Annals of Nuclear Medicine Vol. 20, No. 2, 89–93, 2006

# Evaluation of vascularized graft reconstruction of the mandible with Tc-99m MDP bone scintigraphy

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***Aim:*** The aim of this study was to evaluate the value of bone scintigraphy for the assessment of graft viability following vascularized bone grafts in patients with mandibular reconstruction. ***Methods:*** We investigated 16 patients with vascularized grafts from the fibula (13 patients) and iliac crest (3 patients) in the last 8 years. For the follow up of all these patients, Tc-99m MDP bone scintigraphy was performed between 2–10 days postoperatively. SPECT study was included in 5 patients. For the evaluation of the grafts, a six-grade scoring system was used. The grading system was based on a comparison of tracer uptake between graft and the cranium. The uptake was defined as increasing from grade 6 to grade 1. ***Results:*** Thirteen of the 16 grafts had an uncomplicated clinical course. Complications in the graft occurred in three patients. In the analysis of planar scintigrams, patients with uncomplicated healing showed increased uptake in 12 of the 13 grafts (grade 1–3) and 1 showed the same level tracer uptake compared to cranium (grade 4). In the failed 3 grafts, decreased uptake was observed (grade 5 and 6). In 5 patients, SPECT was performed in addition to planar imaging. In these patients, 4 of the 5 grafts had an uncomplicated clinical course and 1 had a complicated one. In the analysis of SPECT images, while all the grafts with an uncomplicated clinical course exhibited increased uptake (grade 1–3), the failed graft showed decreased uptake (grade 6). ***Conclusion:*** Three-phase bone scintigraphy performed within 10 days after the mandibular reconstruction is a useful tool to monitor the viability and early complications of vascularized mandibular bone grafts. SPECT is also recommended. It may contribute to interpretation of the bone scans and to precise assessment of graft viability.

**Key words:** bone scintigraphy, viability, vascularized grafts, mandibular reconstruction

## INTRODUCTION

Malignancy, radio-osteonecrosis, trauma, infection or congenital anomalies may be reasons for mandibular defects. The management of mandibular defects has changed in the last decade. The most frequently used technique for reconstruction of extended defects is the transfer of vascularized osseous free grafts.[1–5] The fibula, scapula, and iliac crest are the preferred donor sites for reconstruction of mandibular defects.[6–11] It is essential to establish bone viability after vascularized bone grafts transfer. Lack of vitality as a result of vascular occlusion, either arterial or venous, can result in graft necrosis, bone resorption, and poor healing.[12,13] Several diagnostic techniques including bone scintigraphy have been proposed to assess graft viability. Tc-99m methylene diphosphonate (MDP), the most commonly used tracer in clinical bone research, is highly sensitive for blood flow and metabolic activity of bone tissue.[14]

The aim of this retrospective study was to evaluate the value of bone scintigraphy with Tc-99m MDP for the assessment of graft viability following vascularized bone grafts in patients with mandibular reconstruction.

## MATERIAL AND METHODS

In the last 8 years, 16 patients (4 female, 12 male, age 19–67 years) who received autogenous vascularized bone

Received July 4, 2005, revision accepted October 19, 2005.

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grafts for reconstruction of the mandible after partial bone resection were investigated retrospectively. The reason for resection was malignancy in 6 patients (5 squamous cell carcinoma, 1 osteosarcoma), benign tumors in 3 patients (2 ameloblastoma, 1 giant cell granuloma), gunshot wounds in 6 patients and 1 surgical mandibular resection for an unknown cause in childhood. In the analyzed cases, 13 grafts were transfered from the fibula and 3 from the iliac crest. In all grafts scintigraphic evaluation was obtained 2–10 days postoperatively.

