Journal of Clinical Neuroscience xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

Journal of Clinical Neuroscience

journal homepage: www.elsevier.com/locate/jocn

Clinical Study

Co-registration of isotope bone scan with CT scan and MRI in the investigation of spinal pathology

Graeme A. Brazenor [a], Gregory M. Malham [a,*], Zita E. Ballok [b]

[a] Neuroscience Clinical Institute, Epworth Hospital, Melbourne, VIC, Australia
[b] Nuclear Medicine Department, Primary Healthcare Imaging, Epworth Hospital, Melbourne, VIC, Australia

ARTICLE INFO

Article history:
Received 13 August 2013
Accepted 16 November 2013
Available online xxxx

Keywords:
Bone scan
CT scan
Diagnosis
MR
Pathology
Spine
Treatment

ABSTRACT

Image fusion software enables technetium^{99m}-methylene diphosphonate (Tc^{99m}-MDP) bone scan images to be co-registered with CT scan or MRI, allowing greater anatomical discrimination. We examined the role of bone scan images co-registered with CT scan or MRI in the investigation of patients presenting with axial spinal pain and/or limb pain. One hundred and thirty-nine consecutive patients were examined, and thereafter investigated with CT scan, MRI, and/or dynamic plain films. At this point diagnosis (pathology type and anatomical site) and treatment intention were declared. The co-registered Tc^{99m}-MDP bone scan images were then studied, after which diagnosis (pathology type and anatomical site) and treatment intention were re-declared. This data were then analysed to determine whether the addition of co-registered bone scan images resulted in any change in diagnosis or treatment intention. The most significant change in diagnosis was pathology type (10%). Anatomical site changed markedly without overlap of the pre and post-isotope fields in 5%, and with overlap in 10%. Treatment intention had a major change in 3.6% and minor change in 8.6%. In the two groups where there was (i) no obvious pathology after full pre-isotope investigation, or (ii) a spinal fusion under suspicion, addition of the bone scan information led to a major change in the pathology and/or anatomical localisation in 18% and 19%, respectively. The addition of co-registered Tc^{99m}-MDP bone scan images offers significant diagnostic assistance, particularly in the difficult diagnostic groups where a failed spinal fusion may be the suspected pain generator, or when no pain generator can otherwise be found.

1. Introduction

Bone scans are a non-invasive diagnostic modality that use radiolabeled bisphosphonates to identify areas of abnormal osteogenesis. The most widely used radioisotope is technetium^{99m}-labeled methylene diphosphonate (Tc^{99m}-MDP) [1]. The isotope binds to hydroxyapatite at sites of active osteoblast formation. Areas of focal isotope uptake are detected by a gamma camera, identifying pathologies such as degenerative change, fracture, infection, and tumour [2]. Conventional bone scans use planar imaging or tomographic imaging (single photon emission computed tomography [SPECT]). However, these images have low specificity to skeletal anatomy [3]. Recently, image fusion software has been developed to enable images from isotope bone scans to be co-registered with CT scan or MRI [4–6]; this has led to greater anatomic resolution in the co-registered images.

This study aimed to investigate the role of isotope bone scan images co-registered with CT scan or MRI in the investigation of patients presenting to a spine surgeon with axial spinal pain, limb pain, or both.

2. Materials and methods

2.1. Study population

This was a prospective, non-randomised study of 139 consecutive patients presenting to a spine surgeon with axial spinal pain, limb pain or both. Patients were interviewed, examined and then investigated with CT scan, MRI and dynamic radiographs. A pre-isotope scan diagnosis was made with respect to pathology type and anatomic site, and treatment intention was recorded.

Each patient's Tc^{99m}-MDP isotope bone scan images were co-registered with CT scan (or MRI in 19 patients where CT scans were not available) and analysed. A post-isotope scan diagnosis was then made with respect to pathology type and anatomic site, and treatment intention restated.

* Corresponding author. Address: Suite 2, Level 1, 517 St. Kilda Road, Melbourne, VIC 3004, Australia. Tel.: +61 3 9866 6650; fax: +61 3 9866 6681.
E-mail address: gmalham@bigpond.net.au (G.M. Malham).

http://dx.doi.org/10.1016/j.jocn.2013.11.034
0967-5868/

The pre and post-isotope scan diagnoses were compared to determine whether addition of the co-registered isotope bone scan images had resulted in any change in diagnosis with respect to pathology type or anatomical localisation, or in the treatment intention.

