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# Blood-pool SPECT in addition to bone SPECT in the viability assessment in mandibular reconstruction

F. AYDOGAN, E. AKBAY[1], C. CEVIK[1], E. KALENDER

Department of Nuclear Medicine, [1]Otolaryngology Department of Head and Neck Surgery; Mustafa Kemal University, Faculty of Medicine, Hatay, Turkey

**Abstract. – INTRODUCTION:** The assessment of the postoperative viability of vascularized and non-vascularized grafts used in the reconstruction of mandibular defects due to trauma and surgical reasons is a major problem in maxillofacial surgery.

**AIM:** In the present study, we evaluated the feasibility and image quality of blood-pool SPECT, which is used for the first time in the literature here in the assessment of mandibular reconstruction, in addition to non-invasive bone scintigraphy and bone SPECT. We also evaluated whether it would be useful in clinical prediction.

**PATIENTS AND METHODS:** Micro-vascularized and non-vascularized bone grafts were used in 12 Syrian men with maxillofacial trauma. Between days 5-7 after surgery, three-phase bone scintigraphy, blood-pool SPECT and delayed bone SPECT scans were performed. After month 6, the patients were assessed by control CT scans.

**RESULTS:** Of the non-vascularized grafts, one graft was reported as non-viable at week one. At month 6, graft resorption was demonstrated on the CT images. The remaining non-vascularized grafts and all of the micro-vascularized grafts were considered to be viable according to delayed bone SPECT and blood-pool SPECT images. However, only the anterior and posterior ends could be clearly assessed on delayed SPECT images, while blood-pool SPECT images allowed the clear assessment of the entire graft.

**CONCLUSIONS:** The combined use of blood-pool and delayed SPECT scans could allow for better assessment of graft viability in the early period, and can provide more detailed information to clinicians about prognosis in the follow-up of patients undergoing mandibular graft reconstruction.

*Key Words:*
Scintigraphy, Graft viability, Blood-pool SPECT, Bone SPECT.

## Introduction

The reconstruction of mandibular defects resulting from trauma, tumor surgery developmental deformities or infections is the one of the major problems in the field of maxillofaxial surgery[1,2]. Currently, scapula, iliac crest and fibula grafts are commonly used in the reconstruction of mandibular defects[3]. It is crucial to assess bone viability after vascularized or non-vascularized bone graft surgeries. Graft necrosis, bone resorption, and poor healing are seen as a result of vascular occlusion.

As the clinical evaluation of graft healing is highly subjective, several diagnostic techniques are used, including bone scintigraphy[4]. Although radiological evaluations can reveal alterations in bone density, they cannot provide information about osteogenesis and progression. Biopsy is not preferred despite providing useful information, as it is an invasive technique with additional risks and poor patient compliance[1]. For the assessment of blood flow and viability in maxillofacial bone grafts, commonly used techniques include 3-phase bone scintigraphy using Tc-99m methylenedisphosphonate (MDP) and single photon emission computed tomography (SPECT), as they allow for the assessment of metabolic activity and blood flow in osseous tissue[5,6].

We evaluated whether blood-pool SPECT imaging has clinical usefulness in addition to above-mentioned scanning procedures in determining the success or failure of bone grafts at an early period for the first time in the literature.

## Patients and Methods

Non-vascularized (n=5) and micro-vascularized bone grafts (n=7) were applied to 12 Syrian

*Corresponding Author:* Fusun Aydogan, MD; e-mail: drfusunay@yahoo.com

**Table I.** Characteristics of the patients.

| Patient No | Age | Sex | Type of graft | Greft size (cm) |
|---|---|---|---|---|
| 1 | 34 | M | Non-vascularized | 3 × 2 |
| 2 | 19 | M | Microvascularized | 4 × 3 |
| 3 | 19 | M | Microvascularized | 8 × 2 |
| 4 | 17 | M | Non-vascularized | 3 × 2 |
| 5 | 20 | M | Non-vascularized | 3 × 2 |
| 6 | 20 | M | Microvascularized | 5 × 2 |
| 7 | 18 | M | Microvascularized | 6 × 2 |
| 8 | 23 | M | Microvascularized | 4 × 2 |
| 9 | 42 | M | Non-vascularized | 5 × 2 |
| 10 | 22 | M | Non-vascularized | 4 × 2 |
| 11 | 33 | M | Microvascularized | 10 × 2 |
| 12 | 41 | M | Microvascularized | 12 × 2 |

men with maxillofacial trauma aged 17-42 years between 2012 and February 2013 (Table I). Between days 5-7 after surgery, three-phase bone scintigraphy, cranial blood-pool SPECT and cranial delayed bone SPECT scans were performed on all of the patients. Control CT scans were performed on all patients 6 months after surgery. This study was carried out in accordance with the Helsinki Declaration of the World Medical Association, and was approved by the local Ethics Committee.

