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Role of Technetium Scans in Oral and Maxillofacial Surgery

Dr. Mamatha Ns, Dr. Bhavana Koushik, Dr. M. Soundharya, Dr. Mahesh Kumar Ts

Rajarajeswari Dental College & Hospital

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KEYWORDS

Technetium-99m, 99mTc-pertechnetate, bone scintigraphy, bone scan.

ABSTRACT:

Purpose: To evaluate the role of technetium-99m scans in the diagnosis of various pathologies in the field of oral and maxillofacial surgery.

Materials and methods: The PubMed database was searched for articles between January 2010 to November 2020 with the inclusion of studies in English on various pathologies in the field of oral and maxillofacial surgery. Randomised control trials (RCT), non-Randomised control trials (non-RCT), systematic review, meta-analysis, case reports were included. Studies on animal models were excluded. Total of 31 articles were included for this review.

Results A Total of (n=679) patients had been subjected to technetium scans with its application majorly seen in sentinel node biopsy for squamous cell carcinoma followed by for TMJ/ condylar disorders.

Conclusion Technetium-99m scan is the efficient diagnostic modality of the future in diagnosing various pathologies affecting the oral and maxillofacial region.

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1. Introduction

Technetium scans are one of the newest diagnostic imaging modalities, which has a diverse application in the field of oral and maxillofacial surgery. It is one of the least invasive modalities which finds better application in certain pathologies where biopsy is the gold standard for diagnosis till date. Technetium -99m sessambi is injected around the region of interest either one day before the planned procedure or at least 1-2hr before the procedure. Following the injection SPECT scan is commonly performed to view the regions of increased uptake. They find their application in the diagnosis of various pathologies like condylar hyperplasia, brown tumors, osteomyelitis, MRONJ, salivary gland diseases, in SCC for sentinel node biopsies, they can also be used to assess the vascularity of the bone grafts. With the half-life of 6 hours of the radiopharmaceutical, technetium 99 m methylene diphosphonate and the total radiation dose of 0.3 rads, the diphosphonate molecule has increased uptake in the regions with increased vascularity and osteoblastic activity by binding to the calcium ions in the vicinity to form calcium phosphate[1]. With the availability of numerous radioisotopes, the one which produces a more detailed information along with reduced radiation to the patient should be chosen [2].

This systemic review of literature is done with an aim to recognize the numerous indications for the application of the tc-99m scans in the field of oral and maxillofacial surgery. The second aim is to summarize the outcome, advantages and disadvantages of this diagnostic method.

2. Materials And Methods

The online database PubMed was searched for aspects studied (indications, oral and maxillofacial pathologies) were created using combinations of MeSH (Medical Subject Headings) keywords and their synonyms. Inclusion criteria included the articles between January 2010 to December 2020, language: English. Exclusion criteria included non-English language articles,

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duplicates and irrelevant articles and studies done on animal models.

Figure 1 represents a flowchart describing the process of data collection. The articles were assigned a rank based on the level of evidence on the scale of 1 to 4. Level 1 evidence included systematic reviews of randomised controlled trials, level 2 evidence included systematic reviews of cohort studies, individual short studies, level 3 evidence included systematic reviews of case control series, level 4 evidence included case reports, the average LOE in this report was 2.83. Table 1

