



*fusion imaging, hybrid imaging,  
functional imaging, SPECT-CT  
nuclear imaging, nuclear medicine*

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## **SPECT/CT – A NEW ERA IN MEDICAL IMAGING**

We present SPECT-CT, a new fusion imaging modality in the field of Medical Imaging. It combines a nuclear medicine technology (Single Photon Emission Computer Tomography (SPECT)) with a radiological technology (Computer Tomography (CT)) in one device. We illustrate the power of fusion imaging with three cases which we came across since we started fusion imaging in our department. SPECT-CT, as a single modality enables physicians to make more precise reports about distribution, biological activity and categorization of the lesions. This additional information plays an important role in determining the therapy and outcome of the patient.

### **INTRODUCTION**

Nuclear medicine (Emission) imaging renders functional information with limited spatial resolution and few anatomical landmarks while radiological cross sectional (Transmission) imaging provides high spatial resolution and morphologic details without any functional information.

“What is the *biological relevance* of what I see?” is what a radiologist typically has to ask himself while the nuclear medicine physician typically asks himself: “Where is the hot spot *exactly*?” Until recently, both imaging modalities had to be performed in a two-step procedure.

In 1950’s the planar scintigraphic imaging was the first and however crude method to document and display the information. While physicians were struggling with anatomical orientation in planar scintigraphy, the SPECT camera was developed in the 1970’s. Displaying the information three-dimensionally (or in a cross sectional way) made image interpretation easier but detailed anatomic landmarks were still missing due to the nature of the method.

### **SPECT**

SPECT is a nuclear imaging modality that has been in use for the past 40 years, still it did not come into widespread use until 1980’s.

Technological innovations such as:

- SPECT multi head detectors producing high quality images which rival PET studies
- Attenuation correction
- Advancement in software technology enabling Image fusion

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◦ Innovation in the drugs, imaging ligands and molecular targets brought renaissance of SPECT imaging.

Nowadays SPECT imaging provides a spatial resolution of down to 5mm without precise anatomical localisation while a routine CT-study can easily hold 1000 cross-sectional images with a slice thickness of 3mm showing details of 3mm and less.

### FUSION IMAGING

Image fusion (CT or MRI with SPECT) in a retrospective way was therefore the next move. Fusion of the image data sets proved to be easily feasible while anatomically correct and precise image fusion was not yet achieved because of different patient positioning and patient motion during the scans. Maintaining patient positioning for both procedures proved to be very difficult, especially in SPECT as data acquisition takes at least 20 minutes.

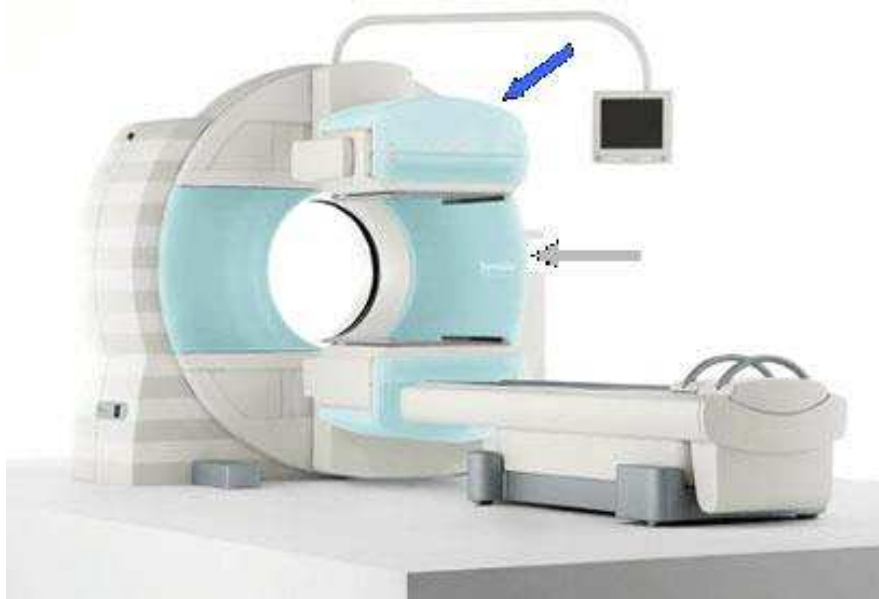


Figure 1: Symbia T2 true point SPECT-CT system with a dual detector variable angle gamma camera (blue arrow) and a dual slice CT scanner (grey arrow)

The next logical step therefore was to combine both imaging modalities in one device. (Fig. 1) By every day, we now realize the need and the power of the Fusion Imaging in clinical practice.

