

Role of Bone Scintigraphy in Oral and Maxillofacial Surgery

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Certificate

This is to certify that the Dissertation entitled “**Role of bone Scintigraphy in Oral and Maxillofacial Surgery**” done by **Dr.Pramod Kumar .G**, Postgraduate student M.D.S Branch I – Oral and Maxillofacial Surgery, Meenakshi Ammal Dental College and Hospitals, Chennai, submitted to The Tamil Nadu Dr. M.G.R Medical University in partial fulfillment for the MDS Degree examination in February 2005, is a bonafide research work done under my guidance and supervision.

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Introduction

Bone scanning is one of the most frequently performed nuclear medicine investigation because of its extreme sensitivity in detecting a bone injury within 24 hours. As functional changes in bone occur much earlier than the gross structural changes, the bone scan will often detect abnormalities before they are evident on X-ray. A bone scan is a test that detects areas of increased or decreased bone metabolism (turnover). The test is performed to identify abnormal processes involving the bone such as tumor, infection, or fracture.

Normally an X-ray becomes positive only after 21 days which is the time taken for bone callus to form. Bone scans are valuable as functional test of bone metabolism that complements the anatomical details available from X-rays, CT and MRI.

Bone scans can be used to diagnose and differentiate bone infections (i.e. osteomyelitis) from soft tissue infections (i.e. cellulitis), as well as detect primary and metastatic malignant disease. They can also be used to assess the vascularity of bone grafts and contribute to the diagnosis of various metabolic bone diseases such as fibrous dysplasia, Paget's disease, osteoarthritis, and

rheumatoid arthritis (RA). It is important to keep in mind that a bone scan can detect 10-15% mineral loss, while standard radiographs will only visualize a bony defect after 35-50% of mineral loss. With this plethora of advantages, its application in various oral and maxillofacial bony pathologies was undertaken in our department.

Review of literature

Graffman S, Rangne A. (1977) stated that the symptoms of an acute osteomyelitis of the jaws are often uncharacteristic, and typical radiographic changes usually do not appear until after the first weeks of disease. Even when such changes are established it is difficult to distinguish an active infectious disease from lasting changes due to a sterilized osteomyelitis. They also added that Scintigraphy with bone-seeking radiopharmaceuticals appears to be a valuable diagnostic technique.

Jacobsson S, Hollender L, Lindberg S, Larsson (1978) in their study, investigated fourteen patients with chronic sclerosing osteomyelitis of the mandible with ^{99m}Tc-labeled bone-seeking agents. Scintigraphic findings were compared with radiographic features. High uptake of diphosphonate and polyphosphate was demonstrated in diseased areas. Good agreement was found between radiography and scintigraphy concerning the extent and

activity of each process. They also discussed use of bone-seeking radiopharmaceuticals in other types of skeletal lesions and differential diagnostic aspects.

Von Wowern N, Hjorting-Hansen E, Edeling CJ. (1978) stated that bone scintigraphy may be used as a differential diagnostic aid in doubtful cases of cherubism and fibrous dysplasia, or to reveal any lesions of other bones. They also stated that the method cannot be used for differentiating between fibrous dysplasia and osteomyelitis, but that bone scintigraphy may be useful in the early diagnosis or the late control of osteomyelitis in the jaws.

Front D, Hardoff R, Robinson E. (1978) bones of the face and skull may be involved directly by adjacent primary tumors of the head and neck. Radiography, at present the standard method for detection of bone involvement in such tumors, is not sufficiently sensitive. Of 22 patients who showed bone involvement in scintigraphy, radiography in 15 was initially normal, in 6 the extent of the lesion was not completely shown and only in 3 was it as informative as scintigraphy. Bone scintigraphy should become a standard method for evaluation of the context of bone invasion by tumors of the head and neck.