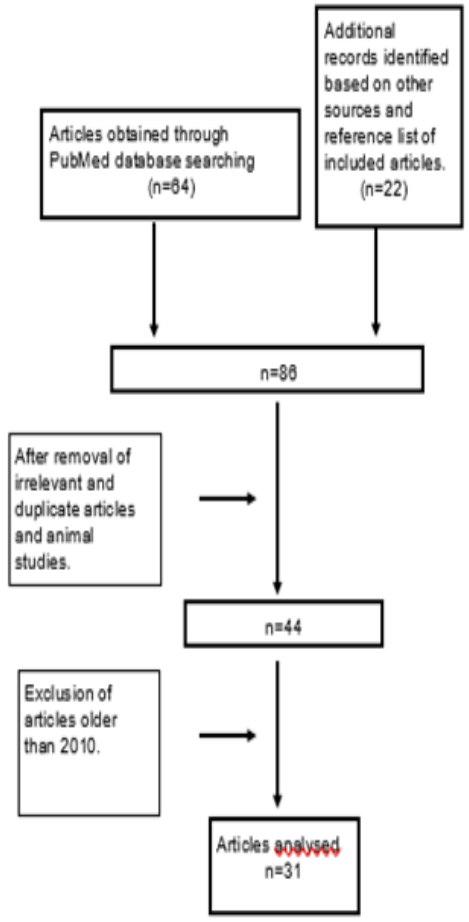

Fig 1 flowchart showing the process

Reference	Type of study	Level of evidence
Bedgoni et al.	Literature review and case report	1
Yu Jin Lee et al.	Literature review	1
Shreenivasa Murthy et al.	Literature review	1
Higginson et al.	Literature review	1
J H Kim et al	Prospective study	3
R Musase et al	Prospective study	3
Chuan Bince et al	Prospective study	3
Alexandre et al	Prospective study	3
Ichiro Ogura et al	Prospective study	3
Bahadur gurbuzer et al	Prospective study	3
Sophie Kuijpers et al	Prospective study	3
Yumiko ohbayashi et al	Prospective study	3
Min seek suh et al	Prospective study	3
H rushinak et al	Prospective study	3
Jamdade et al	Prospective study	3
Bing Wen et al	Prospective study	3
Salazar et al	Prospective study	3
Agarwal et al	Prospective study	3
Diego Lopez et al	Prospective study	3
Mackinaw et al	Prospective study	3
J hernando et al	Prospective study	3
A R Fernandes et al	Prospective study	3
Oliver ristow et al.	retrospective study	3
Karsemakers et al	retrospective study	3
Insook park et al	Case report	4
Yumiko ohbayashi et al	Case report	4
yung Hsiang kao et al	Case report	4
Carl Bouchard et al	Case report	4
Joshua parfitt et al	Case report & genetic pathophysiology review	4

Table 1: level of evidence

3. Results

The search strategies yielded a total of 86 articles, of which 31 was retained after articles on animal study, duplicate, non-English articles were removed. 31 Full text articles on technetium scans were assessed for inclusion eligibility. Published between January 2010 and December 2020, these papers included 4 literature reviews, 18 prospective studies, 2 retrospective reviews, 6 case reports.[31] English language articles were qualitatively and quantitatively assessed in this review and the results are presented in Table 2.

