ROLE OF NUCLEAR MEDICINE IN DIAGNOSIS OF ORAL & MAXILLOFACIAL DISEASES

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ABSTRACT

In present scenario conventional radiographs, CT scan, MRI or ultrasound are commonly used for diagnosis of maxillofacial diseases, but on review of latest literature it is seen that nuclear medicine can work hand in hand with conventional diagnostic aids. Nuclear medicine is a branch that utilizes the radioactive materials to determine the biochemical process of cells which eventually result in assessing the metabolic activity of an organ. This review reveals role of nuclear medicine in diagnosis of maxillofacial diseases.

Key Words: Nuclear Medicine, Maxillofacial Diseases, Radioactive Materials

INTRODUCTION

Medical healthcare has been using nuclear medicine for a long time now but the use of it in dentistry is poorly understood, underutilized, underexplored. In recent time procedures like PET, SPECT, lymph node scintigraphy/sentinel lymph node has made nuclear medicine as adjunct in modern diagnostic arena and justifies its use in dental disease as well. Nuclear medicine utilizes the accumulating action of radioisotopes in cells and so after injecting them, with a help of a specialized gamma camera images are taken at a certain time interval to detect distribution and quantification of isotopes and hence metabolic activity. Head and neck tumors, salivary gland disease, and various metabolic as well as infectious processes of the head and neck region are the areas where radio isotopic scanning can be used in oral and maxillofacial disorders. Plain films radiographs, CT scan and MRI scan are able to provide good soft and hard tissue imaging only when morphological change have occurred but nuclear scanning precede them in diagnosis by detecting metabolic changes earlier than to be seen as morphological changes. With all these observations a dentist must be aware of this specialty and discussion and emphasis should be laid on this for a successful diagnostic and therapeutic implications.

BONE SCAN

Bone scanning is one of the most popular technique used in nuclear medicine. It utilizes the bone seeking property of various radio pharmaceutica (technetium-99m labelled diphosphonates) which gets incorporated in mineral matrix of bones (hydroxyapatite and calcium phosphate) and then images subsequently. It is found that diphosphonate gets incorporated in areas with increase osteoblastic activity and vascularity which allows bone scan to detect osteoblastic activity 10% above normal. Conventional radiographs works on basis of differential absorption of x-rays because of which atleast 30%-50% of bone loss should be present to be detectable as bone erosion. Bone scan uses a radiopharmaceutical technetium-99m labeled with diphosphonates having half-life of six hours and emission of 140kev gamma energy. Since the adsorption of diphosphonates to hydroxyapatite is 40 times more than organic matrix its uptake correlates with degree of mineralization. A normal bone scan should demonstrate symmetry around the midline with uniform uptake of the radiopharmaceutical. A three-phase bone scan is often performed to obtain additional diagnostic information, especially when the clinician is trying to distinguish osteomyelitis from cellulitis. The first phase is called dynamic vascular flow phase in which difference in vascularity is determined by imaging every 2-3 sec for the first 30 sec.
In second phase, difference in regional blood low and vascularity can be appreciated by imaging 5 min after first scan. During this time radiopharmaceutical begins to appear in bone from vascular compartment. 2-4 hours later, A third phase scan called osseous delayed static image is taken for the entire body to determine metabolic activity of bone and hence regional distribution in the skeleton. In non inflammatory conditions is suspected, the third phase is usually the only image obtained.

Some useful applications of bone scan in dentistry includes differentiating body infections from soft tissue infections such as osteomyelitis from cellulitis, diagnosing inflammatory joint disease (TMJ osteoarthritis) and benign malignant metabolic disease. Areas of increase uptake is called ‘hot spot’ whereas areas of decrease uptake is called ‘cold spot’. Lesions resulting from radiation treatment, local vascular compromise, prosthetic joint, early osteomyelitis, multiple myeloma, and avascular necrosis which causes area of decrease uptake or cold spot is also seen on bone scan.

