Assessment of Painful Late Effects of Lumbar Spinal Fusion with SPECT

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The authors reviewed planar, SPECT and other contemporaneous radiologic images of the spine and the medical records of 33 patients with back pain after lumbar fusion surgery in order to determine the value of SPECT in the assessment of painful late effects of spinal fusion surgery. **Methods:** Twenty-one patients had lateral fusion, nine patients had posterior fusion only and three patients had anterior and posterior fusions. There were 24 patients who had surgery more than 4 yr ago (late group, mean 11.8 yr) and 9 patients who had surgery less than 4 yr ago (early group, mean 17.8 mo). **Results:** The most common SPECT abnormality in patients in the late group were lesions in the vertebral bodies and apophyseal joints in the free motion segments adjacent to the fused segments (62.5% of patients). Such lesions occurred in 46% of patients after lateral fusion, in 87.5% of patients after posterior fusion and in 67% of patients after posterior and anterior fusions. No SPECT abnormalities were detected in the fused segments in patients in the late group with solid lateral fusion but were detected in three patients with solid posterior fusion. These results correlate with biomechanical studies that have shown posterior fusion to produce the largest amount and lateral fusion to produce the least amount of stress in the free segments adjacent to the fusion. Lateral fusion was found to have a more stabilizing effect than posterior fusion. **Conclusion:** In addition to the already established value of SPECT in detecting painful pseudoarthrosis, our results indicate that SPECT is of value in the assessment of painful late effects of fusion.

Key Words: spine; radionuclide studies; emission CT; facet joints

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Spinal fusion surgery is performed in patients with back pain when segmental instability is believed to be a significant cause for the pain. The rationale is that pain relief will be achieved once the fusion restricts motion in the painful segments (*1–3*).

Persistent back pain in the first years after a fusion procedure is often related to failure to achieve structural integrity of the fusion, i.e., the graft is not solid, or failure to achieve functional integrity, i.e., the graft is solid but does not stabilize the fused segments and there is continuous motion within the fusion (*4,5*).

Even patients who experience pain relief after successful fusion are at risk of having back pain many years after surgery. Arthrodesis alters the biomechanics of the spine and creates a compensatory increased motion and increased mechanical load on the free motion segments adjacent to the fusion. In time, these free segments may become a new source of back pain (*6–8*).

SPECT of the spine has been previously shown to be of value in detecting painful pseudoarthrosis in patients after lumbar spinal fusion (*9*). The purpose of the current study was to determine the value of SPECT in the assessment of painful late effects of spinal fusion surgery.

MATERIALS AND METHODS

We retrospectively reviewed the planar and SPECT images of 33 patients who had spinal fusion surgery and were referred for scintigraphic assessment of back pain between October 1990 and January 1993. Based on the time interval between surgery and bone scintigraphy, patients were divided into two groups; an early group consisting of patients who had surgery less than 4 yr ago, and a late group consisting of patients who had surgery more than 4 yr ago. The rationale in separating the patients according to the time from surgery was based on clinical follow-up data that have shown that patients early and late after fusion may differ in their causes of back pain (*7*). There were 9 patients in the early group (mean 17.8 mo after surgery, range 8–42 mo) and 24 patients in the late group (mean 11.9 yr, range 5–30 yr). Patients who had repeat fusion surgery (n = 5) were categorized according to the time from the first surgery. Medical records of the patients and all available contemporaneous imaging studies of the spine were reviewed.

Anterior and posterior planar views and SPECT studies of the spine were obtained 3–4 hr after the intravenous injection of 740–925 MBq of ^{99m}Tc-imidodiphosphonate. SPECT studies were performed with a rotating gamma camera (Starport 400 AT, GE Medical Systems, Milwaukee, WI). Until August 1991, 360° acquisition was performed with 64 projections of 20 sec each (n = 5). Thereafter, we performed 180° posterior acquisition with 64 projections of 10 sec each (n = 28) (*10*). For both acquisition techniques, matrix size was 64 × 64 and data were reconstructed using a filtered backprojection technique with a ramp filter and Hanning prefilter with a cutoff frequency of 0.85 and attenuation correction.