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Article citation	Type of study	Number of patients	Indications
Park I, Kang S. J Med Case Reports, 2017:	CR	1	B-cell Lymphoma
Bedogni et al. Osteonecrosis of Jaw After Implant Surgery. J Oral Maxillofac Surg 2010.	CR	1	Oral Bisphosphonate–Associated Osteonecrosis of the Jaw After Implant surgery.
Ohbayashi Y. Et al., Oral Surg Oral Med Oral Pathol Oral Radiol 2013.	CR	1	BRONJ
A.T. Assaf et al. / Journal of Cranio-Maxillo-Facial Surgery xxx (2015)	PS	21	BRONJ/DRONJ
Ogura I, et al. Annals of Nuclear medicine, 2019	PS	13	MRONJ and chronic osteomyelitis.
Gürbüzer et al, J Oral Maxillofac Surg, 2010.	PS	14	Osteoblastic Activity in Extraction Sockets Treated With Platelet-Rich Fibrin
Kim J-H et al, Dentomaxillofacial Radiology, 2012.	PS	22	osteoarthritis of the temporomandibular joint
Murase R et al, Int. J. Oral Maxillofac. Surg, 2015.	PS	16	Oral squamous cell carcinoma
Chuan-Bin Wu J Oral Maxillofac Surg, 2015.	PS	47	Salivary gland diseases
Oliver Ristow J Oral Maxillofac Surg, 2014.	RS	90	BRONJ
Obhayashi Y, et al., Odontology 2016	PS	28	mandibular metabolism during long-term bisphosphonate administration
Min Seok Suh, RSNA, 2016	PS	22	TMJ disorders
Yung Hsiang Kao Oral Maxillofac Surg, 2012.	CR	1	unilateral mandibular hyperactivity
Carl Bouchard J Oral Maxillofac Surg, 2013.	CR	1	Condylar hyperplasia
Parfitt J et al, J Oral Maxillofac Surg, 2015.	CR	1	HPT-JT
Luc H.E. Karssemakers Oral Surg Oral Med Oral Pathol Oral Radiol, 2013.	PS	67	Unilateral condylar hyperactivity
H. Rushinek, Int. J. Oral Maxillofac. Surg, 2016.	PS	51	Unilateral condylar hyperplasia
Jamdade A S et al, Journal of Clinical and Diagnostic Research, 2014.	PS	20	Bone invasion by oral carcinoma
Wen. B et al, Scientific World Journal Volume 2014.	PS	105	Unilateral condylar hyperplasia
Wilson, Schwartz, and Tehrany. J Oral Maxillofac Surg 2013.	CR	1	Brown Tumor In Hyperparathy- roidism.
Clara Isabel Salazar-Fernandez J Oral Maxillofac Surg, 2015.	PS	96	Sentinel Lymph Node Biopsy in Oral and Oropharyngeal Squamous Cell Carcinoma
Agarwal A et al, Ann Surg Oncol, 2015.	PS	101	Sentinel Lymph Node Biopsy in Oral Squamous Cell Carcinoma
López DF, Journal of Oral and Maxillofacial Surgery, 2017.	PS	27	Condylar hyperplasia
Marcinow A M, *JAMA Otolaryngol Head Neck Surg*, 2013.	PS	20	Sentinel Lymph Node Biopsy in Oral Squamous Cell Carcinoma
J. Hernando, P Int. J. Oral Maxillofac. Surg, 2014.	PS	73	Comparison of related complications: sentinel node biopsy versus elective neck dissection
X.-J. Liu, Int. J. Oral Maxillofac. Surg. 2016 .	PS	27	Keratoconjuctivitis sicca
A.R. Fernandes et al. / British Journal of Oral and Maxillofacial Surgery, 2019.	PS	44	Assessment of relative uptake by mandibular condyles in a "normal" population

Table 2: Literature review results, (PS- Prospective study, RS- Retrospective study, CR- Case report)

Indications:

The most common indication for advising a bone scan was for sentinel node biopsy in oral squamous cell carcinoma (n= 326) which is 48.01% of the total reported cases followed by for condylar/TMJ disorders (n=319) which is 46.98%. Other conditions indicated for bone scans were MRONJ (n=28), Browns tumour (n=2), salivary gland disease (n=1) etc.

Tc-m and oral squamous cell carcinoma

5 studies involve the use of technetium scan in the detection of lymph node involvement in cases of SCC1. Tc scans were used as a guidance for performing an accurate sentinel lymph node (SLN) biopsy. The procedure was to inject the technetium-99m nano colloid at a few points around the primary tumour either on the previous day or on the day of the surgery, following which lymphoscintigraphy and few other diagnostic aids like SPECT/CT was performed to correctly identify the SLN. Between the same-day and next-day procedures no significant differences were observed.[3]

99mTc-tilmanocept concept was found to be a better agent in detecting the involvement of SLN in cases of OSCC owing to its high negative predictive value and low false- negative rate, which along with the use of SPECT/CT helped in improved localisation of the SLN preoperatively along with better delineation near the primary tumour.

The false-negative rates ranged from 0% 4, 2.56% (n=1)3, 11% (n=4) 5 and negative predictive value ranged from 100% using 99mTc-tilmanocept in this setting 4, 97.8% 3, 94% 5 with an overall diagnostic accuracy above 95% in all of them. One of the studies used a double SLN mapping with indocyanine green (ICG) and 99m- technetium–tin colloid (99mTc–tin colloid) and found a significantly longer duration of fluorescence because of its enhanced retention capabilities by avoiding flow into the lower-tier nodes. [6] With SNB showing significantly less morbidity than elective neck dissection (END) it is proposed to be a better alternative to END in early stages of cancer.[7]

