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# Nuclear Scanning in Evaluation and Treatment of Thyroid Disorders: A Beginners Guide

*Vandana K Dhingra**

*Department of Nuclear Medicine, All India Institute of Medical Sciences, India*

## Abstract

Thyroid disorders are common worldwide and the biggest fear amongst most patients with neck swellings is thyroid cancer. We need simple techniques in our clinics to diagnose and treat patients with thyroid disorders in order to initiate the right treatment as well as to alleviate patient's anxiety. Incomplete information and ignorance regarding these techniques prevents many clinicians to benefit from these simple and cost effective methods. Thus radioisotope modalities are still underutilized in many countries. We put together a short review by compiling our experience of common ways to effectively utilize radioisotope techniques in thyroid clinics along with literature review from current guidelines in a most simple and easy to understand way for the clinician.

## Introduction

Common thyroid disorders we may come across in our clinic include hypothyroidism, hyperthyroidism as well as nodular thyroid disease (solitary and multinodular goitre). Most thyroid disorders are evaluated with the a combination of the following modalities: the biochemical (Thyroid functions or T4, TSH) values, radiological imaging (US/CT Scan) for anatomical status/ nodules, functional imaging (nuclear scanning and uptake) and pathological (FNAC, Biopsy ) evaluation. The Nuclear Medicine or thyroid scanning remains one of the lesser known modalities in general practices due to its limited availability. We would like to bring forth the practical aspects of utilization of nuclear scanning in practice for decision making in thyroid disorders and highlight the ease with which a nuclear scan can be performed. We will also introduce to the reader about the common Nuclear Medicine therapeutic modalities for thyroid disorders.

## Introduction to Nuclear Imaging of the Thyroid (Thyroid Scintigraphy)

Thyroid gland has the unique ability to take up iodine an essential component of its hormones. The phenomenon of accumulation of iodine in the thyroid gland allowed for the use of iodine isotopes in the diagnosis of thyroid disease as early as about 70 years ago, although the mechanism of iodine uptake at the molecular level has been carefully examined until the late twentieth century. In 1939, a group of scientists from the University of Berkeley documented the uptake of radioactive iodine in human thyroid for the first time. This gave rise to first therapeutic radioiodine applications in patients with hyperthyroidism and thyroid cancer [1,2].

The uptake of iodine in the thyroid gland is attributed to the sodium-iodide symporter (NIS), described in 1993 by Kaminsky et al. [3] though the uptake of iodine by the thyroid cells is still widely used in the evaluation of thyroid function by means of radioiodine uptake test and thyroid Scintigraphy; thyroid evaluation with Technetium Pertechnetate-TC04 (Thyroid Scan) remains a mainstay in functional evaluation of thyroid disorders.

In addition to the morphological information obtained on the basis of ultrasonography, thyroid scintigraphy visualizes the distribution of active thyroid tissue. Therefore, the general indications for scintigraphy are quite wide and include both single thyroid nodule, and multinodular goitre. The test is also used to evaluate the extent of retrosternal goitre (when ultrasound is not able to visualize the lower pole of the thyroid gland) and in suspected ectopic thyroid. In the case of goitre without clear dominance of one of the nodules, scintigraphy is used to select the biopsy site. Thyroid scintigraphy should be performed in all patients with nodular goitre undergoing treatment with radioiodine, since it allows to assess the anatomical distribution of active thyroid tissue, which may be important in the selection of therapeutic 131I activity [4,5]. Keeping in mind the widespread availability and expertise of Ultrasound and needle biopsy the indications have been made very specific to bring

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***Correspondence:***
*Vandana K Dhingra, Department of Nuclear Medicine, All India Institute of Medical Sciences, India,*
*E-mail: modisbanu@yahoo.com*

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**Table 1:** Common Radioisotopes used for Thyroid Scintigraphy.

| Technetium-99m (Tc99m) | Iodine -131 | Iodine -123 |
|---|---|---|
| • Most commonly used<br>• Readily available<br>• Cost effective<br>• Can be done fast<br>• Safe, no side effects | • More physiological agent, used mainly for therapy<br>• More radiation exposure due to beta emission<br>• Used rarely for imaging- in large reotrosternal goitres and carcinoma thyroid | • It is the ideal agent for thyroid imaging<br>• Limited availability and costly<br>• Mostly inofrmation is same as that obtained by Tc scanning<br>• Specific indications include evaulation of organification defects |

maximum benefits from the scanning. In 2009–2010 American Thyroid Association (ATA) and other guidelines have published their recommendations suggesting that the thyroid scintigraphy is useful only in patients with nodule diameter greater than 1 cm, provided that TSH concentration is subnormal. The role of scintigraphy in this case is to show whether a nodule, that is manifested in ultrasound, is a focus of excessive hormonal activity (hot nodule) or accumulates the radiotracer at a level similar to or lower than the rest of the gland (warm or cold nodule). Since the hot nodules are rarely malignant, according to ATA guidelines fine-needle biopsy is not necessary in such a case. At the same time, performing Scintigraphy in all patients with nodular goitre is not recommended by experts, since adequate assessment obtained with ultrasound and cytology is sufficient in most cases [6].

