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Review Article

Scintigraphy: The Illumination of The Buried

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Abstract

It is very important to each a conclusive diagnosis to treat or manage the patient with the best possible treatment modalities, however a proper diagnosis is always a matter of concern, especially when the disease is highly progressive in nature and therefore needs a dynamic diagnostic assessment to understand the rate of disease progression to hinder the disease process at the earliest time period possible. Nuclear medicine imaging not only provides us with vital information about the structural configuration in static position but also functional information of the area of interest. The use of CT and MRI after image acquisition provides anatomical as well as physiological images which can be viewed independently or superimposed as 'fused' multi-planar reconstructions. The high sensitivity levels of nuclear imaging helps to detect even the feeblest pathophysiological changes which are of utmost importance in the process of diagnosis. The capability to detect minor changes at the initial stages itself makes it the preferential choice of diagnostic modality, however they are not the most preferred diagnostic modality owing to factors like reduced accessibility and awareness of the diagnostician, especially in the field of dentistry.

Keywords: Nuclear; Emission; Tomography; Disease; Diagnosis; Isotope

Introduction

Diagnosis is the key to plan and execute any treatment as well as to reach a favorable prognosis and avoid complications. A lot of progress has been done observed in the field of diagnostics which have their implications in medical as well as dental implications which have been significantly showed their effects for patients. In dentistry, IOPA is the basic diagnostic test of choice in comparison to other advanced diagnostic modalities such as OPG, CBCT, CT, Nuclear dentistry (for more advanced case diagnosis).

Nuclear medicine is a branch or field of medicine and medical imaging which makes use of radionuclides and depends on radioactive decay of the radioactive agent in the diagnosis and treatment of disease.[1,2] We are aware of the deleterious effects of nuclear agents, however the armamentarium used in the field of nuclear medicine are non-hazardous and also carry the advantage of being painless, and economical in comparison to other diagnostic modalities for diagnosis and treatment of the individual.

Nuclear medicine imaging not only provides us with vital information about the structural configuration in static position but also functional information of the area of interest [1,2]. The ability of nuclear medicine to detect any anomalies during their functional stage helps in diagnosis and management of the disease process at an very early stage which helps to reach a favorable prognosis.

The radiopharmaceutical compound entails two chemically bound agents, consisting of a radioisotope as well as a tracer. After the radiopharmaceutical drug is administered to the patient, the radioisotope endures decay, while emitting photon emission which may be diagnostic or therapeutic or both in actions. Most commonly the radiopharmaceutical drug is found to be more specific in nature towards the target organ which makes the use of pharmaceutical drug selective for each organ [3].

The drug targets the specific organ and detects the physiological mechanism as well as the pathological changes with increased uptake in the specific regions of the area of interest where there is inflammation or increased cell turnover rate. This radiopharmaceutical drug emits gamma rays from the target organ within the patient, which in turn is detected by external detectors like the SPECT/CT, PET/CT, and more recently, PET/MRI [3].

The use of CT and MRI after image acquisition provides anatomical as well as physiological images which can be viewed independently or superimposed as 'fused' multi-planar reconstructions. This helps in better image detail and 3D image structure for a better understanding of the disease process along with its extent [3].

Radiopharmaceuticals

In the year 1950, radiopharmaceuticals gained importance in diagnosis for specific organs and disease process, especially for the bone to analyze the physiologic and pathologic changes in bone metabolism and blood flow rate, which can be static and dynamic in nature. The localization of radioactive agents helps in detection of distant tumor sites with increased uptake of the radiopharmaceutical agents, commonly termed as "hot spots". The capability to detect minor changes at the initial stages itself makes it the preferential choice of diagnostic modality [4].

These drugs are tagged with a chosen carrier component for appropriate delivery of the drug at the area of interest which are as follows

- **Skeleton:** Pyrophosphate and methylenediphosphonate (MDP) compounds
- **Thyroid gland:** Sodium iodine
- **Pulmonary studies**: Xenon or krypton gas
- Liver, spleen, and bone marrow - sulfur colloid [4,5].
- Oral and maxillofacial area (Osteomyelitis) - Gallium-67-citrate
- Bone (especially dento-maxillofacial region) - Tc-99m-monodiphosphonate (99mTc-MDP)
- Salivary gland imaging - Technetium-99m pertechnetate
- Differentiating benign and malignant disease- F-18-FDG [6].

Most commonly there are three categories of imaging receiving devices in use

- Planar nuclear imaging
- Single-photon emission computed tomography (SPECT)
- Positron Emission Tomography (PET) [4].

Planar nuclear imaging

Anger Gamma Scintillation Camera was developed by Hal O. Anger IN 1950, with it being the most commonly used nuclear imaging device. The camera detects gamma emissions at a given time from a wide area of the patient and concurrent surrounding area. These scintillation cameras transfigures the gamma radiation into light emissions which are further processed to provide useful clinical images on the radiographic film [4].

Single-photon-emission computed tomography (SPECT)

Single-photon-emission computed tomography (SPECT) is the advanced form of planar imaging. It also provides visualization of dynamic action within the specific organ or body system of the individual. SPECT makes use of single photon emitters as tracers without the need of on-site dedicated cyclotrons for production, with the gamma camera recording the tracer as it decays [7].