**PET SCAN**

PET is a functional imaging modality that allows the measurement of metabolic reactions within the whole body. The property of tumors to utilize glucose at a faster rate than normal cells due to increase rate of glycolysis is being used in PET scan. A radiopharmaceutical 18F-fluorodeoxyglucose (FDG) is used most commonly which when injected get phosphorylated and trapped inside cell and shows increase uptake on scan PET camera. Diagnosis of distant metastases, identification of synchronous 2-primaries, detection of carcinoma of unknown primary and detection of residual or recurrent disease are some clinical applications of 18F-FDG PET and PET/CT in head and neck cancer include emerging applications are precise delineation of the tumor volume for radiation treatment planning, monitoring treatment, and providing diagnostic information. Pet scan has also been used in TMD’s. In a study conducted by J. Lee et al. in 2013 18F PET/CT showed high TMJ uptake ratios in TMD with osteoarthritis and demonstrated higher sensitivity and accuracy than those of a conventional bone scan for detecting TMD with osteoarthritis.

**LYMPHOSCINTIGRAPHY**

One of the popular technique already used in breast carcinoma and melanoma find its way to be used in oral and maxillofacial region. Sentinel node mapping is a technique which uses the property of carcinomas to spread via lymphatics. Sentinel node is first draining node of a particular anatomical area. In carcinomas, sentinel node is primary node carrying metastatic cells via lymphatics which further drain into subsequent nodes. If sentinel node is diagnosed to be involved then chances of lymphatic spread to other nodes is present. It prevents unnecessary surgical intervention if sentinel node is found to be negative for metastases. In this technique technetium 99m sulfur-colloid is injected in four to six subcutaneous sites around the neoplastic lesion which is carried to near by node via lymphatics. Gamma camera is used to detect the sentinel node which if found is resected surgically.

**SPECT (SINGLE PHOTON EMISSION COMPUTED TOMOGRAPHY)**

It is an extension of conventional bone scan as it utilizes tomographic technology to provide 3-dimensional images (axial, coronal and sagittal) which thereby facilitates more accurate interpretation and better localization of bone pathology. Various uses of SPECT includes assess the mandibular invasion of squamous cell carcinoma (SCC), determining in the therapeutic course in patients with asymmetrical mandibular condylar hyperplasia and to assess the osseous integration process of dental implants.

**INFLAMMATORY AND INFECTIOUS CONDITIONS**

Inflammation is a dynamic process which occurs in response to external/ internal agents to limit the disease process. Various inflammatory or infectious disease of maxillofacial region included pulpal pathologies, periodontal disease, osteomyelitis, traumatic injuries, TMJ disorders. Bone scan may detect changes in bone much before conventional radiographs and hence some periapical lesions are found on accidentally on bone scans. Baumgartner and Eggli similarly discovered periapical lesion on bone scan of patient with malignancy. When using scans for osteomyelitis which detects relative amount of blood flow to area i.e dynamic flow phase, amount of activity in surrounding tissue due to extravasation blood pool phase, rate of bone turnover in delayed bone phase is useful. Some of the fractures shows negative radiographs findings which may lead to inaccurate diagnosis. Since fracture line are usually the site of increases metabolic activity (increase dye uptake) they can be easily detected using bone scintigraphy. In cases of unhealed fractures normal scintigraphy uptake will never be seen as they will always be in a state of metabolic unrest. The ability of bone scan to show positive result even when the increase in osteoblastic activity nearly increase by 10 percent is advantageous for early detection of bone changes in patients with TMJ osteoarthritis.