Tc-m and TMJ

7 studies described the use of technetium scans in the diagnosis of condylar hyperplasia, which is one of the leading causes of facial asymmetry, that in turn leads to malocclusion, pain, dysfunction etc. The difference in uptake of tc-99m between a normal condyle and the condyle with hyperactivity is recorded on SPECT scans and are compared by drawing region of interest (ROI)

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and comparing it with the other condyle or to the other bones like petrous bone or mastoid processes that can be used as references. It has been hypothesized and proven that a difference in activity of more than 10% between the condyles, and a condyle - to - clivus ratio above 1.44% are suggestive of abnormal turnover rate and anything above 5% warrants further clinical investigations [9]. Technetium-99m is also used in radio-guided surgeries based on the concept that their intake at the hyperplastic regions of the condyle produces significant gamma-emissions which are detected by the gamma-probes that aid in easier bony resections [10]. These scans help in surgical decision making as in, a partial condylectomy is warranted if the relative uptake remains above 55% and less than 55% would be an indication for direct orthognathic surgery [11] [12]. In cases of active diseases, the treatment option ranges from delaying the surgery until the growth stops; condylar reduction followed by orthognathic surgery either immediately or delayed [13]. No association has been noted between the age and bone activity, making the importance of age criteria unclear in the development of unilateral condylar hyperplasia [14].

2 studies described the use of Tc scans in diagnosing other disorders affecting the temporomandibular joint. Standardized uptake value (SUV max)was found be an accurate quantitative parameter in evaluation of TMDs like arthralgia [15] by calculating uptake ratios using the parietal bone [16].

Case Report:

A 47 years old male presented with the chief complaint of inability to chew on left side with deviation of the face for 2 years. Patient gave no history of trauma to the joint. Medical history was non-contributory to the condition.

On Examination: The face asymmetry with deviation of chin towards right side with flattening on the left middle & lower third of the face (figure 2).

Figure 2

TMJ movements were present with adequate mouth opening. Deflection of the jaw towards the right side could be seen with opening (figure 3).

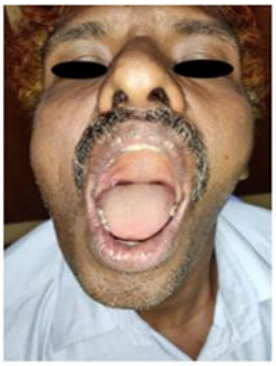

Figure 3

On intra-oral examination, open bite could be appreciated on the left side from midline extending posteriorly (figure 4).

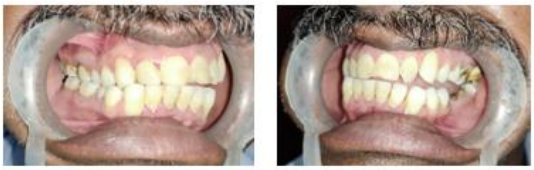

Figure 4

Following, it was provisionally diagnosed as condylar hyperplasia.

Radiographic examination: OPG revealed bulbous enlargement of the condylar head on the left side along with elongated ramus length.

To determine the growth activity in the condyle, a three-phase bone scan with SPECT using Tc99m was done. The scan showed increased radio-tracer uptake in the region of the left condyle of the mandible suggestive of active condylar hyperplasia in the left TMJ (figure 5).

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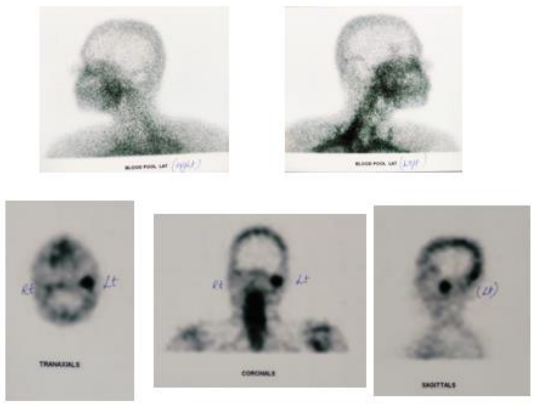