Esdaile J, Rosenthal L.(1983) in their study found that radionuclide joint imaging with the technetium-99m-labeled phosphates is a sensitive technique for the detection of inflammatory articular disease, although it is nonspecific as to the cause of the increased uptake and offers poor resolution in comparison to conventional radiography. They feel that there does not appear to be any place for the routine use of joint imaging of the peripheral joints, as there is little evidence that it benefits patient management. They also feel that scintigraphy is of benefit in the detection of osteomyelitis, Legg-Perthes' disease, and osteonecrosis, where changes may antedate roentgenologic abnormalities. Technetium-99m-phosphates may have an increasing role in the evaluation of knee and hip prosthetic joint loosening and infection, especially regarding the femoral components. Scintigraphy may be useful in excluding synovitis and allaying concern in selected patients with chronic articular pain in whom a conventional diagnostic evaluation is unrewarding. Attempts have been made to use radionuclide joint imaging to quantitate the degree of synovitis present in individual joints, particularly the sacroiliac joints. To date, reliable methods that distinguish normal from abnormal joints have not been established, although this remains an area of potential usefulness and active research. Scintigraphy with ^{99m}Tc-phosphates is useful in the detection of spinal fracture and pseudoarthrosis in individuals with ankylosing

spondylitis.

Djupesland G, Nakken KF, Muller C, Skjorten F, Tohrt R, Eldevik P. (1983) found that the sensitivity of ^{99m}Tc-MDP-bone-scintigraphy in the diagnosis of temporal bone fracture was found equal to that of conventional radiography if the patients were examined 10 days after the trauma. Temporal bone osteomyelitis with concomitant moderate osteosclerosis was demonstrated by bone scintigraphy in 5 cases of mastoiditis with atypical symptoms. A case of apicitis was for the first time demonstrated by scintigraphy. A low sensitivity of ⁶⁷Ga-scintigraphy was demonstrated by positive ^{99m}Tc-bone-scintigraphy and negative ⁶⁷Ga-scintigraphy in a patient with atypical mastoiditis. ^{99m}Tc-scintigraphy was negative in 5 cases of otitis media suppurativa and in 3 cases of otitis media chronica cum cholesteatoma, all with slight degree of osteosclerosis in the mastoid. The sensitivity of ^{99m}Tc-bone-scintigraphy in fracture and osteomyelitis of the temporal bone seems to be a function of the amount of reactive new bone formed.

Cisneros GJ, Kaban LB. (1984) utilized the technique of skeletal scintigraphy for diagnosis and treatment planning in 21 patients with mandibular asymmetry. Diagnoses included hemi facial microsomia (n = 6), condylar hyper or hypoplasia (n = 10), and generalized mandibular

asymmetry (n = 5). ^{99m}Tc-MDP uptake was measured in the right and left condyle, ramus, and body. Uptake was then compared with the known age-adjusted standards. The data were used to determine 1) mandibular growth activity, 2) normal vs. abnormal side, and 3) the effects of operative and functional therapy. The presence of end stage deformity was predicted when mandibular uptake reached the adult norm.

Okuyama T, Suzuki H, Umehara I, Kuwabara Y, Suzuki S, Takagi M (1985) Concluded that aneurysmal bone cyst is rarely found in the mandible, and roentgenographic diagnosis of this condition is not easily made. In this report, the diagnostic value of bone scintigraphy and radionuclide angiography and CT imaging in two cases of aneurysmal bone cyst of the mandible are discussed. Bone scintigraphy with Tc-99m MDP demonstrated ring-like or doughnut-pattern accumulation of radioactivity, which corresponded to the expansile character of the bony lesion. The accumulation of radioactivity was intensive in the peripheral region despite the fact that the lesion was benign. Furthermore, the central rarefaction showed that the lesion was cystic. Radionuclide angiography with Tc-99m HSA, including blood pool scan, did not detect radioactive concentration. Thus bone scintigraphy and radionuclide angiography were found to be essential in the differential diagnosis of aneurysmal bone cyst from other

forms of tumor, especially hypervascularized tumor and central hemangioma of the mandible.

