Intravenous Contrast-Enhanced CT of the Postoperative Lumbar Spine: Improved Identification of Recurrent Disk Herniation, Scar, Arachnoiditis, and Diskitis

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Intravenous Contrast-Enhanced CT of the Postoperative Lumbar Spine:

Improved Identification of Recurrent Disk Herniation, Scar, Arachnoiditis, and Diskitis

J. George Teplick[1]
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Unsuccessful relief of symptoms after back surgery is usually attributable to hypertrophic extradural scar or recurrent herniated disk. Their clinical and myelographic differentiation is difficult, yet important because reoperation is not always beneficial for scar removal. This article examines the usefulness of intravenous contrast-enhanced computed tomography for this problem. Forty-five postsurgical patients were studied; eight had subsequent surgery. In the four with hypertrophic scars, intravenous contrast enhancement of the scar allowed its recognition in each case; in the four with recurrent disk herniation, nonenhancement of the extruded disk allowed its recognition in three. In the other 37 patients who were not reoperated, 33 were believed to have scar on the basis of contrast enhancement. Continuous contrast infusion during scanning, absolute avoidance of patient movement, and careful consideration of other structures in the spinal canal are important in interpretation. The method seems promising for more accurate evaluation of failed back surgery, including the recognition of diskitis.

High-resolution computed tomography (CT) has proven to be the most accurate method for evaluating the causes of failure of relief or later recurrence of symptoms after back surgery [1–6]. Two of the most common causes are hypertrophic extradural scar and recurrent herniated disk [1, 2, 5, 7]. The distinction of one from the other is of considerable importance, since extradural scar removal often leads to further scar formation [1, 2, 6, 8], while removal of a recurrent herniated disk is generally beneficial. Until recently the distinction usually could not be made conclusively before reoperation, and too often the surgeon was disappointed in finding a scar and not a recurrent herniated disk.

Both recurrent herniated disk and symptomatic hypertrophic scar can produce similar low-back symptoms and radiculopathy. Gradually increasing symptoms beginning a year or more after diskectomy are considered more likely due to scar radiculopathy, while a more abrupt onset at any interval after surgery is more likely due to recurrent herniated disk [1, 2]. Myelography, unfortunately, cannot make a reliable distinction in most cases [3, 8–10], since both lesions can create a clear-cut myelographic defect at or near the interspace.

In most CT scans of the postoperative lumbar spine, fairly confident recognition of fibrosis (scar) is possible using recently published criteria [4–6]. However, when the postoperative lesion resembles a typical herniated disk on CT, it may still prove to be a hypertrophic scar mass (figs. 1 and 2). Sometimes repeat postoperative CT scans are helpful. If, over a period of months or years, there is a definite increase of extradural soft tissues, it is highly probable that a recurrent herniated disk has developed. The postoperative extradural tissue, which generally begins as a postoperative hematoma [2, 4–6], tends to diminish slightly as fibrosis develops and matures, but does not usually enlarge. Consequently, an enlarging extradural soft-tissue mass on follow-up CT will mean that a recurrent disk herniation has developed (fig. 3).

To make the distinction with greater certainty, some suggest a CT scan with

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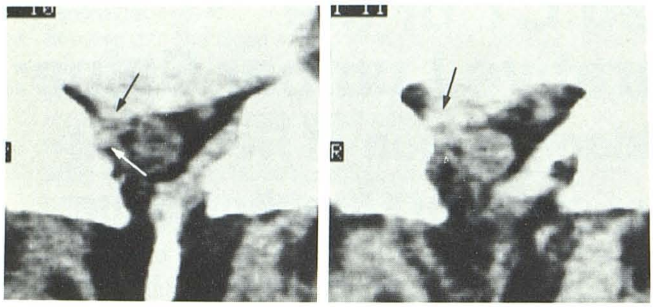


Fig. 1.—Scar resembling recurrent herniated disk: nonenhanced study. After right diskectomy at L5–S1, recurrent S1 radiculopathy developed. CT showed soft-tissue mass and right-sided bulge of anulus (*black arrows*). Right S1 root (*white arrow*) is displaced posteriorly. Thecal sac is not affected. CT findings strongly suggested recurrent herniation, and myelogram showed cutoff of S1 on right. At surgery a hypervascular scar was found, but no disk herniation. Right S1 root was entrapped by scar.