### *Scintigraphic Imaging*

The radionuclides were extracted from $^{99m}$Tc generators (Mon-Tek, Eczacıba ı/Monrol), and MDP (Mon. MDP, Eczacıba ı, Monrol) was labeled and characterized according to the manufacturer's recommendations. After the injection of 740 MBq (20 mCi) of 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 blood pool SPECT images were obtained; and 3 to 4 hours after injection, delayed images were acquired in anterior and both lateral positions, as well as anterior and posterior whole-body scanning. Following the delayed images, SPECT studies were obtained using a rotating double head gamma camera (Symbia S, Siemens Healthcare) equipped with a low energy, high-resolution parallel-hole collimator connected to a dedicated computer system. A non circular orbit was employed to acquire 32 planar images for 180º at 25 sec per frame in a 64 × 64 matrix. The projection images were iteratively reconstructed using a gaussian filter. Coronal, sagittal and transaxial slices of the mandibular tomograms were thus generated.

For the evaluation of the grafts, a six-grade scoring system, introduced by Berding et al[9], was used (d). 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 II).

## Results

No clinical complications developed in the 7 patients with micro-vascularized grafts. Resorption developed in one of the 5 patients with non-vascularized grafts. In the scintigraphic evaluations, the images of blood-pool and cranial delayed phase SPECT were individually graded. The grades were I and III on blood-pool SPECT scans in the 11 patients without complications (Figure 1). Marked focal hyperemia areas at the anterior and posterior ends of anastomosis and linear hyperemia on the inferior aspects of the graft were observed. In these patients, delayed bone SPECTs were graded as II and III (Figure 2). On the delayed bone SPECT scan, it was more challenging to assess the sites of anastomo-

**Table II.** Evaluation of the grafts with the scoring system used 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 |

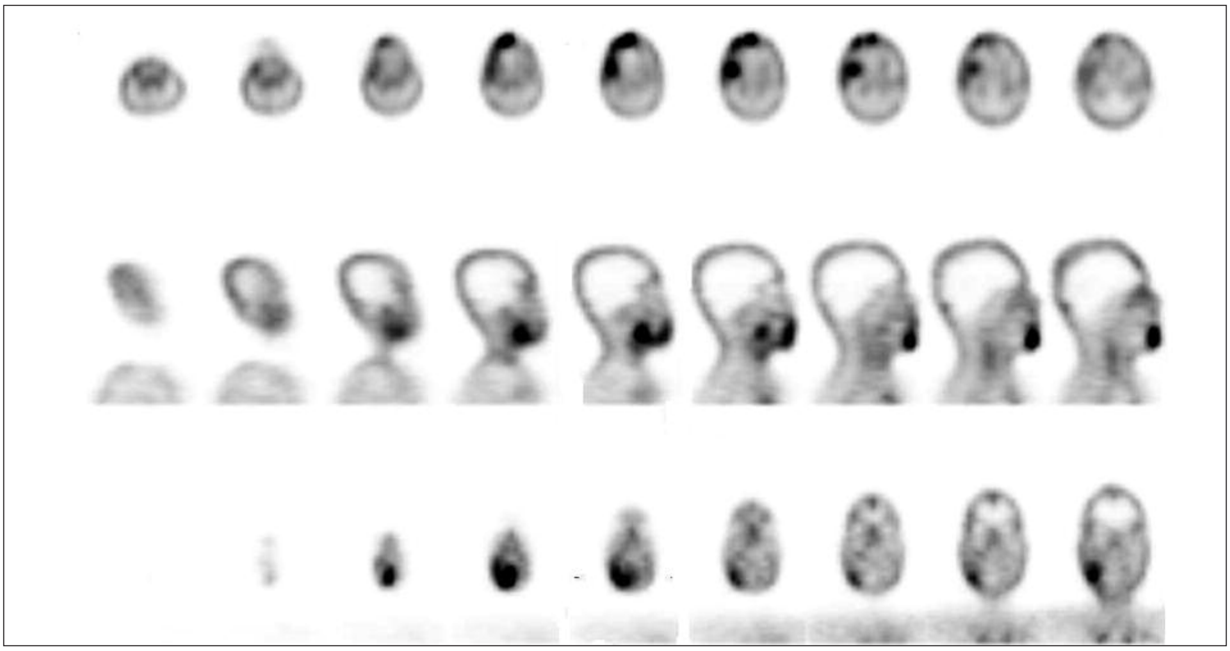

**Figure 1.** Blood-pool SPECT images of a 23-year old patient (Patient 8): a marked hyperemia is seen in entire graft (Grade 1).

sis when compared to images from blood-pool SPECT scans. In addition, viability could not be demonstrated at the inferior and superior aspects of grafts.