### Patient preparation for thyroid scintigraphy

Usually no prior patient preparation is needed for Thyroid Scintigraphy.

In case the patient is taking thyroid hormone replacement therapy or iodine, the study should be done four to six weeks after stopping these drugs.

The female patients who are pregnant or breast feeding the babies should inform the nuclear medicine physician before taking a diagnostic test.

Although the radiation exposure involved is very low, however, in case of pregnancy the procedure would be performed only id really needed at that point (benefit *vs*. risk evaluation).

## The Basic Gamut of Nuclear Medicine in Thyroid Disorder Evaluation

While referring and interpreting results of thyroid Scintigraphy, the physician should be aware of the current situation of the patient:

- History of thyroid disease
- Ultrasound findings
- Current TSH

Used drugs, in particular thyroid hormones, antithyroid drugs and iodine-containing agents (amiodarone, disinfectant and expectorant drugs), these may have effect on overall functioning of the thyroid gland as well as on scan findings

Thyroid Scintigraphy is functional imaging and is interpreted with full knowledge of the patient status for optimal results [6].

- Post surgical detection of remnant /metastasis –diagnostic
- Ablation of remnant/metastasis –therapeutic

### Principles of interpretation of thyroid scan

Thyroid scintigraphy produces an image of distribution of radiotracer in thyroid parenchyma. It helps to diagnose thyroid diseases on the basis of level of radiotracer uptake as compared to surrounding structures, radiotracer distribution in thyroid, any extrathyroidal uptake etc. It gives an idea about thyroid location. It also helps to know thyroid morphology including its size and overall & regional level of thyroid function both qualitatively and quantitatively.

### A normal thyroid scan

Normally the gland is symmetrical and the lateral borders of lobes are straight to convex. Tracer is normally seen in salivary glands and in capillary network of the neck tissue also, called as 'blood pool'. This is seen as a light background along the neck contour.

### Graves' disease

Typical clinical features of Graves' with biochemical parameters and a thyroid scan would complete workup of these patients. Radioiodine therapy is the treatment of choice in non-complicated, small to medium sized goitres . Thyroid Scintigraphy usually shows uniform diffuse enlargement. Tracer is uniformly distributed in the thyroid. Not normally seen pyramidal lobe (a remnant of thyroglossal duct) can be seen in a hypertrophied gland. Tracer is barely trapped in salivary glands due to less tracer availability for extraction to them consequent to higher trapping by thyroid.

## Thyroiditis

The clinical features on recent onset hyperthyroid symptoms accompanied by upper respiratory tract infection features or neck pain are classically accompanied by a scan image of very low or no tracer uptake. This is due to the stunned thyrocytes during the acute phase of imflammation. These patients can be conservatively managed with symptomatic therapy in the form of NSAIDs, low dose steroids, beta blockers. A repeat scan after 3 months would show a resolving thyroid in various stages showing various types of uptake. The scan ensures recovery has been attained and serves as a baseline for future.

### Solitary thyroid nodule

They are usually palpable nodules and are mainly evaluated to rule out malignancy. On thyroid scanning the following types are identified:

• **Warm**: Tracer uptake equivalent to normal tissue, usually means normal level of function in that area. Have a low probability of malignancy.

• **Cold**: Tracer uptake nil or less than normal tissue, means nil or less than normal level of function. Such nodules could result from cystic changes, fibrosis, haemorrhage, adenoma, malignancy etc. Have a high probability of malignancy.

• **Hot**: Tracer uptake higher than normal tissue, means more than normal level of function. They can be Autonomously Functioning Thyroid Nodules (AFTN). Have a low probability of malignancy.