Aitasalo K, Ruotsalainen P. (1985) used Technetium-99m methylene diphosphonate (Sn) scintigraphy with computer analysis to investigate alterations in the pathophysiology of the normal mandible and the pathologic mandible during and after irradiation. Slight but significant elevations of uptake levels were recorded as an early effect of irradiation. The elevations correlated with the duration of treatment and normalized over a follow-up period of 6 to 12 mo. Increased mandibular metabolism was found during irradiation and in osteomyelitis and osteoradionecrosis of the mandible. Scintigraphy with computer analysis proved a simple and valid method in the evaluation of early irradiation damage and pathophysiologic conditions of the mandible. The method can also be used to predict whether the irradiation damage will become irreversible.

Kortekangas AE, Aitasalo K, Ruotsalainen P (1985) in their study used Technetium methylenediphosphonate scintigraphy to study the effect of irradiation on mandibular uptake. Determination of relative mandibular uptake allows comparison of results in different subjects, while determination of individual normalized mandibular uptake increases the significance of differences found in the same

subject at different times. A very uniform increase of about 25% was recorded after radiotherapy of about 50 Gy; the uptake returned to pretherapeutic levels in 9 months. Osteoradionecrosis--and especially osteomyelitis--clearly increases the uptakes above the values of the irradiation effect. To increase the usefulness of scintigraphy in the early detection of an imminent complication, they recommend pretherapeutic control scintigraphy in all cases liable to such complications.

Luyk NH, Laird EE, Ward-Booth P, Rankin D, Williams ED. (1986) evaluated the use of bone scintigraphy to obtain a more accurate assessment of tumour spread in comparison with radiographs and histology. Tumour invasion of bone was shown on scans and radiographs, but periosteal reaction to tumour was detected by scintigraphy only. Thus both scintigraphy and radiography are recommended for preoperative assessment of bony margins for radical resection.

Ahuja RB, Soutar DS, Moule B, Bessent RG, Gray H. (1990) analyzed the accuracy of preoperative assessment in determining invasion of the mandible by intraoral squamous cell carcinoma in 48 patients who underwent mandibulectomy, and the results correlated with the histopathological reports of the resected specimens. Only 50% of the patients underwent the "ideal" surgery based

primarily on clinical judgment, whereas 10 patients in the series were significantly undertreated. Clinical judgment and routine preoperative x-rays are accurate in cases where there is gross involvement of the mandible (17 of 19) but are significantly less successful in determining early bone invasion, invasion of the periosteum, or periosteal new bone formation. In such cases (26 of 48), a technetium-99m bone scan provides additional information. A grading system for reporting orthopantomographs (OPTs) and bone scans has been developed and utilized to form a reference grid to determine the optimum extent of mandibular surgery. The results show that using this protocol, unnecessary mandibular surgery may be reduced and inadequate surgical excision avoided.

Bush FM, Harrington WG, Harkins SW. (1992) Examined panoramic radiographs of the temporomandibular joints of patients with orofacial pain was examined for evidence of pathology by three different groups of four dental specialists and by a group of four general dentists. Bone scans of the same joints were used as the "gold standard" for identification of disorder and indicated a low rate of correct readings by the four professional groups. When the symptomatic side of the complaint was used as the gold standard, there was no statistically significant association with the bone scan observations. Comparative analysis of other patient symptoms showed little agreement with panoramic radiographs and scintigraphy. Reliability

estimates may be highly variable, even among clinical experts. These results show that neither radiological technique would be definitive for diagnosis of TM disorders.

Fischer-Brandies E, Seifert C. (1995) felt that the decision of whether to perform continuity-sparing or resecting surgery of the jaw in cases of malignant oral tumors is often difficult. To aid in this decision, bone scintigraphy was evaluated retrospectively in 304 patients with a squamous cell carcinoma. One hundred forty-five patients showed no accumulation of the radionuclide, and none of them had infiltration by tumor histologically. It was concluded that a bone-sparing resection of tumors close to the jaw may be justified when there is a negative bone scan.