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Observers were blinded to the time, type and levels of fusion. Planar and SPECT images were reviewed independently by three nuclear medicine physicians (EES, RHM, SEI) and the tabulated results are the consensus agreement. The scintigraphic assessment included the following data: whether the fusion mass was visualized, the presence of focal lesions within the fusion and abnormalities in the vertebrae and sacroiliac joints. Radiologic studies were reviewed by an osteoradiologist (MJM) and included plain radiographs (n = 30), flexion-extension radiographs (n = 4), CT scans (n = 16) and MR images (n = 3). For one patient, contemporaneous imaging studies were not available for correlation with bone scintigraphy. The radiologic assessment included the structural and functional integrity of the fusion and abnormalities in the spine and sacroiliac joints. The fusion was thought to be nonsolid if there were defects within the fusion mass and, nonstability was shown by the presence of movement on flexion-extension radiographs, or change in alignment of the fused segments on follow-up radiographs. When correlating the radiologic assessments with the surgical reports for tabulation, the fusion was concluded to be partially solid if radiologic images detected fusion mass in only some of the levels that were documented to be fused surgically but without clear defects or immature bone.

RESULTS

The surgical data and SPECT and radiologic findings of patients in the late and early groups are summarized in Tables 1 and 2, respectively. Eighteen patients in the late group and three patients in the early group had radiologically solid and stabilizing fusions.

The Graft

These successful fusions appeared on SPECT images as areas of diffuse but not increased uptake with no evidence of focal abnormalities within the fusion mass. Lateral fusions were detected lateral to the vertebral column (n = 10) and posterior fusions were detected in the paraspinal region (n = 9) (Figs. 1–3). In one patient, 8 mo after surgery, a solid single-level lateral fusion appearing on SPECT as a focal increase in uptake was misinterpreted to be nonsolid. In another patient with a single-level solid posterior fusion 16 yr after surgery, the fusion was not visualized on SPECT images. The small amount of bone in the fusion seen on radiographs of this patient is a possible explanation. Differences in the amount of bone along the fusion caused inhomogeneity in the uptake along the fusion but was not a cause for focal abnormalities on SPECT images (Fig. 1).

In six patients in the early group and in five patients in the late group, the fusion was radiologically nonsolid, partially solid and/or nonstabilizing. SPECT images detected focal lesions as previously described in failed fusions in all six patients in the early group but only in one patient in the late group (*9,11*) (Fig. 4).

In one patient with a radiologically solid fusion in the late group, SPECT images detected a focal intense uptake within the fusion. This patient had an acute fracture in the lamina and bone remodeling was identified on histologic examination of samples obtained during surgery from the fusion adjacent to the fracture site.

Free Segments Above and Below the Fusion

Lesions in the vertebral bodies and/or in the apophyseal joints in the free segments beyond the fusion were the most common SPECT abnormality in the late group and occurred in 15 of the 24 patients (62.5%). The abnormal segments were immediately adjacent to the fusion (Figs. 3 and 4). In three patients, adjacent segments and segments more remote from the fusion were abnormal on SPECT images. Abnormality in the free segments were detected on SPECT images in 6 of 13 patients after lateral fusion (46%), 7 of 8 patients after posterior fusion (87.5%) and in 2 of 3 patients after anterior and posterior fusion (67%) in the late group.

Fused Segments

In the fused segment, the disc spaces were narrow on radiographs in all patients in the late group. In patients with solid lateral fusions, this finding was not associated with increased vertebral uptake. Vertebral uptake in a fused segment was detected in one patient with nonstabilizing lateral fusion and herniated disc. Abnormalities in the vertebral body and in the apophyseal joints in fused segments were detected in three patients with solid posterior fusion. It was difficult to assess abnormalities in the fused segments in patients after anterior fusion as uptake in the vertebral body was probably caused by the fusion itself in two of three patients.