Figure 5

Tc-m in osteomyelitis and MRONJ

A total of 8 studies are published over medication induced osteomyelitis of the jaw. Bisphosphonates are commonly used medication to treat various conditions like metastatic & metabolic bone diseases, multiple myeloma etc. Some of the drugs used in these studies were Aldronate, Denosumab, pamidronate, zoledronic acid, clodronate etc. The most common long-term side of use of iv bisphosphonates and to a smaller extent, the use of oral bisphosphonates, is the condition known as bisphosphonate induced osteonecrosis of the jaw and the most common triggers for its occurrence include extraction of tooth, implant placement. One suspected contributing factor to the development of MRONJ is the inhibition of osteoclastic bone resorption and jaw remodelling. 99mTc-MDP is often used for the detection of bone remodelling or repair, as it tends to accumulate in osteoclasts at active bone sites, they are also used to check the effectiveness of treatment of BRONJ with drugs like Teliparatide, by comparing the pre and post treatment scans. Bone uptake value (BUV) is the measure used to quantify the accumulation of radiopharmaceuticals in the bone. The measures like the pixel densities and Gray values are used to correlate the osteoblastic activity at the (ROI). For the proper evaluation of certain lesions like MRONJ or chronic osteomyelitis, quantifiable values of standard uptake value SUVmax, SUVpeak, SUVmean and TBU derived from bone SPECT/CT and voxel-based quantitative parameters may be useful. Tc-99m-MDP bone scintigraphy can reliably predict the extent of disease and improve its anatomical localization. [17-24]

TC-m in salivary gland disease:

Various neoplastic (benign or malignant) and non-neoplastic diseases affect the salivary glands. The non-neoplastic diseases include sialadenitis, sialolithiasis, Sjogren's syndrome etc., though various diagnostic modalities have been used in the diagnosis like the use of ultrasonography (USG), computed tomography (CT), Magnetic resonance imaging (MRI). The use of scintigraphy can be used routinely to distinguish various salivary gland disease and to evaluate the glands' function [25].

Two studies dealt with the use of technetium scans in the diagnosis of various salivary gland diseases. A study by Wu et al. used this technique to assess salivary gland function and morphologic data using quantitative indicators and explained its use in determining the location, morphology, and size of the gland. They proved the advantages of tc scans in determining accurately the salivary gland uptake, excretion, and acid reactive functionality. In cases of Sialadenitis, 99mTc-pertechnetate salivary gland scintigraphy showed normal uptake and decreased excretion and in cases with Sjogren's syndrome there was a reduction in both uptake and excretion by the glands. Quantitative methods are needed to assess whether the gland is functioning and hence worth saving. Clinically it is often difficult to distinguish patients suffering from Sjogren's syndrome and sialadenitis because of the common complaint of swelling and discomfort of the affected gland. With the routine examinations such as sialography and labial gland biopsy being more invasive and painful, alternative less-invasive technique like the 99mTc- pertechnetate salivary gland scintigraphy can be used to diagnose and distinguish between the conditions [25]. In the other study, tc scans were used to determine the effect of Carbachol, a parasympathetic mimetic agent in improving the salivary secretion from a transplanted submandibular salivary gland in patients with keratoconjunctivitis sicca during the latent period i.e. between the 7th day and 3 months [26].

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TC-m and other bony pathologies

1 study was on hyperparathyroidism induced browns tumour. Hyperparathyroidism is one of the main causes of metabolic disorders of the bone. The pathology is called the browns tumour, which is a non-neoplastic lesion of highly vascular proliferative granulation tissue along with multi-nucleated osteoclast type giant cells. Technetium scans of the parathyroid gland carried out in patients with a clinical diagnosis of hyperparathyroidism showed presence of "cold" nodules.[27]

One study by Jamdade et al used tc scans in detecting the bone invasion by oral carcinoma using Lewis-Jones diagnostic criteria. They concluded that a combination of tc scan along with panoramic radiograph was an accurate diagnostic aide in detecting bone invasion by oral carcinoma.[28]