All studies were performed as three-phase bone scintigraphy. Single-photon emission tomography (SPECT) study was included in 5 patients. After the injection of 740 MBq Tc-99m MDP, dynamic images were obtained in a 128 × 128 matrix for 30 frames/2 sec. Immediately after the dynamic studies, planar blood pool and 3 to 4 hours after injection, delayed images were acquired in anterior

**Table 1** Evaluation of the grafts with scoring system in bone scintigraphy

| Grade | Uptake in the graft as compared with the cranium |
|---|---|
| 1 | Highly increased |
| 2 | Moderately increased |
| 3 | Slightly increased |
| 4 | Same level or inhomogeneous tracer uptake |
| 5 | Decreased |
| 6 | Absence of tracer uptake |

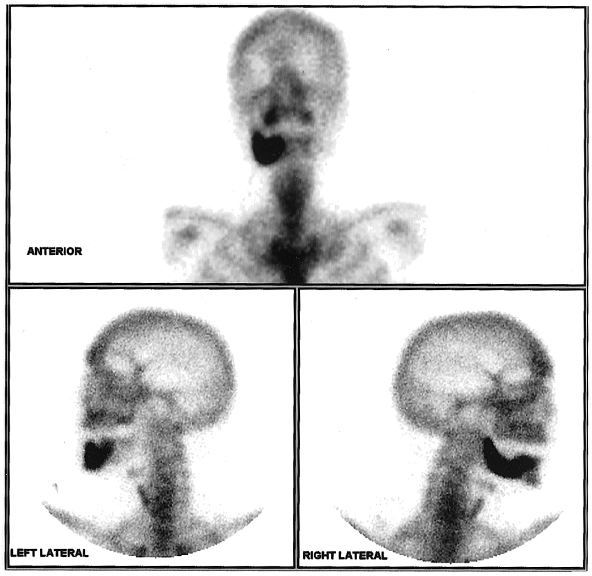
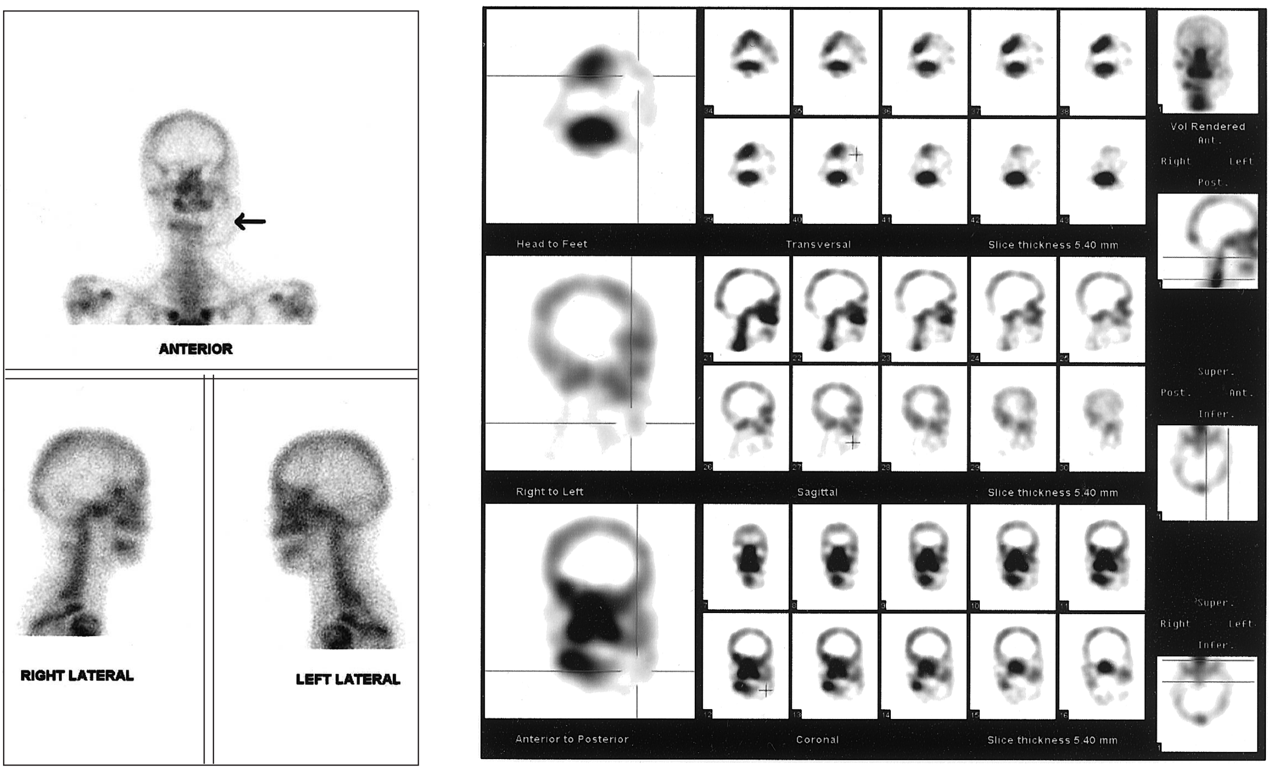



