patients scheduled for subsequent TMJ arthrography.

MATERIALS AND METHODS

Prospective evaluation by MRI and both SPECT and planar bone scintigraphy was undertaken for 31 TMJ of 21 symptomatic adult patients. Ages ranged from 17 to 67 yr (mean, 30.5 yr), with 19 female and two male patients. All patients had a detailed clinical history and a thorough oral and maxillofacial examination (Table 1). Following noninvasive imaging and subsequent arthrography, these patients eventually were treated by one or more of the following means: splint therapy, physical therapy, or TMJ surgery.

High-resolution MRI was performed using 3-in.-diameter counter rotating current loop gap resonators as local receiver coils (*34,35*). Using a 1.5-Tesla commercially available MRI system,* T1 weighted (TR = 500 msec and TE = 20–25 msec) 3-mm thick sagittal tomographic images with a 16-cm field-of-view were obtained. Patients were examined in both jaw-open and jaw-closed positions. Before beginning this prospective evaluation, the appearance on MRI of normal TMJ anatomy was determined by examining a small group of asymptomatic volunteers and symptomatic patients with normal TMJ arthrography. MRI reports were rendered without benefit of scintigraphic or subsequent arthrographic results.

Bone scintigraphy was performed 3 hr after an intravenous injection of 25 mCi (925 MBq) of technetium-99m MDP ([^{99m}Tc]MDP). For planar bone scintigraphy, 500,000-count anterior, right lateral, and left lateral view images were obtained using a gamma camera equipped with a low-energy high-resolution collimator. SPECT examinations were performed with a rotating gamma camera device† equipped with a low-energy, general-purpose collimator. All data were acquired and processed as 64 × 64 matrices. Sixty-four projections over 360° were acquired for 20 sec per projection. Following uniformity correction and filtering of the projections (Hanning filter with a cutoff frequency of 0.8 cycle/cm), 6-mm thick transaxial, coronal, and sagittal tomograms were reconstructed using filtered backprojection with a ramp filter. Planar and SPECT bone scintigraphy were independently evaluated by three nuclear medicine physicians using previously described criteria (*31*). (Normal exam for an asymptomatic individual is shown in Fig. 1.) Planar and SPECT images were evaluated separately without benefit of clinical or radiographic correlation. Planar and SPECT examinations were considered abnormal only if at least two readers agreed on the presence of a positive finding.

Arthrograms were performed after MRI and bone scintigraphy using a previously described technique of contrast material injection into the lower compartment of the TMJ with fluoroscopy, video dynamic study, and spot radiography (unpublished data). TMJ arthrography was performed and reviewed by a skeletal radiologist (GFC) without knowledge of the MRI, SPECT, and planar findings. For this study, exams were interpreted as having either normal or anterior displaced disks. Although perforations and other morbid anatomic changes were occasionally found during arthrography, all TMJs with these abnormalities also had anterior displaced disks. MRI and scintigraphy results were subsequently correlated with the arthrographic findings of an anteriorly displaced disk.

TABLE 1
Clinical Findings

History and symptoms	
Trauma	23%
Symptoms for more than 6 mo	87%
Pain	
Severe	55%
Moderate	32%
Mild	13%
Headache	90%
Physical findings	
Crepitus	13%
Snap	65%
Closed lock	39%
Abnormal bite	65%

RESULTS

Arthrography demonstrated 25 joints with anterior displacement of the disk in addition to six anatomically normal, albeit symptomatic, joints. Correlation of these results with evidence for a displaced disk on MRI, or increased TMJ scintigraphic activity on SPECT or planar imaging, allowed calculation of diagnostic sensitivities and specificities (Table 2). Of the 25 abnormal TMJs, there were only 17 for which both SPECT and MRI were positive (Fig. 2). In addition, there were two TMJs with abnormal arthrography for which SPECT was positive but MRI was falsely negative. Only one TMJ with arthrographic proof of a displaced disk was falsely normal on both SPECT and MRI.