2.2. Imaging protocol

Triple phase bone scans were performed using a dual head gamma camera (e.cam, Siemens, Erlangen, Germany). Following the bolus intravenous injection of 800 megabecquerels (MBq) of Tc^{99m}-MDP, 120 perfusion phase images, each of 1 second duration, were obtained immediately followed by blood pool images for 2 minutes using a 256×256 pixel matrix. Delayed static images were obtained 3 hours post-injection using a 256×256 pixel matrix for 4 minutes, followed by SPECT images of the same spinal region. SPECT images were acquired in a 128×128 pixel matrix with 60 projections over 360 degrees for 20 seconds per projection. Axial, coronal and sagittal tomograms with a slice thickness of 4 mm were reconstructed using iterative reconstruction (four iterations and eight subsets). Raw data of multislice CT scan (Sensation, Siemens) or MRI (1.5 Tesla, Sigma Excite, GE Healthcare, Little Chalfont, Buckinghamshire, UK) images of the same spinal region were exported to the workstation (e-soft, Siemens) for co-registration. Special care was taken to position all patients similarly for anatomic and functional imaging, including the use of knee rests and pillows. Advanced image fusion software (Syngo, Siemens) was used for co-registration of the cross-sectional functional and anatomic images.

No instance of significant mis-registration was detected. Radioisotope uptake was graded as normal, physiological or abnormally increased in relation to anatomic structures, and, in patients with a history of prior spinal surgery, in relation to the fusion hardware. Images were interpreted by an experienced nuclear medicine physician (Z.B.).

2.3. Statistical analysis

Statistical analyses included chi-squared testing between groups. Statistical analysis was carried out using the Statistical Package for the Social Sciences version 19.0 (SPSS, Chicago, IL, USA) with statistical significance set at $p < 0.05$.

3. Results

The study cohort comprised 139 patients with a mean age of 68.1 years (range 19–90 years) and 58% were male.

Provisional classifications of the patients' pathologies before isotope bone scans are listed in Table 1. The two most frequent provisional pathologies were spinal degenerative disease in 75 patients (54%) and no obvious pathological diagnosis (after CT scan, MRI and dynamic radiographs) in 39 (28%). The change in frequency, after addition of Tc^{99m}-MDP bone scan images co-registered with CT scan or MRI, is shown in Table 2. Pathology type changed in 14/139 patients (10%). Anatomic site had a major change (without overlap of the pre-isotope and post-isotope fields) in 7/139 patients (5%) and changed with overlap in 14/139 (10%). The treatment intention had a major change in 5/139 (3.6%), and minor in 12/139 (8.6%).

The pathological diagnosis changed in 14 patients (10%) after addition of Tc^{99m}-MDP bone scan images co-registered with CT scan or MRI. In these 14 patients, after initial imaging with CT scan, MRI and dynamic plain films, seven patients had no obvious pathology detected, three patients were suspected of having failed fusions, two patients were provisionally diagnosed with degenerative disease, one patient was thought to have an osteoporotic insufficiency fracture, and one patient was thought to have recurrence of C7 myeloma. The revised pathology diagnoses are listed in Table 3.

A major change in anatomic localisation after consideration of the isotope scan images occurred in seven patients (5%) (Table 4). There was no overlap of the pre and post-isotope anatomic sites in three cervical, two lumbar and two sacral causative pathologies. All seven patients who had their anatomic localisation changed without overlap also had their pathology type changed. In contrast, only half of the 14 patients with anatomic overlap changed pathology type.

Comparing before and after addition of the isotope scan images, treatment intention underwent minor changes in 12/139 (8.6%) and major changes in 5/139 (3.6%) patients. The five patients who underwent major changes in treatment intention are listed in Table 5.

Table 1
Pre-isotope scan pathology classification

Pathology type	Number	%
Spinal degenerative disease	75	54
No obvious pathology (after CT scan, MRI, dynamic radiographs)	39	28
Suspected failed spinal fusion	16	12
Osteoporotic insufficiency fracture	3	2
Inflammatory arthropathy	3	2
Trauma	2	1.3
Malignancy	1	0.7
Total	139	100

Table 2
Change in pathological diagnosis, anatomical localisation and treatment intention after addition of isotope bone scan images co-registered with CT scan/MRI

Change following addition of Tc^{99m} bone scan images	Number	%
Pathology type	14	10
Anatomical localisation		
Major change without field overlap	7	5
Change with field overlap	14	10
Treatment intention		
Major change	5	3.6
Minor change	12	8.6

Tc^{99m} = technetium^{99m}.

Table 3
Change in pathological diagnosis in 14 patients following addition of isotope bone scan images co-registered with CT scan/MRI

Pre-isotope scan pathological diagnosis	Post-isotope scan pathological diagnosis
No obvious pathology	Paranasal sinusitis Inflammatory cervical arthropathy Enthesopathy of ischial tendons Failed incorporation cervical strut graft Degenerative sacroiliac joint Degenerative L3/4 facet joints Sacral ala fracture
Suspected failed spinal fusion	Degenerative L2/3 facet joints Medial tibial plateau fracture Degenerative C2/3, C7/T1 facet joints
Spinal degenerative disease	Rheumatoid arthropathy C1/2 facet joints Osteoporotic insufficiency fracture L2
Osteoporotic fracture	Degenerative disease thoracic spine
Multiple myeloma (recurrent)	Degenerative disease C3/4 facet joints

Please cite this article in press as: Brazenor GA et al. Co-registration of isotope bone scan with CT scan and MRI in the investigation of spinal pathology. J Clin Neurosci (2014), http://dx.doi.org/10.1016/j.jocn.2013.11.034