**Fig. 1** Delayed images of right mandibular reconstruction using a vascularized fibular graft show grade 1 uptake (*arrow*).




A B

**Fig. 2** (A) Delayed planar and (B) SPECT images of a left mandibular reconstruction using a vascularized fibular graft. Decreased uptake in the graft (*arrow*) compared with the cranium (grade 6) is seen.

and both lateral positions. Following the delayed images, SPECT studies were obtained using a rotating gamma camera (Starcam 4000i, GE) equipped with a low energy, high-resolution parallel-hole collimator and connected with a dedicated computer system. A circular orbit was employed to acquire 64 planar images for 360° at 30 sec per frame in a 64 × 64 matrix. Projection images were reconstructed using a ramp filter without any attenuation correction. Coronal, sagittal and transaxial slices of mandibular tomograms were generated. For the evaluation of the grafts, a six-grade scoring system, introduced by Berding et al.,[12] was used. The grading system was based on a comparison of tracer uptake between graft and the cranium. The uptake was defined as increasing from grade 6 to grade 1 (Table 1). Grade 1 corresponded to high uptake in the graft compared with the calvarium, grade 2 indicated moderately increased uptake, grade 3 corresponded to slightly increased uptake, grade 4 indicated the same level or inhomogeneous tracer uptake, grade 5 represented decreased uptake, and grade 6 corresponded to an absence of tracer uptake in the graft.

## RESULTS

Thirteen of the 16 grafts had an uncomplicated clinical course for a mean period of 4 years (range, 1 to 7 years) after reconstruction. Complications in the graft occurred in three patients. Necrosis developed in these grafts, necessitating their removal.

Three-phase bone scintigraphy indicated the later occurrence of complications to the graft. With regard to scintigrams performed within 10 days after mandibular reconstruction the following observations were made. In the cases in which grafting was successful, blood flow images showed patent anastomoses. However, in the failed grafts, uptake was decreased. In all grafts that presented a tracer uptake higher than grade 5 (grade 1–4) the further course was uncomplicated. Twelve of the 13 viable grafts showed significantly increased tracer uptake (grade 1–3; Fig. 1) and 1 showed the same level tracer uptake compared to cranium (grade 4). In the failed grafts (n = 3) decreased uptake was observed (grade 5 and 6; Fig. 2A).

In 5 patients, SPECT was performed in addition to planar imaging. In these patients, 4 of the 5 grafts had an uncomplicated clinical course and 1 had a complicated one. In the analysis of SPECT images, while all the grafts with an uncomplicated clinical course exhibited increased uptake (grade 1–3), the failed graft showed decreased uptake (grade 6; Fig. 2B). The tracer uptake was estimated to be equal on both SPECT and planar imaging in 4 cases and higher on the SPECT images in one case. In this case, the uptake in the graft was classified as grade 4 on planar images and grade 1 on SPECT scans.