Sacroiliac Joints

Twenty-five of 33 study patients (76%) had asymmetric uptake in the sacroiliac joints (SIJ) with the side of bone graft harvesting showing less activity than the contralateral side. A diagnosis of sacroiliitis was suggested on correlative studies in only two patients.

The presence of solid fusion was not appreciated on anterior and posterior planar views in 10 patients in the late group. Eight of these were posterior fusions. In this group, planar images detected an abnormality in the fused segments in only 4 patients compared to 7 patients on SPECT images, and an abnormality in the free segments in only 9 patients compared to 15 patients on SPECT images. In the early group of patients, two cases of nonsolid fusions were missed on planar images which detected only diffuse normal uptake with no focal lesions.

Spinal stenosis and soft-tissue complications identified radiologically were not appreciated scintigraphically.

DISCUSSION

Lesions in the vertebral bodies and in the apophyseal joints, which most likely reflect intervertebral spondylosis and apophyseal joint osteoarthrosis in the free motion segments adjacent to the fusion, were the most common SPECT abnormality in patients with back pain long after surgery (62.5% in the late group) (*11–13*).

Lesions in the adjacent free segments were more commonly detected in patients after posterior paraspinal fusion than in patients after lateral intertransverse fusion (87.5% and 46%, respectively). These results correlate with the

TABLE 1A
Surgical Data and SPECT Findings in Patients After Fusion Surgery

Patient no.	Sex/Age	Surgery data: Indications for fusion surgery	Surgery data: Fusion levels	Surgery data: Years after surgery	SPECT findings: Uptake in the graft* Diffuse	SPECT findings: Uptake in the graft* Focal increased	SPECT findings: Abnormal uptake in fused segments	SPECT findings: Abnormal uptake in free segments
Lateral fusion								
1	M/69	disc disease	L4-L5	10	+	–	–	VB: L3 AJ: L5-S1
2	M/37	spondylolisthesis L5 on S1	L4-S1	9	+	–	–	–
3	F/41	spondylolisthesis L5 on S1	L4-S1	10	+	–	–	VB: L3-L4
4	F/54	recurrent disc	L4-S1	9	+	–	–	VB: L3 AJ: L3-4
5	F/39	sp ondylolisthesis L5 on S1	L4-S1	7	+	–	–	–
6	M/37	disc disease	L4-S1	9	+	–	–	AJ: L3-4
7	F/56	spinal stenosis	L4-S1	7	+	–	–	–
8	F/56	spondylolisthesis L5 on S1	L4-S1	7	+	–	VB: S1	–
9	M/48	disc disease	L4-S1	6	+	+	Lamina: L5	–
10	F/53	disc disease	L4-S1	15	+ (L4-5 only)	–	–	VB: L3 AJ: L2-3, L3-4
11	F/36	spondylolisthesis L5 on S1	L4-S1	8	+ (L5-S1 only)	–	VB: S1, L5	–
12	M/56	disc disease	L4-S1	5	+	+	–	AJ: L3-4
13	M/39	disc disease	L4-S1	8	+	–	Lamina: L5	–
Posterior fusion								
1	F/60	disc disease	L4-S1	19	+	–	VB: L5 AJ: L4-5, L5-S1	–
2	M/65	spinal stenosis	L3-5	5	+	–	VB: L5 AJ: L3-4, L4-5	VB: L2, S1 AJ: L2-3, L5-S1
3	F/48	disc disease	L4-S1	21	+	–	AJ: L4-5	AJ: L3-4
4	F/58	trauma	L4-S1	17	+	–	–	VB: L3
5	M/51	recurrent disc	T12-L4	17	+	–	–	AJ: L5-S1
6	F/34	scoliosis revision	L4-S1	9 6	+	–	–	VB: L3 AJ: L2-3, L3-4
7	F/59	recurrent disc	L4-5	16	–	–	–	AJ: L1-2, L2-3, L3-4
8	M/28	disc disease	L5-S1	8	–	–	–	VB: L4
Anterior and posterior fusion								
1	F/32	scoliosis, disc	L1-S1 (post) L3-4 (ant)	15 2	+	–	– L3-4	AJ: T12-L1
2	M/47	scoliosis revision	L3-S1 (post) L4-5 (ant)	18 8	+	–	– L4-5	–
3	M/67	trauma L3-L5 (ant)	L3-L5 (post)	17	+	–	–	AJ: L3-4, L5-S1

*SPECT appearance of the graft: diffuse = solid grafts appear as areas of diffuse, not increased uptake with no focal abnormalities within the graft; focal increased = areas of focal increased uptake reflect failure in the structural integrity of the graft.

