The continued importance of post-therapy whole body planar imaging in the era of hybrid imaging: a pictorial review

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Learning objectives

1) To briefly outline the role of radionuclide therapy in treating certain malignancies, focusing on thyroid and neuroendocrine tumours.

2) Describe current practice for pretreatment imaging of neuroendocrine and thyroid tumours, including modalities and body parts usually included in the studies.

3) Reinforce the added value of post-therapy whole-body planar imaging in demonstrating distant metastases not included on hybrid imaging, and illustrate this with examples from our centre.

4) Reinforce the added value of whole body planar imaging in the assessment of benign or malignant disease when performing hybrid bone imaging.
Background

Radionuclide therapy has many applications. Using molecules that have high affinity for tumour cell surface antigens as carriers, radionuclides can be used for targeted treatment of tumours [1], with benefits including less exposure and toxicity to normal tissues [2]. Common examples of the applications of radionuclide therapy include in thyroid cancer, neuroendocrine tumours and in patients with bone metastases and lymphomas [2, 3].

Standard practice is to perform post-therapy whole-body planar imaging as this can have improved sensitivity for detection of occult sites of disease not included on the pre-treatment diagnostic imaging [4]. Owing to dose and time implications, routine diagnostic imaging prior to radionuclide therapy often excludes much of the appendicular skeleton thus missing distal metastases. In order to reduce CT artefact, shoulders are typically flexed and upper limb lesions may also not be scanned.

In addition, conventional cross sectional imaging performed for the investigation of benign or aggressive musculoskeletal pathologies focuses on the region of symptoms and clinical interest and therefore may miss other potential pain generators or incidental findings elsewhere in the skeleton.

This pictorial review addresses the value of whole body imaging in both a post radionuclide therapy and diagnostic, scintigraphic bone imaging setting using examples from our own practice.
Findings and procedure details

Conventional imaging protocols prior to treatment depends upon tumour type.

**Neuroendocrine tumours**

In the case of neuroendocrine tumours, whilst CT is often the initial modality in diagnosis, functional imaging can also be valuable in aiding diagnosis given that these tumours express somatostatin receptors. Traditionally, this was through somatostatin receptor scintigraphy, using Indium-111 labelled octreotide [5].

Recently, newer somatostatin analogues coupled to PET tracers have been developed, which to some extent overcome the limitations of Indium-111 labelled somatostatin receptor scintigraphy, with improved spatial resolution, reduced non-specific uptake in other tissues, and imaging on the same day as injection or tracer [5]. A well-known example is 68Gallium-DOTA peptides, where conventionally a half body study from skull base to mid-thigh is performed.

Whilst surgery is the first-line, curative treatment option, somatostatin analogues and targeted radionuclides can be used therapeutically, especially for patients with non-operative, incurable, well differentiated tumours or those that have a low proliferation index [5].

**Thyroid tumours**

With thyroid disease, much of the initial characterisation of lesions is performed with ultrasound. Nuclear medicine studies using Technetium-99m-pertechnetate have a limited role in diagnosis of thyroid carcinoma but can help to provide functional information in the assessment of thyroid nodules that maybe malignant [6]. Typically, in the absence of macroscopic metastatic disease, patients with presumed localised, well-differentiated thyroid cancer, do not routinely undergo imaging beyond the neck prior to surgery.

Therapeutically, radioiodine therapy using 131-I has been well accepted, and can be split into 'ablation', in order to destroy normal remnant thyroid tissue, or 'treatment', targeted towards the malignancy itself in the thyroid bed or distant functioning metastases [6].

**Post therapy whole body planar imaging**

As outlined above, conventional pretreatment imaging does not include the whole body in the absence of specific indications. In our centre, post therapy whole body imaging is
performed as standard and has highlighted several instances of distant disease, which were not included on the pretreatment/initial diagnostic studies. Some examples are detailed here.

**Example 1**

31 year old male with well differentiated metastatic pancreatic neuroendocrine tumour (PNET), with the primary malignancy within the tail of the pancreas. Post therapy imaging (Fig. 1 on page 7) following administration of Lutetium 177 DOTATATE shows extensive metastatic disease, including deposits in the skeleton outside the field of view included on the diagnostic Ga 68 DOTATATE study (Fig. 2 on page 7).

**Example 2**

81 year old male with metastatic atypical bronchial carcinoid. Post therapy Lu-177 DOTATATE imaging (Fig. 3 on page 8) shows additional uptake in the proximal left tibia not included on the diagnostic Ga 68 DOTATATE study (Fig. 4 on page 9).

**Example 3**

40 year old female with papillary thyroid cancer formally staged and histologically graded pT3 N1b Mx, diffuse sclerosing variant with lymphovascular invasion and extrathyroidal extension post surgery. Static post therapy views of the neck following Iodine 131 therapy show uptake relating to the thyroid bed and cervical nodes (Fig. 5 on page 10), however the whole body planar imaging performed post therapy shows diffuse uptake in the lungs (Fig. 6 on page 11). The uptake in the lungs corresponded to previously occult diffuse miliary metastatic disease on the SPECT/CT (Fig. 7 on page 12 Fig. 8 on page 13).

**Example 4**

37 year old male with follicular variant papillary thyroid cancer pT4(m) N1b M1. Initial post surgical but pre radioiodine therapy FDG PET/CT demonstrated non-FDG avid pulmonary nodules (Fig. 9 on page 13) with no other evidence of FDG avid distant disease or abnormality on the CT component of the study (Fig. 10 on page 14). Post Iodine 131 therapy planar and SPECT/CT imaging showed iodine avid residual disease in the neck, extensive pulmonary metastases (Fig. 11 on page 15 Fig. 12 on page 16) and bone metastasis in the left acetabulum (Fig. 12 on page 16 Fig. 13 on page 17).

**Example 5**


27 year old male who initially presented with left groin pain. MRI performed following initial referral showed increased marrow signal on STIR sequences along the symphysis pubis, more marked on the left, extending into the superior and inferior pubic ramus (Fig. 14 on page 18 Fig. 15 on page 18). On subsequent Tc99m labelled MDP bone scan with SPECT/CT, there was corresponding increased tracer uptake in this region (Fig. 16 on page 19). Whole body planar imaging highlighted other areas of pathological tracer uptake in the skull distant to the initial site of concern (Fig. 17 on page 19 Fig. 18 on page 20). Intense uptake was demonstrated at the base of the skull, as well as smaller areas in the clivus and left maxilla localised to bony expansion and ground glass change on SPECT/CT in keeping with polyostotic fibrous dysplasia.

Example 6

33 year old male with multiple known bone lesions in the ribs and clavicle. Diagnostic whole body planar imaging demonstrated uptake in the known lesions in the thorax, but also showed additional uptake in the left sacro-iliac region and T10 vertebral body (Fig. 19 on page 21). This correlated with further abnormalities demonstrated on the SPECT/CT (Fig. 20 on page 21). Appearances were in keeping with polyostotic fibrous dysplasia.
Images for this section:

![Fig. 1](image)

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Fig. 18
Conclusion

Conventional diagnostic imaging prior to radionuclide therapy does not cover the whole body. These case examples demonstrate the critical importance of whole body planar imaging in addition to hybrid SPECT/CT in post therapy and diagnostic settings. In patients who have had radionuclide therapy, whole body planar imaging allows the detection of previously occult sites of disease. In a diagnostic setting, the acquisition of whole body planar imaging can provide additional information and characterise clinically important findings separate from the region of clinical interest when referred for imaging by the clinical team.
References


