Bone Scanning in the Early Assessment of Nasal Bone Graft Viability

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This study examined the role of radionuclide bone scanning in the early assessment of free autologous cancellous bone grafts in augmentation rhinoplasty and compared the failure rates of grafts taken from the calvaria and ilium. Twenty patients had three-phase bone scanning of the facial regions performed between 2 and 15 wk after rhinoplasty, and a comparison was made with the results of clinical assessment and X-ray findings 3 mo after surgery. Eleven patients had grafts taken from the calvaria and nine had iliac grafts. On lateral views, bone graft uptake of isotope, which was less than or equal to the adjacent soft tissue, was found in 2 out of 20 patients and this finding predicted subsequent graft failure as measured by clinical assessment and X-ray evidence of bone resorption. Both failures had grafts taken from the calvaria while none from the ilium failed. These failure rates, however, were not significantly different.

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Augmentation rhinoplasty is employed after trauma, after resection of malignancy, for repair of congenital defects, and in cosmesis. The use of autologous cancellous bone grafts in this procedure has been shown to have significant advantages over the use of either cartilaginous grafts or the use of nonorganic materials such as silastic (*1–5*). These grafts are usually harvested from the iliac crest (*2,6*) or calvaria (*1,3,7,8*), with the calvaria being considered superior by some (*1,3,8*).

The results of such bone grafts have usually been assessed by the degree of patient and surgeon satisfaction with the final result and by radiologic assessment of the extent of bone graft resorption (*1–3,5–7*). However, these methods cannot provide an early assessment of revascularization of the bone fragments: a factor which ultimately determines graft outcome (*9–14*).

Radionuclide bone scanning has been shown to be a useful method of determining bone graft vascularity and hence viability at a relatively early stage for both cortical (*12,15*) and cancellous (*9,10,16–18*) grafts. It therefore provides a way of predicting graft failure before X-ray or clinical changes are apparent. This allows intervention before nonviable bone tissue becomes necrotic, infected, or the region fibroses. Bone scanning has been studied in grafts to other sites in the facial skeleton in humans (*17–19*), but it has not previously been systematically assessed in rhinoplasty. Rhinoplasty may well represent a different situation as bone grafts are being placed in a highly vascular region that is not contiguous with other bony structures.

The current study had a number of purposes. First, it looked at the timing of revascularization of free autologous cancellous nasal bone grafts as measured by radionuclide bone scanning. Second, it examined the usefulness of bone scanning in the early assessment of the ultimate success or failure of these grafts. Third, it compared the results of grafts from calvarial donor sites with those from iliac sites to determine whether either site produced better graft survival.

MATERIALS AND METHODS

Patients

Twenty patients (9 males and 11 females aged 17 to 43) who presented consecutively for augmentation rhinoplasty using bone grafts were studied. Only one patient had had previous surgery, and twice he had undergone insertion of silastic prostheses with an unsatisfactory result on each occasion. Eleven subjects had partial thickness bone grafts harvested from the calvaria, while the other nine had similar grafts harvested from the iliac crest.

Bone Scanning

Each patient had three-phase bone scintigraphy of the facial skeleton performed both preoperatively and postoperatively. The first 10 patients also had a delayed single-photon emission computed tomography (SPECT) study of the head performed.

For the radionuclide angiography, the patient was positioned with the nose centered in the field of view of a GE 400 AC analog camera interfaced with a PDP 11/34 computer. All studies were acquired using a LEAP collimator. A bolus of 1 GBq of technetium-99m-MDP (methylene diphosphonate) was injected via an antecubital vein and a 2-sec/frame dynamic image was collected for 30 sec. Immediately follow-

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ing this, 400,000 count blood-pool images of the anterior face positioned identically to the blood flow images and 300,000 count images of both laterals of the face were performed. Three hundred thousand count views of the anterior face and similar images of right and left laterals of the skull were taken 3 hr later. The initial patients had normal size delayed images, however, it was found that in patients with grafts harvested from the calvaria the harvest site appeared in the field of view interfering with acquisition. Images of the face only, magnified times 2, were therefore acquired to exclude the donor site.