With fusion imaging, one is able to identify regions with non-specific activity, to detect abnormalities with inherently low resolution and to localize and categorize a lesion correctly. With exact

co-registration algorithms [1, 2] in fusion imaging, it now becomes possible to follow changes in receptor expression (a marker of biological activity) and tumor extent (morphological situation) over time in a patient quite efficiently.

### QUESTIONS ANSWERED BY SPECT-CT:

#### **Nuclear Oncology:**

Where is the location and how is the biological activity of the tumor?  Case 1

#### **Orthopaedics:**

How does the bone react to altered biomechanics (trauma, surgery)?  Case 2

#### **Endocrinology:**

Is there any remnant of the gland after surgery, if so where is it located?  Case 3

CLINICAL CASES EMPHASIZING THE POWER OF FUSION IMAGING

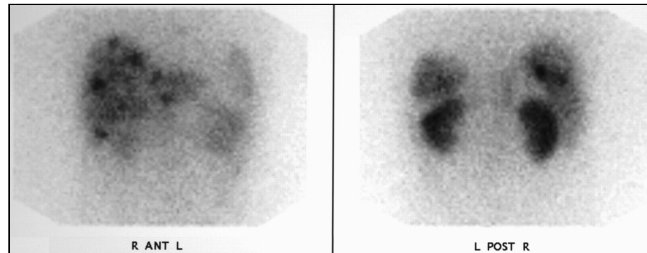
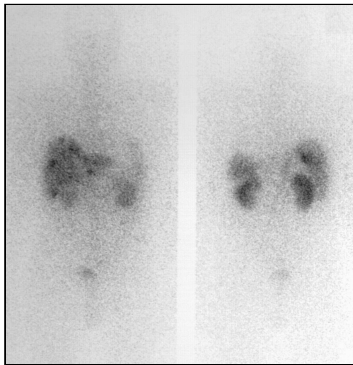
***Case 1 – Fusion Imaging in Nuclear Oncology***

***Evaluation of lesions in Peptide Receptor Radionuclide Imaging***

***Brief History:***

A 58 years old male patient diagnosed with a metastatic neuroendocrinal tumor of the midgut was referred to our department for Peptide Receptor Radionuclide Therapy. 28 hours after injection of <sup>90</sup>Y-DOTATOC and <sup>111</sup>In-DOTATOC, he had undergone SPECT / CT Fusion imaging.