Positron emission tomography

PET produces a three-dimensional picture of the dynamic functional processes in the human body by analyzing the metabolic activity of the tissues. Herein, a positron emission radionuclide – or tracer – able to track a specific biologic process at molecular level is injected into the patient and the decay of these radioactive 3 tracers are decay detected using a PET scanner [7].

Positron emitters are radionuclides like fluorine-18, carbon-11, oxygen-15 and nitrogen-13, which in their non-radioactive state are normal constituents of all biologically active molecules (fluorine is a suitable substitute for hydrogen) and are therefore potentially suitable to label any molecule without altering its metabolic pathway [7].

As tumor cells have cell multiplication potential, hence a glucose analogue like FDG is used as a tracer, both because flourine-18 is quick to decay, thus limiting patients radiation exposure and because it is a natural indicator of cellular metabolic state, predominantly increased in cancer cellular deposits [7].

Fluorine-18 is the most commonly used radioisotope used in positron emission tomography (PET). Here, the target is to study the glucose metabolism with PET scanning by recording the positrons released from positron-emitting isotopes which intermingle with proximate electrons to overwhelm one another, producing two gamma rays move in opposite directions to each other. Rings of detectors within the PET scanners detects gamma emissions with the scintillation detectors in PET scanners sensitive to the high-energy photons (511 keV) which are emitted by these isotopes with the signals from the detectors are processed, resulting in transverse images of the radionuclide distribution in the patient [4].

Applications in dentistry

Bone Scintigraphy

Helps in detection of osteoblastic activity in the skeleton with increased uptake on administration of 99mTc-MDP with a half-life of 6 h and 140 keV gamma energy.[8] Bone scintigraphy has advantages like high sensitivity, assessment of parenchymal function and excretion of major salivary glands, as well as detection of skeletal metastases [9,10].

TMJ imaging

Help to detect early changes in the TMJ skeleton, including the abnormalities of the disc joint, facial skeletal growth assessment, synovitis, and quantification of arthritis in patients with rheumatoid arthritis or osteoarthritis [4,11,12]. The radiopharmaceutical agent of choice being the radionuclide 99mTc with SPECT the imaging modality of choice, because the TMJ is a small joint with proximity to the skull base and paranasal sinus. Thus, SPECT scan, distinct to the double-dimension highlighting, present TMJ separately from the parts of high bone density. It provides high sensitivity is high and low specificity. It also detects any inflammation, trauma, or tumors which upsurges the local isotope concentration [11-13].

Trauma

The high sensitivity levels of nuclear bone imaging helps to detect even the most feeble fracture levels at the initial stages itself in comparison to other diagnostic modalities [4]. Apparently, Zwas., *et al.* in the year 1987 provided the interpretation as well as classification of bone scan findings in case of stress fractures. Also, the healing process in stress induced fractures was well detected in nuclear imaging in comparison to that observed amongst other diagnostics [4,14].

Inflammation

In case of inflammation there is increased blood supply noted with a higher number of cells being concentrated in that region, which may be misleading in nature which diagnosing any tumor or any other condition. However, it shows the exact pathophysiologic changes which are been processed within the body systems. A large number of studies have shown significantly positive results indicating the superiority as well as a co-diagnostic test to reach a conclusive diagnosis [4].

In 1986, Jeffcoat and colleagues conducted a study in 12 patients with severe periodontal disease, which laid the foundation of use of radiopharmaceutical drug in the field of dentistry, wherein they found a significant association between high uptake of the radionuclide and teeth involved with bone loss with a sensitivity of 81%, and specificity was 78%. Similarly, it also detected active bone loss with an accuracy of 80% [15].

Further, the use of nuclear medicine along with imaging, especially in the cases of malignant disease and metastasis has been the most common concern that has been addressed and supported over the years with studies which shows its significant role and impact in diagnosing the disease process [16,17].

Nuclear medicine and grafts

The use of nuclear medicine to monitor the changes after graft placement has lately gained importance as the administered radiopharmaceutical drug can detect early bony changes as well as any osteoblastic activity of significance.

The study conducted by Berding., *et al.* concluded that [18F-] PET (fluoride ion and positron emission tomography) depicted increased blood flow activity in onlay grafts and regions of osteosyntheses, indicating bone repair in the graft and adjacent host bone early after surgery [18].

It has also been observed that PET offers further acumen into the biology of graft incorporation [19]. However, literature data has made it evident that SPECT is more sensitive than planar imaging for assessing graft viability.

Conclusion

Nuclear dentistry has proven its substance as the diagnostic as well as the therapeutic modality in the field of dentistry. However, it is not used with the same dynamism as that observed in the field of medical specialty. The use of nuclear dentistry in the diagnosis and management of the disease processes needs proper education and reinforcement amongst general dentists and oral medicine as well as oral surgeons. Further there is a dearth need for increasing the accessibility and equipment for diagnosis across the region to encourage the use of such diagnostic cum management/treatment procedure.

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