VB = vertebral body; AJ = apophyseal joint; AJD = apophyseal joint disease; DSN = disc space narrowing; sp st = spinal stenosis; Post = posterior; and Ant = anterior.

results of Lee et al. (*6*) who investigated the biomechanical effects of different types of fusion in human cadaver spines. Posterior, lateral and anterior interbody fusion were all found to produce increased stress in the adjacent free segments, particularly in the apophyseal joints, but posterior fusions were found to produce the largest amount of stress and lateral fusions the least amount of stress. The free segments which appeared abnormal on SPECT images were usually immediately adjacent to the fusion. Of the free segments, the segments immediately adjacent to the fusion have been shown biomechanically to be predisposed to the largest stress (*6,14*).

TABLE 1B
Surgical Data and Radiologic Findings

Patient no.	Sex/Age	Surgical data: Indications for fusion surgery	Surgical data: Fusion levels	Radiologic findings: Graft appearance	Radiologic findings: Abnormalities in fused segments	Radiologic findings: Abnormalities in free segments
Lateral fusion						
1	M/69	disc disease	L4-L5	Solid	DSN: L4-5	sp st: L2-3 DSN: L3-4, L5-S1 AJD: L5-S1
2	M/37	spondylolisthesis L5 on S1	L4-S1	Solid	DSN: L4-5, L5-S1	AJD: L3-4
3	F/41	spondylolisthesis L5 on S1	L4-S1	Solid	DSN: L4-5	DSN: L3-4
4	F/54	recurrent disc	L4-S1	Solid	DSN: L5-S1	anterolisthesis L2-3, L3-4 DSN: L2-3, L3-4 AJD: L2-3, L3-4
5	F/39	spondylolisthesis L5 on S1	L4-S1	Solid	Listhesis: L5-S1 DSN: L4-5	–
6	M/37	disc disease	L4-S1	Solid	DSN: L4-5	–
7	F/56	spinal stenosis	L4-S1	Solid	DSN: L4-5, L5-S1	sp st: L2-3, L3-4
8	F/56	spondylolisthesis L5 on S1	L4-S1	Solid	Listhesis: L5-S1 DSN: L5-S1	–
9	M/48	disc disease	L4-S1	Solid	Fracture of lamina: L5 DSN: L4-5, L5-S1	AJD: L3-4
10	F/53	disc disease	L4-S1	Partially solid	DSN: L4-5, L5-S1	DSN: L2-3, L3-4 AJD: L1-2, L2-3, L3-4
11	F/36	spondylolisthesis L5 on S1	L4-S1	Partially solid	Listhesis: L5-S1 Herniated disc L4-5	–
12	M/56	disc disease	L4-S1	Solid, non-stabilizing	Retrolisthesis: L4-5 Residual disc: L4-5 DSN: L4-5	AJD: L2-3, L3-4
13	M/39	disc disease	L4-S1	Not solid	DSN: L4-5	AJD: L3-4
Posterior fusion						
1	F/60	disc disease	L4-S1	Solid	DSN: L4-5, L5-S1 AJD: L4-5, L5-S1	DSN: L3-4 AJD: L2-3, L3-4
2	M/65	spinal stenosis	L3-5	Solid	DSN: L3-4, L4-5 AJD: L3-4, L4-5	Retrolisthesis: L2-3 DSN: L2-3, L5-S1 AJD: L2-3
3	F/48	disc disease	L4-S1		Not available	
4	F/58	trauma revision of fusion	L4-S1	Solid Solid	DSN: L4-5 DSN; L2-3, L3-4	DSN: L3-4 –
5	M/51	recurrent disc	T12-L4	Solid	DSN: L2-3, L3-4	–
6	F/34	scoliosis revision	L4-S1	Solid	DSN: L4-5, L5-S1	DSN: L3-4
7	F/59	recurrent disc	L4-5	Solid	DSN: L4-5	DSN: L1-2, L2-3 AJD: L2-3, L3-4, L5-S1 Arachnoiditis
8	M/28	disc disease	L5-S1	Not solid	DSN: L5-S1	Retrolisthesis: L4-5 DSN: L4-5
Anterior and posterior fusion						
1	F/32	scoliosis, disc	L1-S1 (post) L3-4 (ant)	Solid Solid	DSN: L1-2, L2-3, L3-4, L4-5	AJD: T12-L1
2	M/47	scoliosis revision	L3-S1 (post) L4-5 (ant)	Solid Solid	DSN: L4-5	–
3	M/67	trauma	L3-L5 (post) L3-L5 (ant)	Solid Solid	DSN: L3-4, L4-5	DSN: L1-2, L2-3 AJD: L5-S1