***Planar Scintigraphy:***

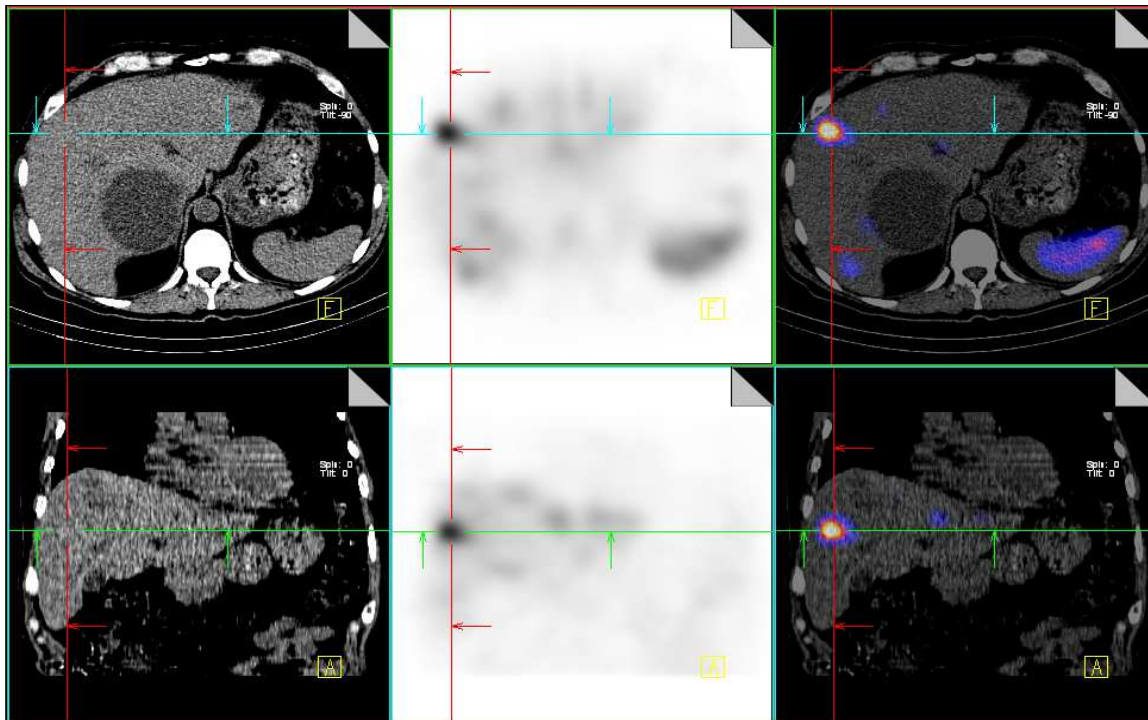


*The planar images give an overview of the distribution of the metastases without precise localization and intensity values.*

***CT Image:***

***SPECT Image:***

***Fused Image:***



***SPECT-CT Fusion Image:***

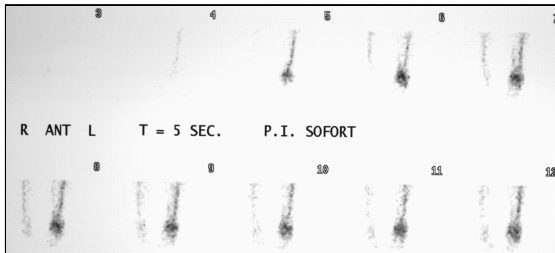
With fusion imaging, it is very well possible to correlate the lesions with varied homogeneity in CT with the lesions of varied uptake in SPECT. This helps in detecting and localizing the tumor and gives valuable information about the biological activity of the tissue [3].

## **Case 2 – Fusion Imaging in Orthopaedics** **Localisation of Osteochondrosis dissecans in bone scan**

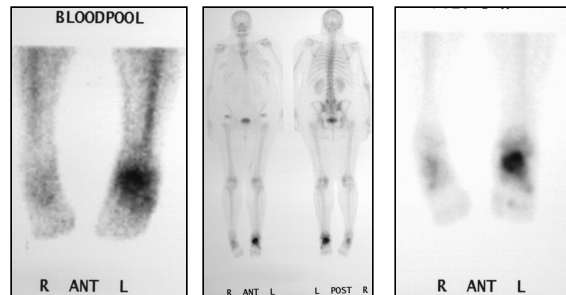
### ***Brief History:***

A 50 year old lady with pain in the left foot and Insulin dependant Diabetes Mellitus was referred to our department. She underwent a three phase  $^{99m}\text{Tc}$  - dicitruxonate bone (DPD) scintigraphy.

### ***Planar Scintigraphy:***



*arterial phase: early enhancement in the left foot.*

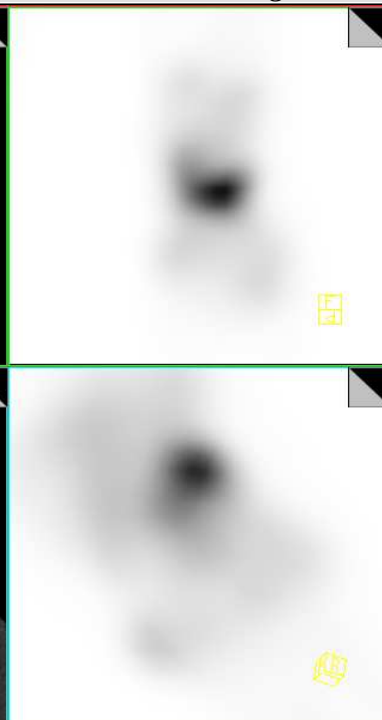


*blood pool phase: hyperperfusion in the left foot.  
 mineral phase: intense uptake in the region of the talonavicular joint.*