Aigner RM, Fueger GF, Ritter G (1996) conducted a study on neonatal osteomyelitis, a rare, potentially crippling disease, requiring early diagnosis and effective therapy. This study of 20 neonates analyzed the diagnostic value of three-phase bone scintigraphy (motivated by its controversial role), plain radiography and local clinical signs in neonatal osteomyelitis and complicating septic arthritis. The sensitivities for detecting focal skeletal involvement were as follows: bone scintigraphy 90%, radiography 65%, and clinical local signs 20%. Reliable scintigraphic signs were localized hyper perfusion (phase

I), vasodilation (phase II) and hot or cold lesions on 3-h images. Radionuclide angiography definitely increased the validity of bone scintigraphy. During there follow-up, the reduction or normalization in focal hyperperfusion was the first and most sensitive sign of an adequate response to antibiotic treatment; persistence (or recurrence) of focal hyperperfusion, increasing relative uptake ratios and the appearance of new foci of bone involvement indicated escape from antibiotic therapy. Radiography revealed no pathological signs in 35% of cases, soft tissue changes in 20% and effusion of the hip joint in 45%. Local clinical signs were not a reliable predictor of scintigraphic or radiographic findings. They consider bone scintigraphy in neonatal osteomyelitis to be a successful, efficient and cost-effective diagnostic modality, not only for early diagnosis, but also during follow-up.

Higashi K, Wakao H, Ikuta H, Kashima I, Everhart FR Jr. (1996) concluded that detecting osseous involvement is clinically important in the management of oral carcinoma. Thirty-one patients with osseous involvement due to oral carcinoma who underwent panoramic radiography and bone scintigraphy were evaluated retrospectively. Bone scintigraphy confirmed osseous involvement in all 31 (100%) of these patients. In 27 (87%) of 31 patients with osseous involvement, both the panoramic radiogram and bone scintigraphy were positive. In the remaining four

patients (13%), bone scintigraphy was positive for mandibular or maxillary invasion, while panoramic radiogram was negative. There were no instances of an abnormal radiogram with a normal bone scintigraphy. These findings strongly suggest that bone scintigraphy is more sensitive than panoramic radiography in detecting osseous involvement of the mandible and maxilla due to oral carcinoma. Furthermore, bone scintigraphy was a critical pre-surgical in determining the extent of the osseous involvement.

Bachmann G, Rossler R, Klett R, Rau WS, Bauer R (1996) conducted a prospective study of 85 patients with oral cancer, treated with high-dose radiation therapy, to assess the value of magnetic resonance imaging (MRI) and scintigraphy for diagnosis of pathologic changes in the mandible. During postradiotherapeutic monitoring, radiation osteomyelitis occurred in 12 cases, tumor recurrences infiltrating the mandible in five cases, and progressive periodontal disease in nine cases. MRI permitted early diagnosis of radiation osteomyelitis in 11 out of 12 cases; only two cases were false positive. In scintigraphy with ^{99m}Tc -HDP, all alterations of the mandible, such as osteoradionecrosis, tumor infiltration, and periodontitis, showed a high uptake, resulting in a sensitivity of up to 100%, but a low specificity of 57%. Scintigraphy permitted assessment of the extension and

location of the lesions. Both methods were superior to conventional radiography and clinical examination and should be integrated into a comprehensive follow-up program after radiation therapy.