Tc-m and extraction socket evaluation

One study Gubuzer et al, used bone scintigraphy based on technetium-99m methylene diphosphonate uptake in third molar extraction sockets to evaluate the effects of platelet-rich fibrin (PRF) on bone healing. Early bone healing was compared by evaluating the scintigraphic differences between the PRF-treated and non-PRF treated sockets by postoperative week 4. Regions of interest of equal size were drawn on both operation sites on the mandible to delineate the osteoblastic activity quantitatively. Temporal bone could also be used as a reference for normal bone activity.[29]

4. Discussion

The numerous pathologies affecting the oral and maxillofacial region require various diagnostic methods for proper diagnosis as an aide in formulating a proper management plan. One such diagnostic aide of recent times, the potential of which hasn't been completely explored yet, is the use of bone scintigraphy, a valuable and versatile nuclear medicine tool. The most commonly used radio tracer Technetium-99m (Tc99m) complexed to a diphosphonate, either methylene diphosphonate (MDP) forming Tc99m-MDP or hydroxy diphosphonate (HDP) forming Tc99m-HDP. With the help of an appropriate clinical history along with use of other diagnostic modalities for correlation, technetium scans can be advised in a variety of pathological conditions like fractures, condylar hyperplasia, salivary gland diseases, squamous cell carcinomas, certain bony pathologies like Paget's disease, fibrous dysplasia, osteoid osteoma, browns tumour etc. Tc99m phosphonates localize to bone in proportion to osteoblastic activity as seen at sites of bony remodelling and, to a lesser extent, localizes in proportion to blood flow and its delivery of the radio-tracer. The specificity of skeletal scintigraphy, therefore, relies heavily on an appropriate clinical history and correlation with other imaging modalities.

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 three phases include:

- The dynamic vascular flow phase, where imaging is performed every 2-3 seconds for the first 30 seconds. In this phase, each side can be compared and differences in vascularity can be seen.
- The blood pool image at five minutes, where the radiopharmaceutical is mostly in the vascular compartment but is starting to appear in bone. This phase demonstrates regional differences in blood flow and vascular permeability.
- Two to four hours later, the osseous delayed static image is obtained usually for the entire body demonstrating regional distribution in the skeleton. This phase reflects the metabolic activity of the bone in question. In non- inflammatory conditions, the third phase is usually the only image obtained. [1-2]

Quantitative variables like ROI, SUV, etc. are used measure the amount of radioisotope uptake. ROI or Region of Interest is drawn over a SPECT where transverse slices are reconstructed in trans axial projection. Square 3×3-pixel ROIs are drawn over the area of concern e.g. the condyles over three consecutive slices and the region with the highest radio tracer count is made the centre of the image. The mean radiotracer count ratios are calculated by comparing the site of complaint with the normal site taken for comparison.[8]

SUV or Standard Uptake Value is another quantitative measure where, SUV = (tissue radioactivity/ voxel volume) / (injected radioactivity/body weight), where tissue radioactivity means a tissue radioactivity concentration measured by SPECT which is obtained by multiplying the SPECT counts and Becquerel calibration factor (BCF). Various SUV parameters are further obtained using the equation to calculate SUVmax, SUVmean, SUVpeak, MBV(metabolic bone volume)& TBU(total bone uptake) values.17

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Implication of results for patients: It could provide a better, less invasive and less painful and more accurate alternative in the process of diagnosis of various pathologies.

In terms of cost: higher cost of its setup. Higher cost would discourage its application especially in developing countries like India.

Implication of results for oral and maxillofacial surgeons: better diagnostic modality would ease the diagnosis of various conditions for the OMF surgeon, without the need to perform biopsy in many cases

5. Future Studies

The diversified application of the technetium -99m bone scans could become the gold standard for detecting and diagnosing various pathologies and conditions affecting the oral and maxillofacial region hence more studies need to be carried out to compare it's the accuracy with other invasive techniques of diagnosis presently used and its role as a quantitative parameter.

6. Conclusion

technetium or bone scans are the future of improved diagnostic methodologies which has a very versatile application in the field of oral and maxillofacial surgery.

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