**MALIGNANCIES**

Head and neck Cancer (HNC) is the fifth most common cancer worldwide, with an estimated annual global incidence of 533100 cases and is among the four major non-communicable fatal diseases the other three are Cardiovascular, COPD and Diabetes Mellitus. Accurate staging at the time of diagnosis is critical for selection of the appropriate treatment strategy. CT and MR imaging rely on criteria of contrast-enhancement patterns and nodal size for detection of lymph node metastases which are not specific and may escape detection of metastases within normal size lymph nodes. Increase radiotracer deposition occurs in
areas of increased osteoblastic reparative activity. The presence of multiple, randomly distributed areas of increased uptake of varying size, shape, and intensity is highly suggestive of bone metastases. The ability of scans to image whole body in a single scan is useful to assess primary tumour, secondary metastasis, nodal staging and potential secondary primary carcinoma. In literature review PET has sensitivity 87% and specificity 89% as compared 62% and 73% respectively in CT scan in head and neck carcinomas. PET has shown to be having greater sensitivity (78% as 57%) and accuracy (92% Vs 76%) for detection of nodal metastasis in clinical N0 condition. Unknown primaries are major concern in HNC as they lead to inaccurate diagnosis and unnecessary procedures which increases cost, patient discomfort, morbidity and precious time. Role of nuclear medicine in this aspect is significant. Treatment response assessment has also used PET scan for evaluation of healing, by assessing reduction in metabolic activity and hence uptake on multiple PET studies over baseline value. Post chemotherapy study done by Ong et al shows that negative PET scan after chemotherapy treatment avoids the need for neck dissection. Similarly low values on PET after chemotherapy in patient having lymphadenopathy has prevented unnecessary neck dissections with negative predictive value (NPV) and specificity (97% and 89%) respectively. Role of PET /CT in radiation planning is being studied and it is assumed that PET /CT may increase gross target value since metabolic active cells can be detected in normal size lymph nodes. Variation in target volume can be done according to disease spread. With detection of metastasis, treatment planning can be modified accordingly. Studies done by Soto et al, Nabroths child et al. have also emphasized role in PET/CT in treatment planning for radiotherapies.

**FIBRO-OSSEOUS LESIONS**

Bone dysplasia refers to abnormality in which normal bone is replaced by fibrous tissue containing abnormal bone or cementum or trabeculae of metaplastic bone. Bones scans are useful to determine extent and activity in these lesions. Various disease like Pagets disease, Fibrous dysplasia having multisessous involvement can be detected using bone scans effectively.

**BONE GRAFT PROCEDURES**

Osseous implants have become an internal part of rehabilitation nowadays ranging from replacement of single tooth to whole arch rehab to implants after surgical procedures. Available bone density, type of bone, site and quality all determine the success and failure of implants. Use of bone scans/PET scans to determine viability of bone graft is useful in predicting graft failure. Since clinical monitoring of these vascularized grafts is difficult bone scans are useful studies done by harbert. Kärcher et al - schimming et al - have shown significant role of nuclear medicine in determining success/failure of bone grafts.

**DEMERITS**

Inspite of many advantages over conventional radiological examinations, PET/CT have some disadvantages too. These scans can lead to false positive and false negative results. For example, active periodontal disease can result in an increased uptake of the radiopharmaceutical in the alveolar processes of the mandible and maxilla which may mimic neoplasia. Increased activity in the cervical spine can be due to arthrosis. In Dental Implant surgeries the role of PET/CT is limited as compared to Dentscan. In growing children, there is increased activity in the epiphysal plates. PET scan give false positive results. FDG may accumulate in non-neoplastic tissue such as new granulation tissue, areas of inflammation, and early post-operative scarring. For example, the oral squamous cell carcinoma patient with a recently irradiated neck would likely have a false positive result for two to three months after the conclusion of radiation treatment. False positives results can also occur in conditions such as tuberculosis and sarcoïdosis. Overall, while the sensitivity can be lacking, the specificity is high. Cumberosome procedure, long interval waiting, high cost, variable patient compliance, sensitivity to injected dyes are other some disadvantages of nuclear medicine. Metallic implants, respiratory motion, contrast medium, and truncation are some of the causes of artifacts commonly seen in PET/CT images. Due to their high CT number resulting from high photon absorption, metallic materials like implants, dental fillings, hip prosthetics and chemotherapy ports shows streaking artifacts. All these lead to high PET scan value which are can cause overestimation and false positive result. Difference in size of the field of view between the CT (50 cm) and PET (70 cm) tomographs leads to truncation artefacts in PET/CT scan.

**CONCLUSION**

With the expansion of diagnostic imaging, it has been customary for dental practitioners should be well versed with the various indications for nuclear imaging techniques in oral/dental pathologies. PET/CT imaging increases the accuracy of diagnosis by combining anatomic information with functional imaging. Although not specific, exquisite sensitivity makes it useful screening procedure for many pathologic conditions. For a proper diagnostic approach and follow up, morphologic and physiologic imaging modalities, in combination, should support each other in offer valuable information in the diagnosis of maxillofacial jaw bone lesions.

**References**