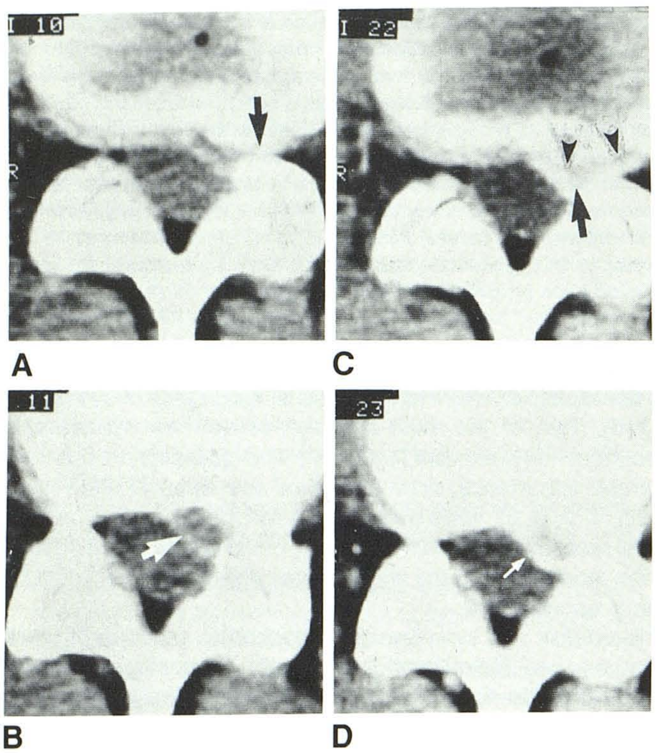


Fig. 2.—Scar stimulating recurrent herniated disk: enhancement distinction. **A** and **B**, Preenhancement scans in patient with recurrent radiculopathy symptoms. **A**, extension of anulus (*arrow*) into left neural foramen, suggestive of recurrent herniated disk. **B**, 4 mm caudad. There appears to be only oblique band of scar (*arrow*) with strands of fibrosis coursing through fat in left recess. **C** and **D**, Postenhancement scans at same levels indicate that entire bulge in **A** is enhancing scar (*black arrow*). More lucent edge of anulus is now visible (*arrowheads*) and appears to have normal shape. Scar and strands in **B** have been virtually totally enhanced (*white arrow*). Surgery was not performed in light of this study.

metrizamide [5, 6, 8, 11], while others depend on the higher CT density of the herniated disk compared with a scar. However, neither technique has proven highly accurate in making the distinction [3, 7–10].

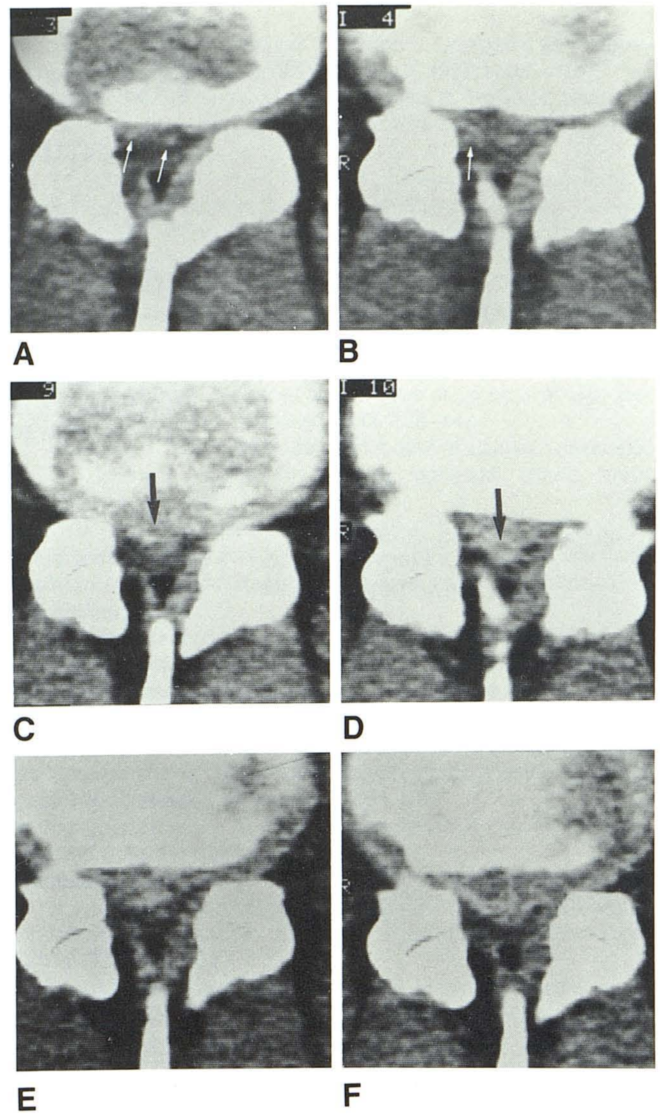


Fig. 3.—Recurrent herniated disk: enhancement corroboration. About 1 year after right diskectomy at L4–L5, this 36-year-old man had recurrent low back pain and mild radiculopathy. **A** and **B**, Consecutive CT sections show right laminectomy and a few isolated, very small areas of fibrosis (*arrows*), but no other significant extradural tissue. **C** and **D**, 2 years later. Corresponding sections show new triangular soft-tissue mass projecting from anulus into canal (*arrows*). This development after essentially negative prior postoperative scan suggests recurrent herniated disk. **E** and **F**, Contrast-enhanced study demonstrates nonenhancement of soft-tissue mass, further corroborating its identity as herniated disk.