The SPECT images were acquired over 64 angles with each angle collected for 30 sec. These scans were reconstructed using an in-house developed Metz prefilter (*20*) and Philips Gamma-11 software and were then displayed as standard transaxial, sagittal, and coronal slices.

To allow assessment of the time course of revascularization, the timing of the bone scan was varied after surgery. Five patients had their bone scans performed 2–3 wk postoperatively, 10 had scans 4–8 wk postoperatively, and the remaining 5 were scanned 10–15 wk after surgery. Two patients had two postoperative scans performed, one because of failure of the initial scan to visualize the grafted bone.

An assessment of the success of revascularization and the volume of revascularized bone was obtained by dividing the bone scans into four categories. This grading system was based on the uptake by the graft fragments compared with that of the frontal bones on lateral views (Fig. 1).

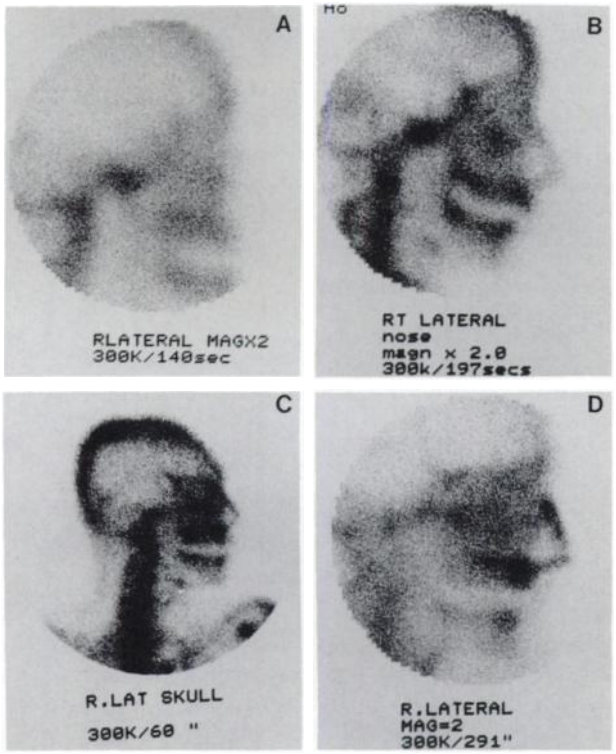

FIGURE 1
Lateral facial views showing bone scan grading system. (A) Grade 0: Graft uptake equal to or less than adjacent soft tissue. (B) Grade 1: Graft activity greater than soft tissue but less than frontal bones. (C) Grade 2: Graft activity equal to frontal bones. (D) Grade 3: Graft activity greater than frontal bones.

X-rays

Thirteen patients had radiographs of the nasal bones performed 3 mo after surgery as part of their routine postoperative follow-up. The graft was classified as either resorbed or intact, depending on its appearance on lateral views.

Clinical Progress

Patients were routinely reviewed by the operating surgeon, who assessed their progress clinically 3 mo after surgery. At this time, the grafts were classified according to their success or failure.

Statistics

The failure rates of grafts taken from the calvaria and ilium were compared using Fisher's exact probability test. The bone scan grades for the two donor sites were compared using the Wilcoxon two-sample test.

RESULTS

The bone scan results according to donor site are shown in Table 1. Their correlation with clinical results and X-ray assessment of the degree of bone graft resorption 3 mo after surgery is shown in Table 2.

Only two patients were considered to have failure of their grafts when assessed by the surgeon 3 mo after surgery (Table 3). In both of these cases, bone scanning showed uptake by the grafts that was less than or equal to the adjacent soft tissue (grade 0). These two patients were also the only two who showed resorption of the bone grafts on X-ray. All other patients were regarded by the surgeon as having successful grafts clinically; all had isotope uptake by the grafts of greater than the adjacent soft tissues (grades 1 to 3), and the 11 who had X-rays showed no evidence of bony resorption. In none of the 10 SPECT studies was graft uptake discordant with that seen on the planar views.