There were five false-positive SPECT examinations of the TMJ. These were instances in which symptomatic joints (i.e., TMJs thought to have significant internal derangement by an oral surgeon) were associated with increased scintigraphic activity but normal disk position by arthrography (Fig. 3). MRI was also falsely positive for two of these five joints.

Although SPECT is superior to planar imaging, as an initial screening test for internal derangement of the TMJ, it failed to detect five of the abnormal joints that were correctly identified by MRI. However, SPECT did correctly predict abnormalities in two other joints that were felt to be normal in MRI.

DISCUSSION

With a sensitivity of 0.88, MRI is suitable for use as a high sensitivity noninvasive screening test to establish

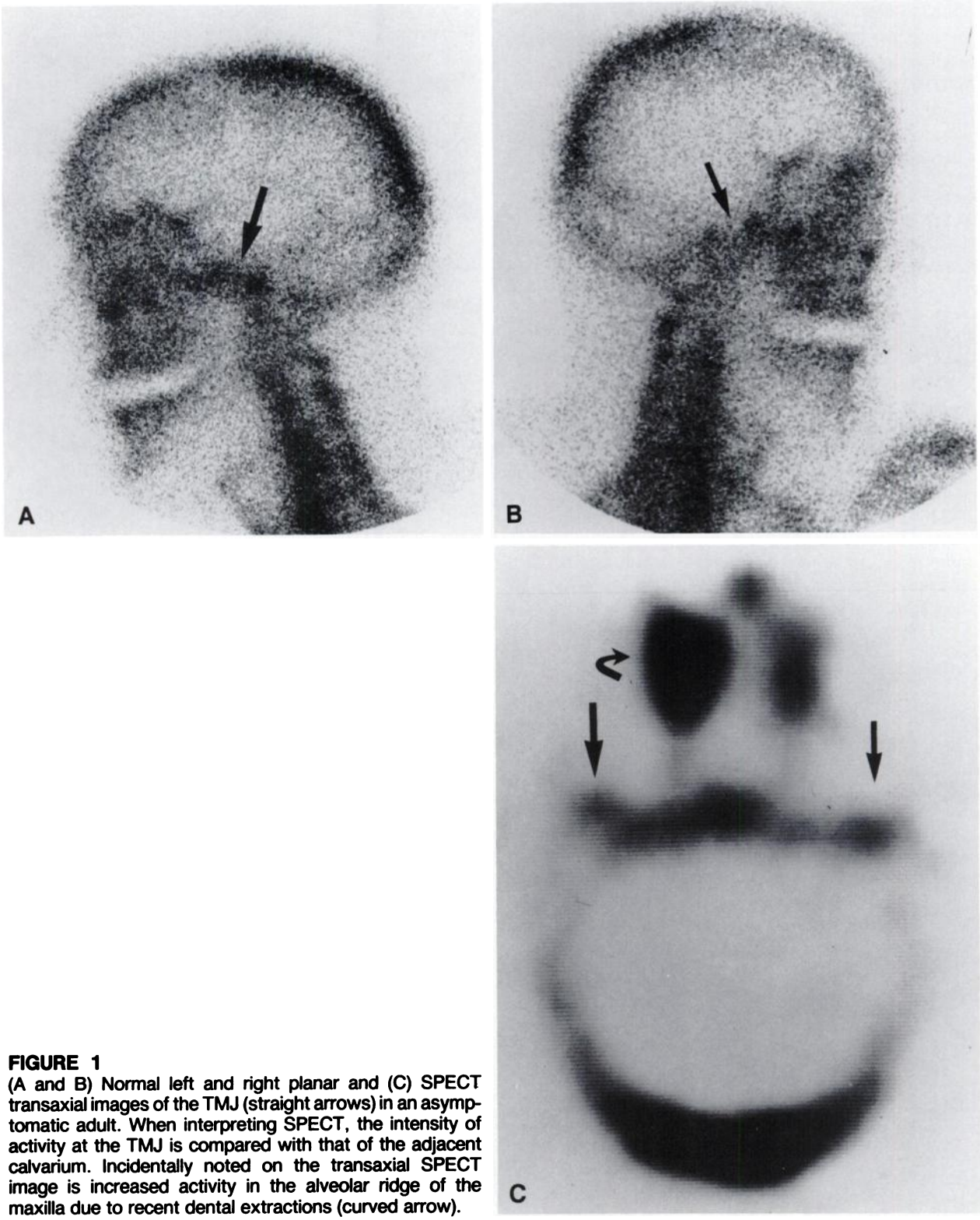

FIGURE 1
(A and B) Normal left and right planar and (C) SPECT transaxial images of the TMJ (straight arrows) in an asymptomatic adult. When interpreting SPECT, the intensity of activity at the TMJ is compared with that of the adjacent calvarium. Incidentally noted on the transaxial SPECT image is increased activity in the alveolar ridge of the maxilla due to recent dental extractions (curved arrow).

the presence of an abnormal anteriorly displaced disk. The sensitivity of SPECT was only 0.76. Although this difference is not statistically significant, the result suggests that MRI correlates more closely with morbid soft-tissue joint anatomy. However, SPECT did detect two abnormal joints that were not correctly identified by MRI. If both MRI and SPECT had been used in combination to screen for internal derangement of the TMJ, the sensitivity would have risen to 0.96. There were no instances in which planar scintigraphy provided information not available on the SPECT images. However, the relatively low 0.56 sensitivity of planar imaging