Recently, Schubiger and Valavanis [8] observed enhancement of extradural scar or fibrosis on CT after intravenously administered contrast material. The anulus or herniated disk did not enhance, allowing it to be distinguished from scar.

We used contrast enhancement on 45 patients and confirmed the findings of Schubiger and Valavanis [8]. Enhancement of extradural scar tissue is due presumably to a large number of blood vessels that are demonstrable in histologic sections, notwithstanding a popular belief that scars are rather avascular. The normal anulus has no vascular supply, receiving its nourishment from the end-plates of the adjacent two vertebrae. Accordingly, it does not enhance.

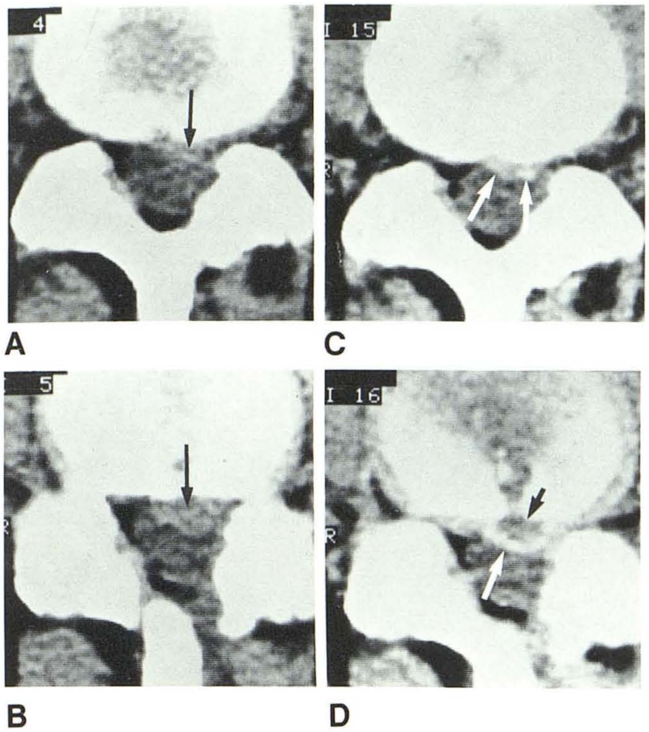


Fig. 4.—Recurrent herniated disk: enhancement demonstration. **A** and **B**, Preenhancement scans show soft-tissue collections (*arrows*) in anterior canal on left. **C** and **D**, Postenhancement. Corresponding sections show enhancing scar (*white arrows*) and, in **D**, nonenhancing area just anterior to scar (*black arrow*), consistent with herniated disk. At surgery unenhanced density proved to be recurrent herniated disk, which was surrounded posteriorly by scar, exactly as seen on enhancement scan.

Subjects and Methods

Intravenous contrast enhancement CT studies were done on 45 patients who had recurrent radiculopathy from 6 months to 13 years after diskectomy. The selected patients were those whose prior postoperative CT scan showed a soft-tissue mass density that could not be confidently labeled as scar tissue only.

The interspace in question was first scanned without enhancement while a 5% glucose solution was slowly infused via a 19 gauge needle. This was done to avoid a later needle insertion that might trigger an inadvertent change in the position of the patient.

On completion of the preliminary CT slices, 100–150 ml of Conray-60 was infused as rapidly as possible, usually taking 3–5 min. After the infusion of 100–150 ml, but with the contrast material still running rapidly, a repeat scan was obtained of the interspace. Generally another 150 ml of contrast material was started before the scan was obtained to ensure continued infusion during scanning.

Since both the pre- and post-contrast-infusion scans are obtained on the same CT run, corresponding sections before and after infusion can be viewed simultaneously on the CRT at the same window and level settings and photographed together.

Alternatively, we also found that a 75 ml rapid intravenous bolus of contrast material immediately followed by scanning could sometimes be satisfactory. However, since enhancement after such a bolus tends to disappear rapidly, the continuous infusion method proved more reliable and has become our standard technique. Apparently the rapid rise and fall of blood level contrast after bolus is less reliable for consistent maximum enhancement than a rapid constant infusion.