Machens HG, Pallua N, Becker M, Mailaender P, Schaller E, Brenner P, Bihl H, Friedl W, Berger A. (1996) described a new agent to detect local infection and inflammation by using Technetium (99m-Tc)-labelled, polyclonal human immunoglobulin (HIG). In this study, they tested 99m-Tc HIG in 55 patients with suspected chronic (n = 42) and acute (n = 13) skeletal infection. Diagnosis was proven operatively (n = 44) and clinically (n = 11), including microbiological culture tests (n = 46). A gamma camera scan was performed 4 and 24 hours after i.v. injection of 500 MBq 99m-Tc-HIG. 99m-Tc-HIG scanning achieved a sensitivity of 91% and a specificity of 93%. They found one false negative and five false positive scintigraphic results in 55 patients. No clinical or biochemical side effects were encountered after 99m-Tc-HIG injection. They recommend this technique especially for localisation of low-grade, chronic osteomyelitis. The mechanisms and kinetics of 99m-Tc-HIG, however, are worth investigating more extensively.

Korner T, Kreuzsch T, Bohuslavizki KH, Brinkmann G, Kohnlein S.(1997). Concluded that in the diagnosis of

lower jaw osteomyelitis, three-phase bone scintigraphy can be replaced by the MRI

Nedim C.M. Gulaldi, Jalal S, Mojgan M, B. Caner, Kenan A, and Erbeni G, (1998) they concluded that static – phase bone scintigraphy showed that when freeze- dried heterograft material is used to fill extraction cavities, it stimulates osteoblastic activity, which in turn leads to acceleration healing process and helps to maintain the linearity of bony structure. Moreover, radionuclide study can be evaluate the viability of freeze – dried hetero grafts in the 4th postoperative week, at which time no additional increase in perfusion resulting from trauma was found in our series.

Harada H, Takinami S, Makino S, Kitada H, Yamashita T, Notani K, Fukuda H, Nakamura M. (2000) found that three-phase bone scintigraphy was use to check the anastomotic patency and monitor the viability of vascularized bone grafts. Ten consecutive patients who underwent vascularized bone grafting of the mandible were reviewed. A successful clinical outcome was achieved in 8 patients. The graft failed in 2 patients. In this series, 3-phase bone scintigraphy of radiolabeled (99m)Tc-methylene-diphosphonate was performed at 7 days, and at 1, 3, 6, and 12 months after reconstruction. Assessments made using 3-phase bone images were compared with the

clinical findings. The clinical outcome of the cases presented in there series correlated extremely well with 3-phase bone images. Three-phase bone scintigraphy is a useful method for the assessment of patency and viability of vascularized bone grafts. The use of this method can be very helpful in assessing the anastomotic patency and viability of a graft which for clinical reasons is suspected of being non-viable.

T Sato, H Indo, Y Kawabata, R Agarie, T Ishigami and T Noikura (2001) evaluated a patient with SAPHO syndrome (synovitis, acne, pustulosis, hyperostosis and osteitis) by combined scintigraphy. ^{99m}Tc HMDP scintigraphy showed accumulation in the sternum and lumbar vertebrae as well as the right mandible, whereas ⁶⁷Ga citrate showed an accumulation in the right mandible, but not in the sternum or lumbar vertebrae. These results are consistent with chronic osteomyelitis in the mandible.

M. Kawano, Junichi taki, Hiroyuki T, Katsuro Tomita and Norihisa Tonami, (2002) They concluded by saying that, three – phase bone scintigraphy is a modality to evaluate distraction osteogenesis compared with clinical indices. Three phase bone scintigraphy performed in the distraction phase could predict the outcome of distraction osteogenesis. The delayed image of 3- phase bone

scintigraphy, especially, is an excellent modified for assessing distraction osteogenesis.

Epstein, A Rea, & O Chahal (2002) concluded that the use of bone scintigraphy (bone scan) in the diagnosis of temporomandibular joint (TMJ) disease has been infrequent, as compared with traditional radiographic techniques. Bone scans have the potential to detect active bone remodeling whereas corresponding radiographs may be normal or document past structural change in the joint. Traditional radiographic findings and relevant clinical signs and symptoms correlated with bone scans may aid in the diagnosis of TMJ disease and possibly affect treatment and prognosis of individual cases. The use of bone scans as an additional tool in diagnosing TMJ disease was assessed in these patients. Their findings on bone scan were evaluated and a change in preliminary clinical diagnosis or treatment was made in 60% of cases because of the findings on bone scintigraphy. Bone scintigraphy may be valuable to assess progress of TMJ inflammation or remodeling, and may affect diagnosis and treatment of patients with TMJ tenderness.