See Table 1A for definitions.

TABLE 2
Surgical Data, SPECT and Radiologic Findings in Patients Early After Surgery

		Surgery data			SPECT findings				Radiologic findings		
					Uptake in the graft*						
Patient no.	Sex/Age	Indications for fusion surgery	Fusion levels	Months after surgery	Diffuse	Focal increased	Abnormal uptake in fused segments	Abnormal uptake in free segments	Graft appearance	Abnormalities in fused segments	Abnormalities in free segments
Lateral fusion											
1	F/39	disc disease	L4-S1	13	+	–	VB: L5	–	Solid	DSN: L4-5	
2	F/32	spondylolisthesis L5 on S1	L5-S1	8	–	+	–	–	Solid	Listhesis: L5-S1	–
3	M/22	recurrent disc	L4-S1	24	+	+	–	–	Not solid	DSN: L4-5 Scar: L4-5	–
4	M/52	disc disease	L4-S1	42	+	+	–	–	Not solid	DSN: L4-5	–
5	M/47	disc disease	L4-S1	17	+	+	–	–	Not solid	DSN: L4-5	–
6	M/30	disc disease	L4-S1	10	+	+	–	AJ: L2-3, L3-4	Not solid	Anterolisthesis: L4-5 DSN: L4-5	–
7	F/36	spondylolisthesis L5 on S1	L5-S1	10	–	+	VB: S1	–	Not solid	Listhesis: L5-S1	–
8	M/67	recurrent disc	L3-L5	8	+	+	–	AJ: L5-S1	Solid not stable	Retrolisthesis: L3-4 Scar: L3-4 DSN: L3-4	sp st: L2-3 DSN: L1-2 AJD: L5-S1
Posterior fusion											
1	M/45	disc disease	L4-S1	28	+	–	VB: L5	–	Solid	DSN: L5-S1	–

*SPECT appearance of the graft: diffuse = solid grafts appear as areas of diffuse, not increased uptake with no focal abnormalities within the graft; focal increased = areas of focal increased uptake reflect failure in the structural integrity of the graft.

VB = vertebral body; AJ = apophyseal joint; AJD = apophyseal joint disease; DSN = disc space narrowing; and sp st = spinal stenosis.

The somewhat higher incidence of lesions in the free segments adjacent to the fusion identified in our study is probably the result of bias in our study patients who were not consecutive patients with fusion but only those patients selected by the clinician for scintigraphic assessment of back pain as compared to some clinical follow-up studies. These may well be the patients with the most severely disabling pain (*7*).

While failure of fusion in the early years after surgery commonly requires repeat surgery, patients with back pain long after fusion surgery are usually treated with medications and less than 5% are treated surgically. If apophyseal joint disease is felt to have a major contribution to the pain, apophyseal joint injections and denervation can be considered (*5,15*).