In the patient who developed resorption, the blood-pool SPECT and delayed bone SPECT images were considered to be grades 5 and 6, respectively. Visually, focal hyperemia and activity were only observed at the anterior end. Other areas in the graft were observed as being hypoactive (Figures 3-4).

On the control CT scans 6 months after surgery, graft resorption was demonstrated in the patient considered to be non-viable on scintigraphy, while graft was demonstrated to be viable in the patients considered to be viable on scintigraphy (Figures 5-6).

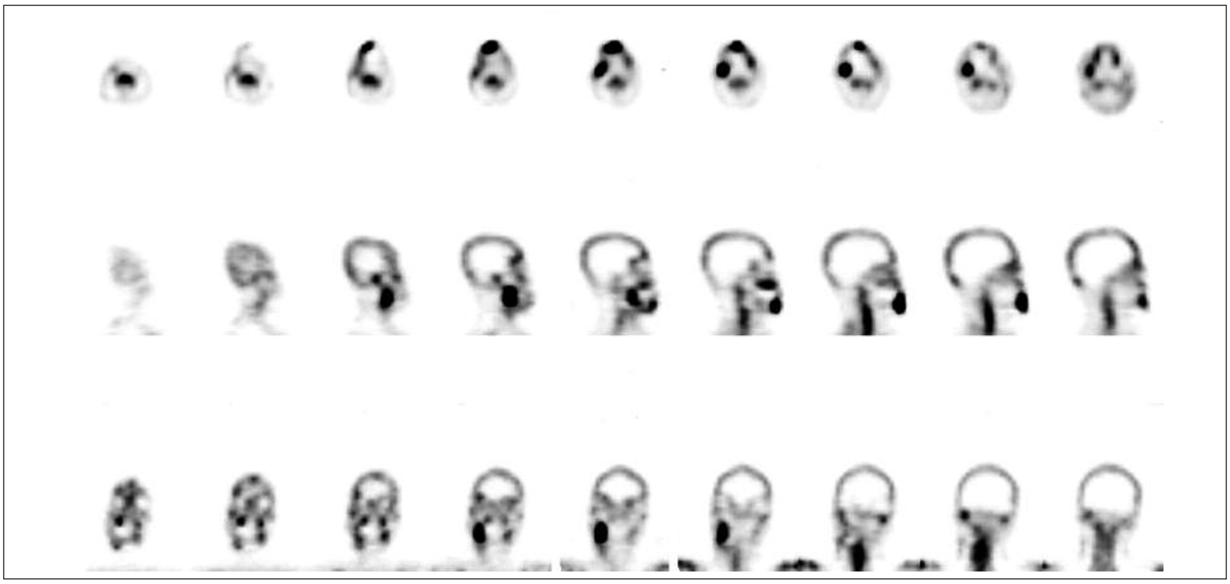

**Figure 2.** Delayed bone SPECT images of the same patient: Increased activity uptake at the anterior and posterior ends of the graft.