Pier FN, Massimo A, Konrad W, A Fior, Lorenzo T & Wkretschmer. (2002) concluded that bone scan evaluation appeared to be a precise technique in monitoring the different phases of distraction. It is easy to repeat

whenever necessary. Early & late complication of soft tissue healing, movements of the bone segment, as well as the osteogenesis were detectable. In the authors opinion bone scan evaluation can play an important role in monitoring distraction osteogenesis.

Dobo NC, Koranyi M, Keszthelyi G, Fejerdy P, Ackermann G, Galuska L. (2003) concluded that investigation with the scintigraphic images of jaws may have a diagnostic value of bone alterations of dental origin? Anterior view of whole body bone scintigraphy revealed hot spot on jaws of 61% (279) of patients. Twenty-six patients (mean age 58.3 year) from all of those who had increased tracer uptake (ITU) in the maxillo-mandibular region were called back for dental examination. 279 out of 459 (61%) patients had ITU in the maxillo-mandibular region. Dental examination revealed the dental origin of ITU in all cases. In case of periapical pathosis tracer uptake showed 28.79% increase compared to the contralateral side. In marginal periodontitis 23.82% ITU was found. In case of loading due to prosthesis 13.06% ITU was observed. The mean DMF-T value was 26.36 +/- 4.52 (D = 4.12, M = 20.8, F = 1.44). The prosthetic index was 0.42 on the mandible. The above mentioned data mean very low oral health conditions of the patients included in this examination. The results show that bone

scintigraphy is a valuable procedure in detecting tooth related jaw lesions. Bone scintigraphy provides very useful data on oral health of these patients. Enrolling of these patients into regular dental care is inevitable.

Baur DA, Heston TF, Helman JI. (2004) reveals that nuclear medicine studies often play a significant role in the diagnosis and treatment of oral and maxillofacial diseases. While not commonly used in everyday dental practice, the dental provider should have a conversational knowledge of these imaging modalities and understand the indications and limitations of these studies. The purpose of this study is to discuss the nuclear medicine that have applications in the head and neck region as well as their indications, limitations, and diagnostic conclusions that can be drawn from these studies.

Zhibin Y, Quanyong L, Libo C, Jun Z, Hankui L, Jifang Z, Ruisen Z. (2004) evaluated the characteristics of fibrous dysplasia (FD) of bone on bone scans and to evaluate the diagnostic value of radionuclide bone scans in FD. Radionuclide bone scans were performed in 42 cases of histopathologically proven FD and the results were compared with other imaging modalities. A retrospective study method was used to analyze the imaging results. Although FD showed nonspecific increased ^{99m}Tc MDP uptake, its appearance is different

than bone metastases and other bone diseases. Combining scans with x-rays and other imaging modalities can improve the diagnostic accuracy of this disease. Radionuclide bone scans are of certain value in the diagnosis of FD. The diagnostic specificity of FD with radionuclide bone scanning can be improved in association with other imaging modalities such as x-rays.

Summary and Conclusion

Bone Scintigraphy studies often play a significant role in the diagnosis and treatment of oral and maxillofacial diseases.

While not commonly used in everyday practice, today's maxillofacial surgeon should have a conversational knowledge of these imaging modalities and understand the indications and limitations of these studies.

The purpose of this study is to discuss the **Bone Scintigraphy** (nuclear medicine studies) that has applications in the head and neck region as well as their indications, limitations, and diagnostic conclusions that can be drawn from these studies.

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