Solid lateral fusions have been shown on biomechanical studies to have a stabilizing effect on the fused segments. As the result of immobilization, the height of disc spaces within the fusion is decreased on radiographs. In our patients, these changes were not associated with increased uptake. SPECT lesions in the fused segments were detected, however, in two patients with unstable lateral fusions. Solid posterior fusions, in contrast to lateral fusions, have been shown to allow a small but significant motion within the fusion and to have a harmful effect on the apophyseal joints and discs within the fusion (*6*). In our patients, lesions in the vertebral body and/or the apophyseal joints were detected in three patients in the late group with solid posterior fusion.

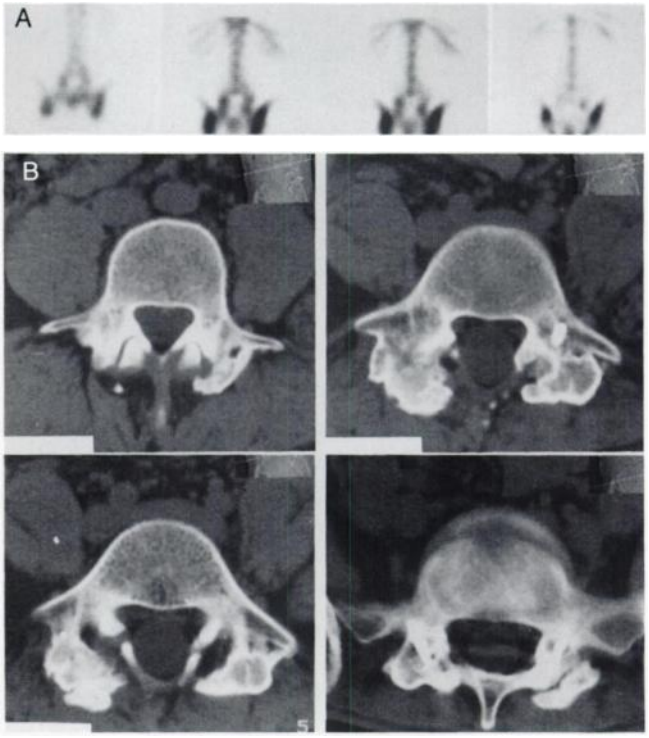

FIGURE 1. The effect of different amounts of bone along the fusion. Solid lateral L4-S1 fusion 7 yr after surgery: (A) SPECT and (B) CT scan. The uptake in the fusion may appear inhomogeneous in some of the SPECT slices but not focal as in a failed fusion (compare to SPECT images in Fig. 4). Axial CT images through the L4 and L5 vertebral bodies demonstrate variable amounts of solid bone graft accounting for the inhomogeneous SPECT uptake. Bone graft was harvested from the right side.

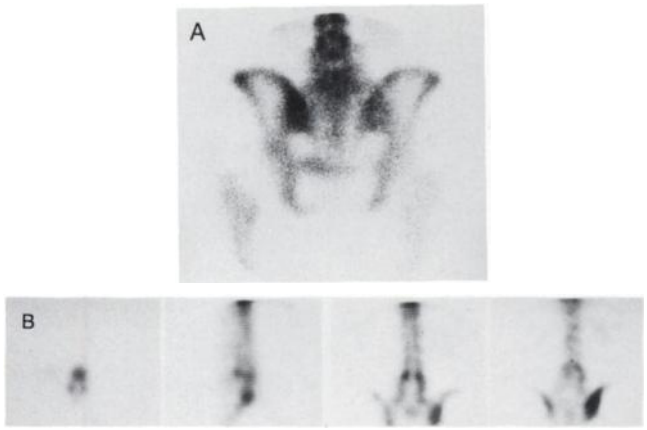

FIGURE 2. Apophyseal joint disease above a solid lateral L4-S1 fusion 9 yr after surgery: (A) Planar and (B) SPECT. Bone graft was harvested from the right side.