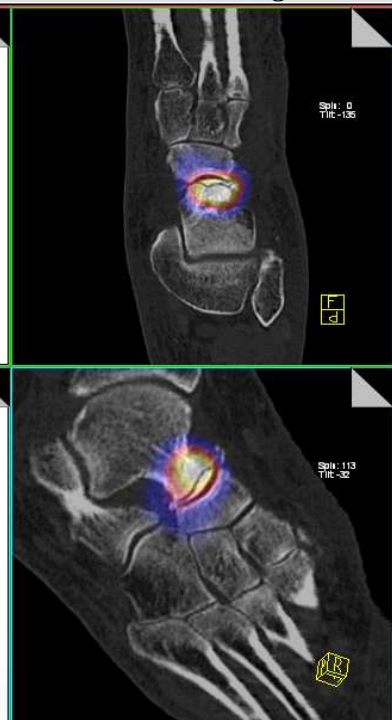
### ***CT Image:***



### ***SPECT Image:***



### ***Fused Image:***



### ***SPECT-CT Fusion Image:***

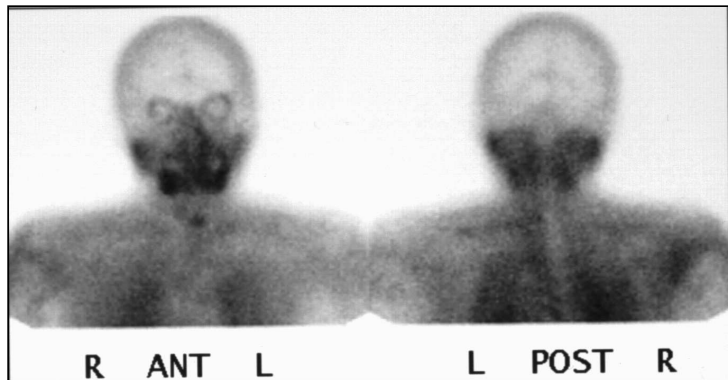
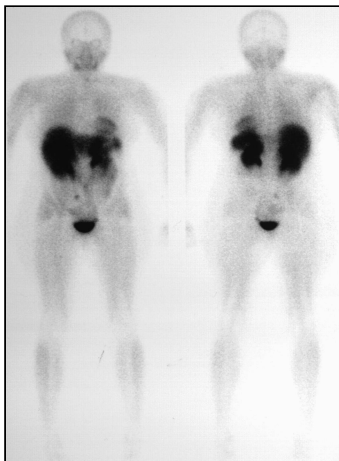
Only with SPECT-CT it is possible to correlate an increased uptake in the talonavicular region with an osteochondrosis dissecans (OD). Using only SPECT and planar scintigraphy one could have easily misdiagnosed the OD for severe degenerative changes in the joint.

### **Case 3 – Fusion Imaging in Endocrinology** ***Localisation of Parathyroid gland***

***Brief History:***

A 55 years old female patient was diagnosed with well differentiated papillary thyroid cancer. Four years ago, she underwent a total thyroidectomy with lymph node dissection and re-implantation of parathyroid gland. One month later, she was given two courses of Radio-Iodine therapy. She was referred to our department to exclude recurrence of the tumor. She underwent Parathyroid imaging with <sup>99m</sup>Tc-Sestamibi.