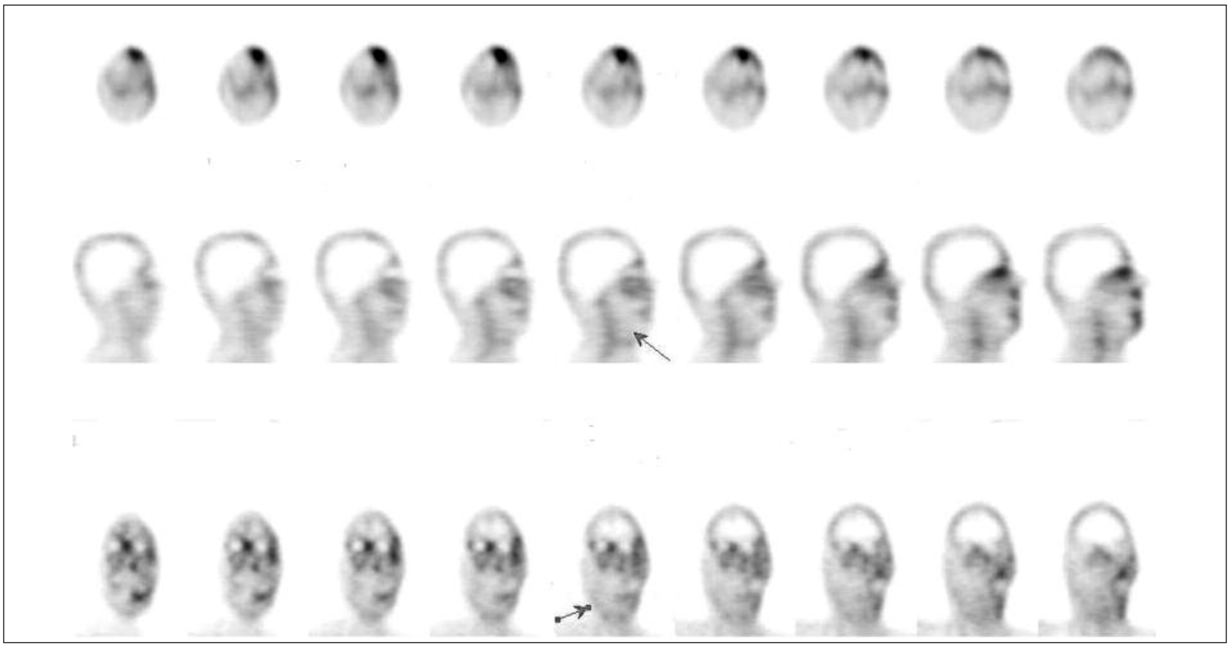

**Figure 3.** Blood-pool SPECT images of a 42-year old patient (Patient 9): a focal hyperemia at the anterior end of graft is seen as well as decreased activity uptake in the other regions (Grade 5).

## Discussion

At mid-1970s, the first reconstruction using a free osteocutaneous flap was performed, and mandibular reconstruction by Hidalgo microvascularized fibular graft was first performed in 1989[7,8]. Graft monitoring during surgery is one of the major issues in reconstructive surgery. If vascular occlusion occurs in the graft, flap necrosis, poor healing and graft failure will de-

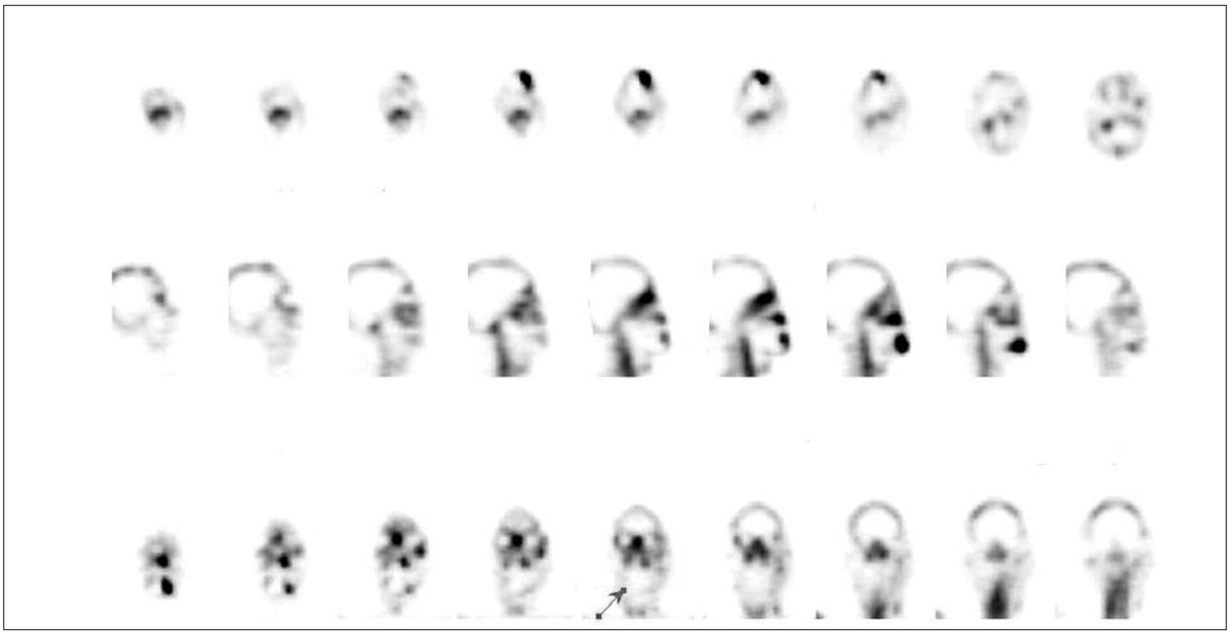

**Figure 4.** Delayed bone SPECT images of the same patient: there is only activity uptake at the anterior end. Other regions are seen as being hypoactive (Grade 6).