Of the 11 patients whose grafts were harvested from the calvaria, 2 had grafts which were regarded as failures clinically and both had grade 0 uptake and X-ray evidence of bone graft resorption. One was scanned at both 4–8 wk and 10–15 wk after surgery, while the other was scanned at 10–15 wk only. Of those grafts taken from the ilium, all were clinically successful and none had grade 0 uptake. The failure rates of the grafts

TABLE 1
Number of Patients from Each Donor Site Group with Each Bone Scan Grade

Bone scan grade	Donor site	
	Calvaria*	Iliac crest*
0	2	0
1	4	4
2	2	1
3	3	4

* No significant difference between donor sites ($p > 0.10$).

TABLE 2
Comparison of Bone Scan Grade with Clinical Progress and X-Ray Assessment of Bone Graft Resorption

Bone scan grade	Clinical		X-ray	
	Success	Failure	Normal	Resorbed
0	0	2	0	2
1	8	0	7	0
2	3	0	2	0
3	7	0	2	0

taken from the two different sites, however, were found not to be significantly different ($p>0.25$).

As a measure of the volume of revascularized bone, and hence of the success of the graft, the bone scan grades of the grafts taken from the calvaria and ilium were compared. Again no significant difference was found between grafts taken from each site ($p>0.10$).

DISCUSSION

Radionuclide bone scanning is an accepted method for the early assessment of bone graft viability in many sites (*9,12,13,15,17–19*). Bone grafts to various sites in the facial skeleton have been assessed by bone scanning, and it has been suggested that SPECT adds extra information in this region (*14,21*). The nose, however, offers a different environment. First, it is highly vascular and revascularization of grafts might therefore be expected to occur earlier in this region than in other sites in the face. Second, most of the graft is not contiguous with adjacent bone, hence, interpretation of bone scans should be less difficult.

The current study shows that bone scan evidence of revascularization of free cancellous bone grafts in the nasal region is present at least as early as 2–3 wk after surgery compared with the 6 wk (*18*) and 3 wk (*13*) reported for iliac grafts to the mandible in the dog model or the 4 wk reported for split rib grafts to the mandible in the human (*17,19*). It also shows that radionuclide bone scanning can be used as an early predictor of graft outcome in the nasal region. When assessed on delayed lateral facial views, uptake of isotope by the bone grafts which was equal to or less than the adjacent soft-tissue uptake was predictive of subsequent graft failure assessed 3 mo after surgery by clinical means and radiographic evidence of bony resorption.

TABLE 3
Success Rates of Bone Grafts According to Donor Site

Donor site	Success	Failure
Calvaria	9	2*
Iliac crest	9	0*

* No significant difference between failure rates ($p > 0.25$)

This was true for scans performed at 4–8 wk and 10–15 wk after surgery. Scans performed 2–4 wk after surgery were able to predict graft success. However, no failures occurred in this patient group so the efficacy of bone scanning at 2–4 wk after surgery in the prediction of graft failure is inferred rather than proven.

Delayed SPECT studies of the head did not contribute any extra information in the prediction of graft failure in the first 10 patients, including one patient with a failed graft. This differs from some other published work (*14,21–23*), which suggests that the skull and facial region is best assessed by SPECT scanning. The fact that nasal bone grafts are positioned away from the complicated bony anatomy of the skull, and can be projected off the skull using lateral views, probably explains why SPECT was not helpful.

Radionuclide angiography also proved unhelpful. However, no postoperative infections were encountered and dynamic studies would be expected to be most helpful in differentiating osteomyelitis from cellulitis or normal postoperative change.

Reports using animal models show that grafts taken from the calvaria maintain their volume better than those taken from the ilium, especially when grafted to skull or facial sites (*10,16,24*), and it has been suggested this is also true for humans (*1,3*). In the current study, only two grafts were considered to be inadequate and both were taken from the calvaria. One of these patients had previously undergone insertion of silastic prostheses twice and this may have resulted in scarring, reduced vascularity, and, hence, inadequate invasion of the bone grafts by new blood vessels. The other patient could not be distinguished preoperatively from patients who had successful grafts. However, no statistically significant difference was found between the failure rates of grafts taken from the two sites nor the volume of revascularized bone as assessed by bone scan grades.

In conclusion, planar bone scanning is a useful method in the early detection of nasal bone graft failure. A larger study is required to answer the question of whether calvarial or iliac donor sites produce lower failure rates in humans.

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