Of the five patients with nonsolid or nonstabilizing fusions in the late group, four showed no corresponding focal abnormality within the fusion on SPECT images. Previously published results have shown a high sensitivity of SPECT in detecting painful pseudoarthrosis (*9*). Such abnormalities were detected in all six patients with failed fusions in the early group in our study. These facts suggest that the four late cases of failed fusion with normal SPECT may be a reflection of the scintigraphic natural history of nonsolid fusions rather than false-negative SPECT cases. It seems likely that the increased metabolic activity associated with pseudoarthrosis in the early years after surgery decreases and ceases with time. Of the five patients in the late group with failed fusion, the patient who had focal lesions on SPECT images was the patient who had the shortest time interval between surgery and SPECT.

The sacroiliac joints may be another source of back pain. Increased uptake in the SI joints in patients after spinal surgery has been shown to be more commonly associated with the increased mechanical load induced by surgery than with infection or malignancy (*16*). Visual assessment of asymmetric uptake in the sacroiliac joints in patients after fusion does not imply that pathology in the sacroiliac joints is the cause for pain, as such asymmetry was detected in a large number of patients in our study simply as a result of bone graft harvesting.

As in previous correlative studies, there were discrepancies between SPECT and other imaging modalities in our study (*12,13,17*). The difference in clinical significance between radiologic lesions with and without corresponding increased uptake is not known. Some authors believe that radiologic lesions with no corresponding increased activity are lesions which do not alter the skeletal metabolic activity and therefore are of less clinical importance (*13,14*).

The presence of soft tissue complications and spinal stenosis, which is a relatively common late adverse effect of fusion, cannot be appreciated scintigraphically (*7*). SPECT should therefore be considered complementary and not a replacement to other imaging modalities in the assessment of back pain in patients long after fusion.

SPECT was found to have a clear advantage over planar images in detecting lesions in patients with back pain early

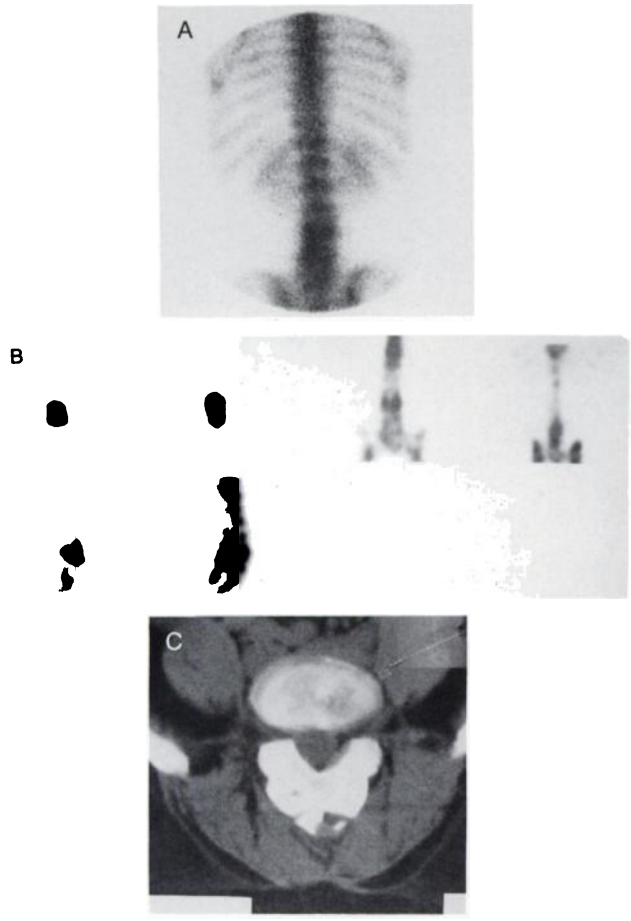

FIGURE 3. A solid posterior L4-S1 paraspinal fusion 17 yr after surgery: (A) Planar, (B) SPECT and (C) CT scan. On SPECT images the fusion is best appreciated on the midsagittal slice. There is abnormal uptake in the vertebral body and apophyseal joints above the fusion. Solidly incorporated bone graft posterior to the lamina and spinous process is identified on the axial CT image.