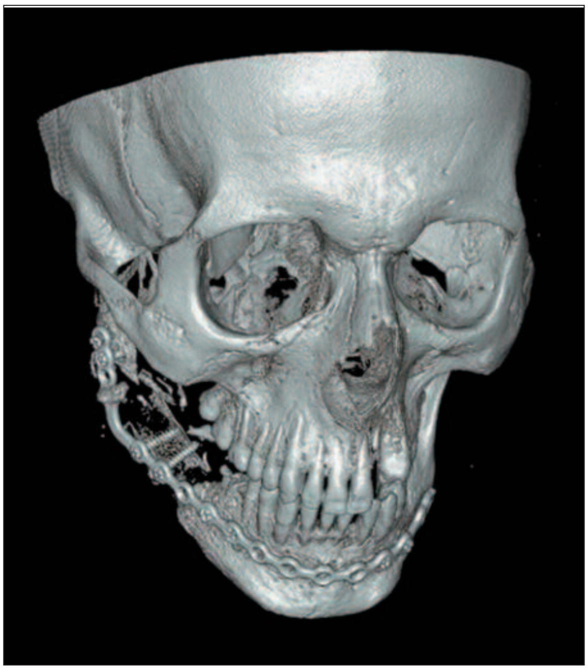

**Figure 5.** Graft resorption is seen on the control CT at 6 months in the patient, with no graft viability.

velop[9]. Thus, the first 2-week period is critical in graft supply and viability[10]. In our study, bone scintigraphy was performed between days 5-7 after surgery. Radiological evaluations provide reliable information after a change by 30-40% occurs in bone mineral content, which takes a few months[9,11]. In our study, while graft viability was predicted on the day 7 by using scintigraphy, it was only demonstrated on CT scans at month 6.

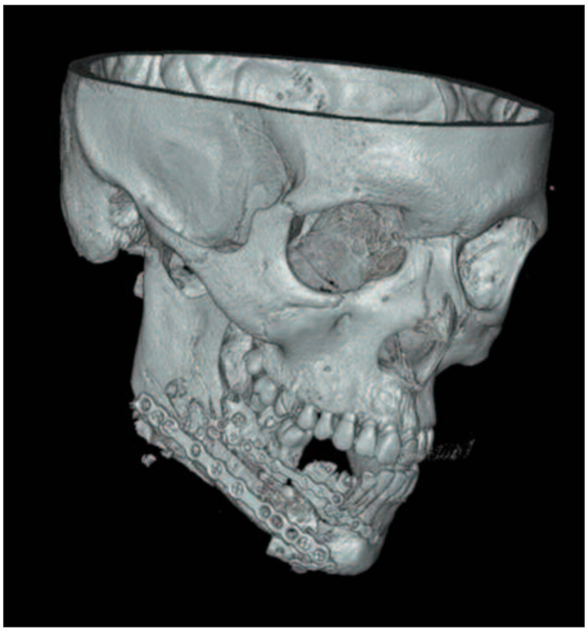

**Figure 6.** It can be seen that the osseous structure in normal in the control CT at 6 months in the patient demonstrated in Figures 1 and 2.

Although angiography can show the patency of vessels, it isn't capable of showing the micro-circulation. Furthermore, it is an invasive technique with poor patient compliance. As it has a potential to cause endothelial damage in the vessels of anastomosis, its use is avoided in routine practice[9,11]. Bone scintigraphy is an easy, non-invasive and effective modality in the assessment of postoperative graft viability[2,9-11]. Planar bone scintigraphy can fail to provide sufficient information at the vertebra, pelvis, hip, knee, temporamandibular region, wrist and ankle where complex osseous structures are present[6]. SPECT imaging has some advantages over planar imaging such as enabling 3-dimensional evaluation, ensuring the differentiation of superimposed activity and enhancing the image activity acquired from the lesion by increasing the signal: background ratio[5,6]. Bone SPECT is widely used to assess bone graft viability in mandibular reconstruction[9]. Lukash et al[12] demonstrated that SPECT imaging has excellent prognostic value in the viability of vascularized bone grafts. Moreover, Meningaud et al[13] demonstrated that it has an excellent prognostic value in the assessment of free mandibular bone grafts. We also concluded that the locations of anastomoses and the supply of non-vascularized and micro-vascularized bone grafts were better visualized by obtaining blood-pool SPECT images, which were used for the first time in the literature in addition to delayed SPECT images.

## Conclusions

The combined use of blood-pool and delayed SPECT scans can allow for better assessment of graft viability in early period that currently used techniques, and can provide more detailed information to clinicians about prognosis in the follow-up period.

### Conflict of Interest

The Authors declare that there are no conflicts of interest.

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