## Multinodular Goitre

It usually develops in the population living in iodine deficient

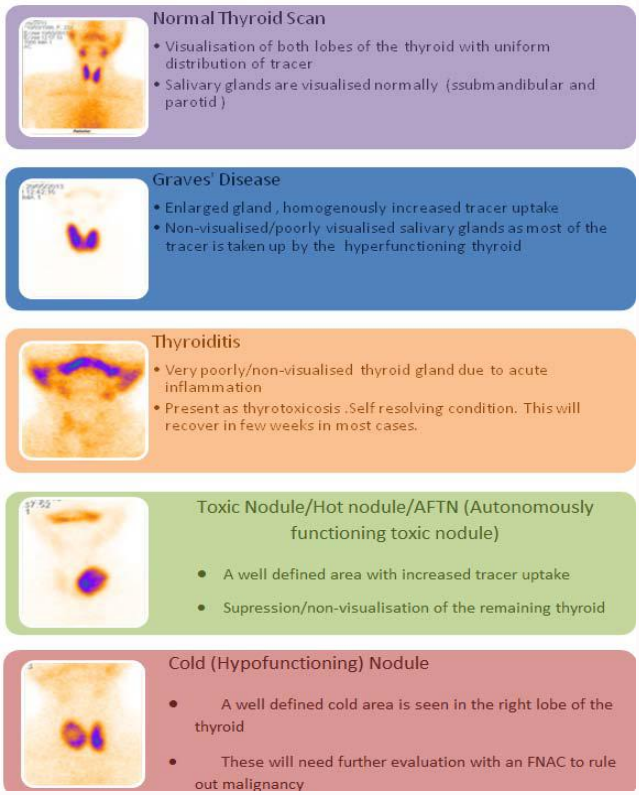


**Figure 1:** Thyroid Scan pictures in common conditions seen in your clinic.

regions due to periods of nutritional iodine deficiency interspersed with iodine sufficiency resulting in compensatory thyroid hypertrophy and regression to normalcy respectively. This causes nodularity, focal haemorrhages, calcifications, cyst formation and scarring in the gland. Thyroid size is usually grossly increased with non-uniform enlargement in general. The tracer distribution can also be inhomogeneous in case of a nodular pathology because different areas/nodules can have different levels of function. Therefore, on scintigraphy the tracer trapping is variable, higher/lower than normal in some areas. Some nodules may become autonomous i.e. independent of TSH control and can show hyperfunction resulting in toxic MNG. In such cases areas of increased radiotracer uptake i.e. hot nodules can be seen. The toxic multinodular goitre needs treatment to prevent long term complications of suppressed TSH. Usually high doses (15-25 mCi) of Radioiodine are very successful for subtle control of the subclinical toxicosis status. However if compression symptoms are present then surgery is more beneficial.

### Toxic autonomous nodule

It is also called as Autonomously Functioning Thyroid Nodule (AFTN) i.e. independent of TSH control. Image shows a focal increased tracer uptake confined to a nodule that occupies most or all of the thyroid lobe. The remaining gland is non-visualized due to total suppression of TSH stimulation . These patients can be treated successfully with radioiodine therapy/surgery.

### Thyroid dysgenesis/Agenesis/Ectopic thyroid

Thyroid scanning with I-131 is the gold standard for imaging of functioning thyroid tissue in the body. A screening with Tc-99m scanning can be done followed by I-131 imaging if indicated.

## Thyroid Cancer Management

Radioiodine is used widely in management of differentiated thyroid cancers. Initially role of thyroid Scintigraphy is in the diagnosis by the way of detection of cold nodules.

In any differentiated thyroid cancer (papillary/follicular) thyroidectomy is the recommended modality of therapy (Details of types of surgery are beyond the scope of this text). Total thyroidectomy followed by a radioiodine ablation is the treatment of choice. Ablation means destruction of all the thyroid tissue (including normal) with Radioiodine (I-131).

The principles involved are:

1. It would help to locate any functioning metastasis (whole body scanning is done post therapy).

2. Follow up with Serum Thyroglobulin and /or I-131 scanning- it becomes easier to detect any recurrence after ablation as the thyroglobulin levels would show a subtle rise which is not reliable if the ablation has not been done. Common areas involved are local recurrence (neck); cervical/mediastinal lymph node metastasis; lung metastasis; bone metastasis.

3. Any recurrence/metastasis can be managed with radioiodine therapy in addition to surgical intervention.

## PET (Positron Emission Tomography)

PET is a nuclear medicine modality commonly used for evaluation of cancers. The details are beyond the scope of this text but we can brush upon the common areas in thyroid disorders where PET (with F-18 FDG) imaging plays a role :

- Thyroid incidentalomas are seen in about 2% of patients undergoing PET scan for other problems. Evaluation of these can lead to detection of several occult/asymptomatic thyroid cancers.
- Evaluation of equivocal thyroid nodules by scanning and cytology [7].
- Management of thyroid carcinomas.

## Conclusion

Thyroid Scanning/Scintigraphy is a simple, non-invasive, cost effective tool for evaluation of most thyroid disorders. If used appropriately it can answer the queries which a clinician sitting in his clinic with a *'patient'* and a '*thyroid profile/US/FNA report'* needs to answer.

In addition to diagnostics, radioiodine (I-131) therapy plays a very important role in treatment of hyperthyroidism. It can be a surgeon's partner in effective management of thyroid carcinomas.

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