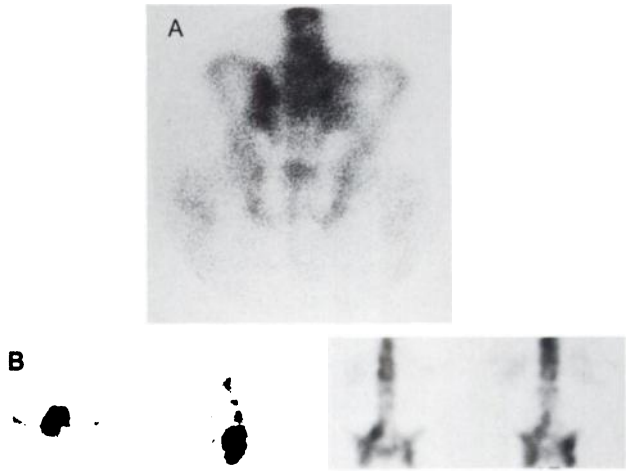

FIGURE 4. A failed lateral L4-S1 fusion, 17 mo after surgery: (A) Planar and (B) SPECT. SPECT images show a focal intense uptake within the fusion. Bone graft was harvested from the right side.

after fusion and even more so in patients with back pain long after surgery.

In summary, SPECT abnormalities were more commonly related to failure of fusion in patients early after surgery and to late adverse effects induced by apparently solid fusion in patients long after surgery. In addition to the previously established value of SPECT in detecting painful pseudoarthrosis, our results indicate that SPECT is of value in detecting painful late effects of spinal fusion.

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EDITORIAL

SPECT Evaluation of Lumbar Spinal Fusion: Will It Make the Medal Round?

In "The Assessment of Painful Late Effects of Lumbar Spine Fusion with SPECT," Even-Sapir et al. discuss a surgical procedure that is frequently performed, yet provokes a great deal of controversy (*1*).

In industrial countries, low back pain is common; up to 80% of the population is afflicted at some time in their lives. Among chronic conditions, low back problems are the major cause of activity limitations in the population under age 45. Numerous surgical and nonsurgical methods have been proposed to deal with conditions producing low back pain.

In 1911 Russell A. Hibbs and Fred H. Albee introduced lumbar spine fusion. Since that time, fusion of the lumbar spine by a variety of techniques has been proposed to restore stability in a number of congenital, acquired, and developmental spinal disorders. Although the enthusiasm for this procedure has waxed and waned, the operation is still commonly performed. Data from the National Hospital Discharge Survey, based on the Medicare population, reveals that between 1979 and 1987, spinal fusion was one of the fastest growing procedures performed on the lower back. The data shows that there was a 200% increase in the spinal fusion rate between 1979 and 1987 in individuals over age 65. Fusion is frequently performed in association with decompressive procedures; the theory being that laminectomy and discectomy reduce stability of the spine and that fusing the affected vertebral area will assure stability helping to prevent further back problems.

This editorial is not intended to outline the pros and cons of fusion, however, it is fair to say that the discussion of advantages and disadvantages of lumbar fusion remains one of the more heated debates in orthopedic and neurosurgical literature. One of the issues fueling the controversy is lumbar fusion's high rate of failure.

The primary cause of failure is the lack of formation of a solid, bony mass, i.e., pseudoarthrosis. It is thought that this failure to achieve solid fusion may lead to loss of alignment, instability, pain and potential neurological damage. The incidence of failure, or pseudoarthrosis is high and approximately the same whether the anterior, posterior or intratransverse process technique is used. The incidence also varies depending on the number of motion segments fused and the method used to subsequently diagnose pseudoarthrosis.

The reported incidence of failure varies from 9.5% when the diagnosis is based on radiological assessment, to as high as 30% when diagnosis is based on "routine second surgical look." The radiological approach is either a static one where an attempt is made to reveal the actual defect within the fusion mass, or a

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