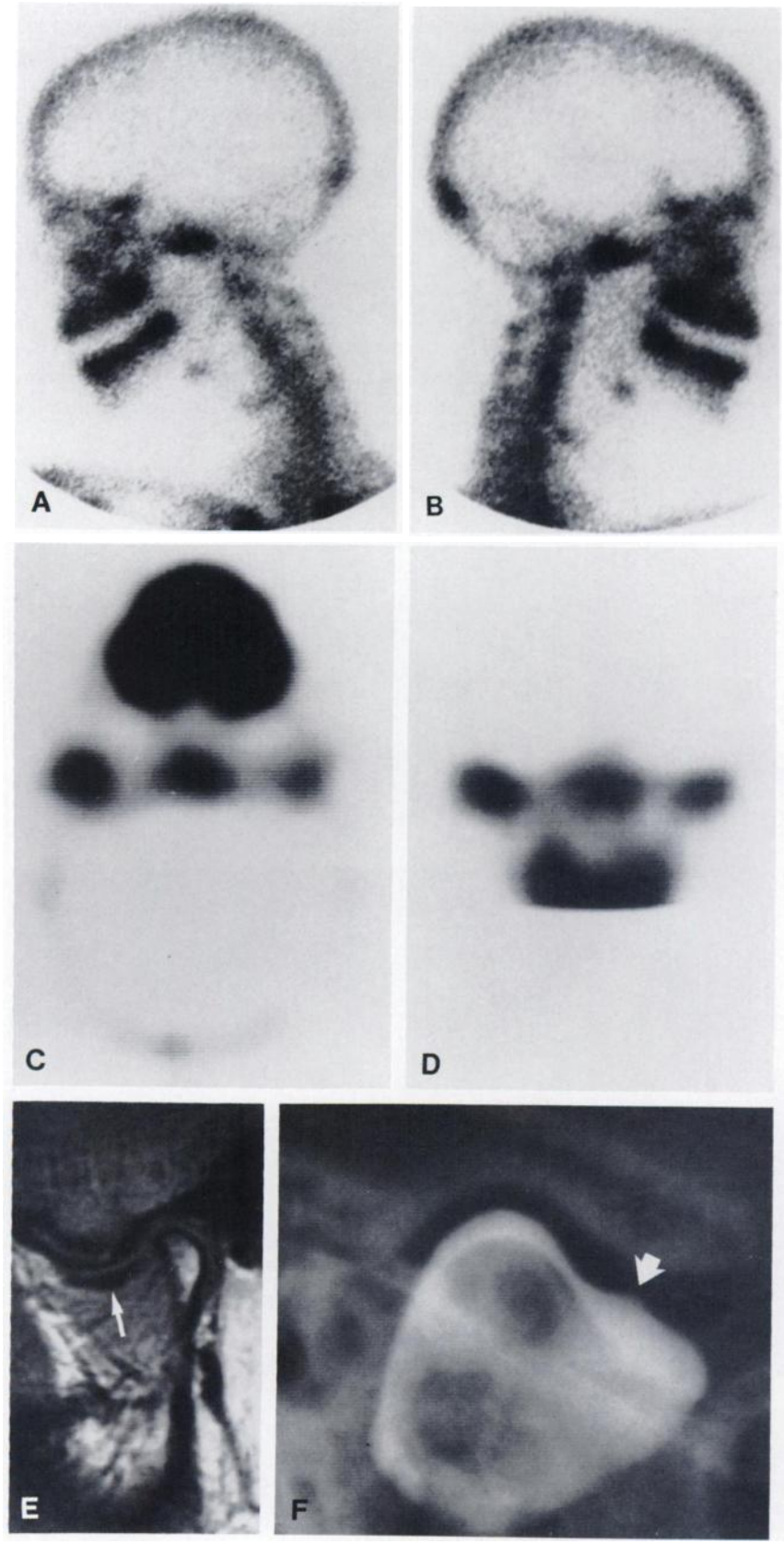

FIGURE 2
Symptomatic 17-yr-old female with bilateral TMJ pain and snap on opening of the jaw. (A–D) Planar, coronal SPECT, and transaxial SPECT images show increased activity, right greater than left, in the TMJ. Also present is increased activity along the alveolar ridge of both the mandible and the maxilla. (E) MRI shows an anteriorly displaced disk (arrow). (F) Arthrography confirmed the anterior displacement of the disk (arrow).

TABLE 2
Diagnostic Efficacy of Noninvasive Imaging Technique When Compared with Arthrographic Proof of TMJ Status

Modality	Sensitivity (n = 25)	Specificity (n = 6)	Accuracy (n = 6)
MRI	0.88	0.50	0.81
SPECT	0.76	0.17	0.49
Planar	0.56	0.33	0.39

(Table 2) might be improved upon if one choose to use pinhole collimation and/or both open- and closed-mouth positioning.

The low (0.17) specificity of SPECT, reported to be as high as 0.70 in other series (*31*), may reflect the fact that only symptomatic TMJs were included in this series. Possibly, the increased scintigraphic activity about these TMJs reflects functionally significant abnormal joint mechanics without any anterior displacement of the disk. Unfortunately, there is no proof for the cause of jaw pain for four of these joints at the time of bone scintigraphy. However, they all improved significantly following splint therapy or other conservative TMJ treatment. One patient subsequently went on to surgery and was found to have anterior disk displacement despite the earlier normal arthrogram.

We conclude, as has been shown previously (*31*), that SPECT rather than planar imaging is the optimal technique for TMJ scintigraphy. MRI correlates more closely with anatomic information about disc position obtained during TMJ arthrography. Although SPECT examinations were also abnormal in many of the patients with anteriorly displaced disks, this examination may identify functionally significant abnormalities of the TMJ. In the future, cost may play a role in deciding which imaging test should be used for TMJ evaluation. Currently at our institution an MRI examination is