***Planar Scintigraphy:***

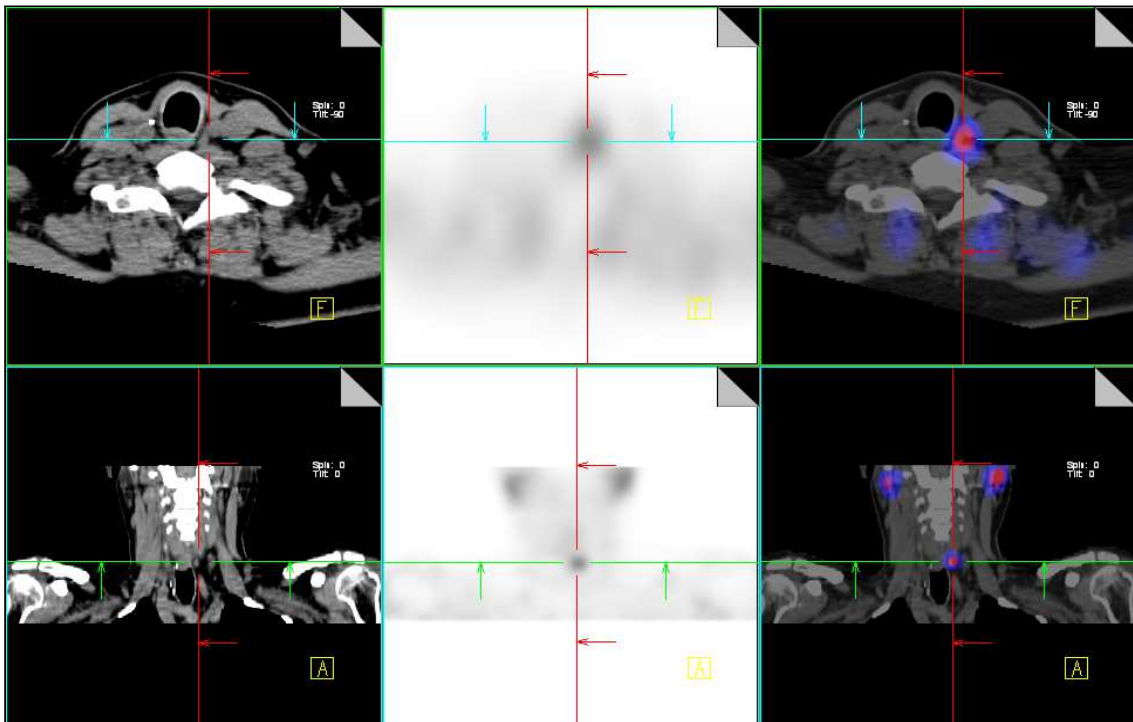


*A small uptake in projection on the middle of the neck is seen in the planar images*

***CT Image:***

***SPECT image:***

***Fused Image:***



***SPECT-CT Fusion Image:***

From the CT-image alone it is difficult to distinguish between a lymph node and a reimplanted parathyroid gland. With SPECT-CT fusion imaging we are able to localize and identify the lesion clearly as the reimplanted parathyroid gland.

## CONCLUSION:

The lack of anatomical landmarks in functional imaging methods e.g. SPECT studies resulted in the development of combined imaging modalities (fusion imaging) such as SPECT/CT or PET/CT to give anatomic details from MRI or CT studies.

Fusion Imaging provides us with additional information when compared to side-by-side SPECT and CT. This is relevant in increasing the accuracy of the diagnosis and is influencing the therapeutic procedure.

## WHAT IS NEXT IN FUTURE?

With increasing knowledge in the field of radiochemistry, it is possible to tag a specific molecule of our interest to  $^{99m}\text{Tc}$  or  $^{111}\text{I}$ , thereby imaging receptor distribution eg. Somatostatin receptor imaging using DOTATOC.

SPECT/CT is gaining importance in the field of molecular imaging due to the advantage of using multiple radionuclides with different energies (eg. in the same session) and the availability of the radionuclides.

## BIBLIOGRAPHY:

- [1] L HALLPIKE AND D J HAWKES Medical image registration: an overview *Imaging* 14: 455-463 (2002)
- [2] DEREK L G HILL, PHILIPP G BATCHELOR, MARK HOLDEN AND DAVID J HAWKES Medical image registration *Phys. Med. Biol.* 46 No 3 (March 2001) R1-R45
- [3] KRAUSZ Y, KEIDAR Z, KOGAN I, EVEN-SAPIR E, BAR-SHALOM R, ENGEL A, RUBINSTEIN R, SACHS J, BOCHER M, AGRANOVICZ S, CHISIN R, ISRAEL O. SPECT/CT hybrid imaging with  $^{111}\text{In}$ -pentetreotide in assessment of neuroendocrine tumors. *Clin Endocrinol (Oxf)*. 2003 Nov;59(5):565-73.