## DISCUSSION

Vascularized osseous free grafts are used to good advantage in maxillofacial surgery for the reconstruction of mandibular defects following mandibular resection. Early graft survival is critically important for the success of the transplantation. The critical period for the diagnosis of graft failure is the first two weeks after transplantation.[12] However, in the immediate postoperative period, survival of the graft, remains difficult to monitor by clinical evaluation and diverse radiological imaging modalities. The most common cause of postoperative perfusion disturbances is thrombosis of the arterial or venous anastomosis, which cannot be detected by clinical examination in purely osseous transplants. If a skin island is present, the healing process can be followed directly by observing its color and capillary refill.[7] However, viability of the skin island does not always guarantee that the bone graft is also viable. X-ray is unreliable for determining bone graft viability during the first month because changes in the mineral content can only be detected if the alteration amounts to at least 30%–40%.[15,16] CT and MRI are not so successful for evaluating viability. Both diagnostic modalities (CT and MRI) are restricted by well known artifacts from teeth, their fillings and metallic devices.[17,18] Angiography can detail the microvascular surgery but it can not show the microcirculation that determines viability, and its invasiveness precludes its routine use. The sufficiency of the blood supply and the viability of the graft can be proved early if viable osteocytes are present in a histological examination. However, this requires the invasive procedure of a bone biopsy.[19] Bone scintigraphy as a non-invasive method plays a valuable role in determining vascular patency of the grafts.[20–27] Tc-99m MDP is the most commonly used tracer in clinical bone research. Its uptake on bone reflects blood flow and metabolic activity of bone tissue. Therefore, the uptake of the Tc-99m MDP in the grafted bone is usually interpreted as evidence of bone survival and patent microvascular anastomoses. In an animal study with dogs, Bos[15] found that bone scintigraphy is very useful, but only in the first postoperative weeks. When an initially negative scan was obtained, patent anastomoses were very unlikely. If scintigraphy is performed more than 1 week postoperatively, there is the risk of a false-positive bone image due to the onset of "creeping substitution" whereby new bone is formed on the surface of the graft. However, Takao et al.[28] performed sequential bone scans in man of reconstructed mandibles with either revascularized iliac crest or fibula grafts until 6 weeks after surgery and found no false-positive scans. These results were supported by some other authors.[12,29]

In some sites it may be difficult to visualize the graft clearly because of the difficulty of separating the overlying soft tissues with hyperemia in the recent postoperative period from the bone. Therefore, bone SPECT has been recommended in several studies.[12,21,26] The major advantage of SPECT over planar imaging is the improvement in lesion contrast by enhancing the signal-to-noise ratio by removal of superimposed activity, both anterior and posterior to the area of interest. In the literature, while some authors have reported a good correlation between SPECT and bone scintigraphy,[25,30,31] some reported higher tracer uptake on the SPECT images.[12,27] In the present study, due to the retrospective character of the study SPECT was available in addition to planar imaging in only 5 of the investigations and not for the whole range of uptake grading. Three-phase bone scintigraphy indicated the later occurrence of complications to the graft. In all grafts that presented a tracer uptake higher than grade 5 (grade 1–4) the further course was uncomplicated. Complications developed in all of the grafts presented as grade 5 and 6. In the analysis of 5 cases in which both SPECT and planar bone scintigraphy were performed, the tracer uptake was estimated to be equal on both SPECT and planar imaging in 4 cases and higher on the SPECT images in one case. In the latter, the uptake in the graft was classified as grade 4 on planar images and grade 1 on SPECT scans.

## CONCLUSION

Three-phase bone scintigraphy performed within 10 days after the mandibular reconstruction is a useful tool to monitor the viability and early complications of vascularized bone grafts. SPECT is also recommended. It may contribute to interpretation of the bone scans and to precise assessment of graft viability.

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