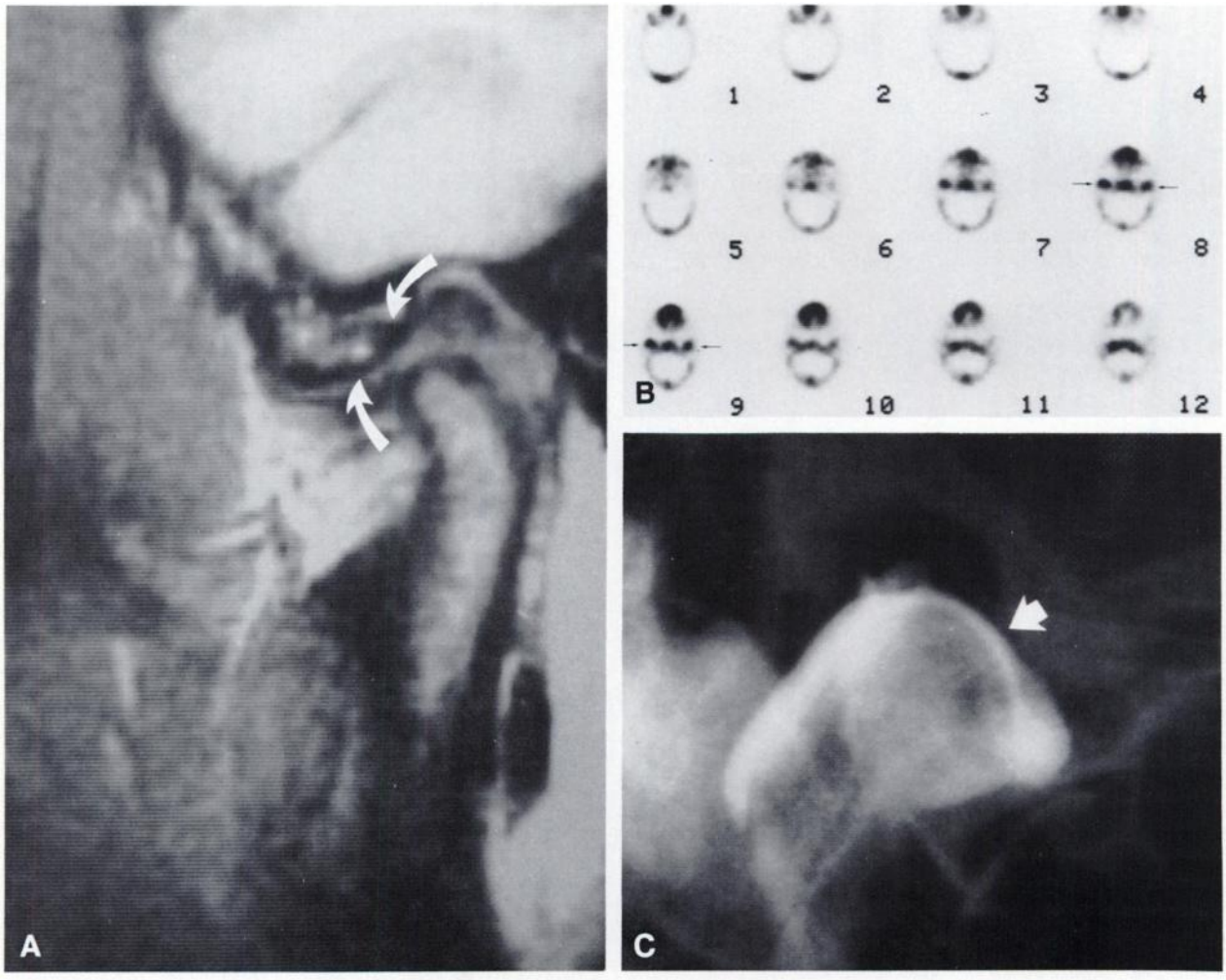

FIGURE 3
Symptomatic 25-yr-old male with prior jaw trauma, severe joint pain, and headache, with findings of a closed lock on physical examination. A: Normal MRI of the right TMJ (arrow indicates position of the disk), B: Positive 6-mm thick sequential SPECT transaxial images (arrows), and C: Normal arthrogram (arrow indicates position of the disk). Note that the intensity of the activity in the region of the TMJ is significantly greater than that seen in Figure 1. Ten months later, the patient had substantial relief of symptoms with only conservative therapy.

approximately twice the cost of a SPECT study. Either MRI or SPECT is suitable for noninvasive confirmation of the clinical diagnosis of TMJ derangement and, when both techniques are employed, the joint diagnostic sensitivity is well over 0.90.

NOTES

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† 400T, General Electric Medical Systems, Milwaukee, WI.

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