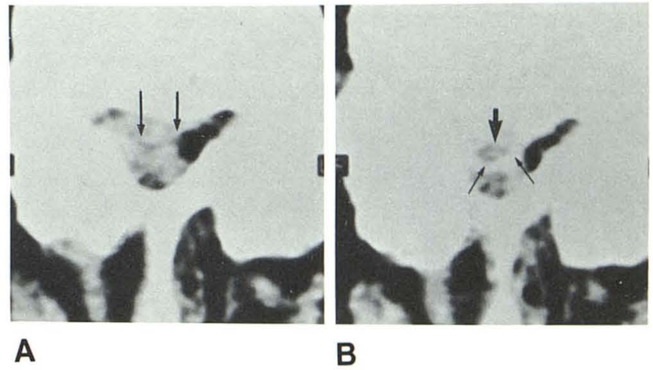


Fig. 5.—Recurrent herniated disk: enhancement demonstration. **A**, Preenhancement. Large, irregular soft tissue in right recess and anterior canal (*arrows*) was considered probable scar, but herniation could not be ruled out clinically or myelographically. **B**, Postenhancement. Extensive enhancing scar (*small arrows*) contains nonenhancing area (*large arrow*). Unenhanced density proved to be recurrent herniated disk fragment within dense scar.

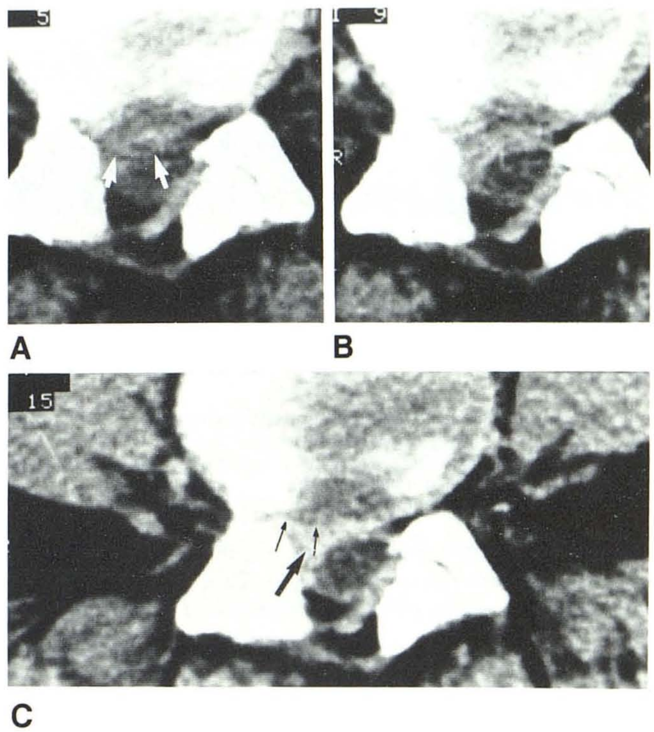
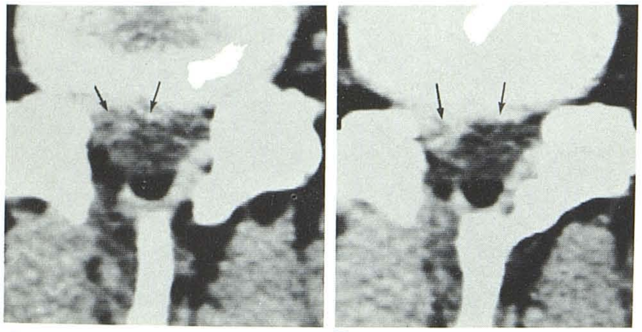


Fig. 6.—Recurrent herniated disk: failure of detection by enhancement technique. **A**, Preenhancement. Annular bulge (*arrows*) on right and center of canal had appearance of herniated disk, although CT density was not as high as usual. **B**, After 100 ml of contrast material. Enhancement is not marked. **C**, After 150 ml of contrast material. Enhancement appears more intense. Enhanced triangular scar (*large arrow*) extends from dural sac to "anulus." Slight but definite focal bulge of anulus (*small arrows*) was not considered significant. At surgery bulge anterior to scar proved to be part of a larger recurrent herniated disk.

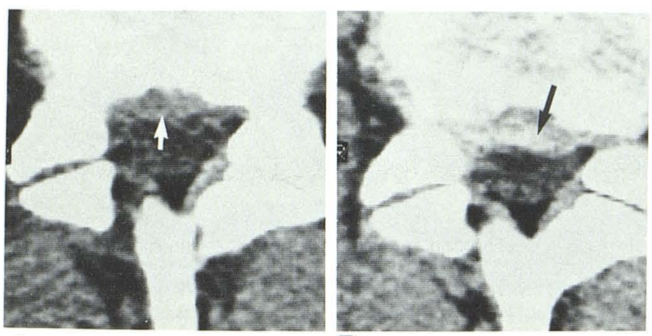
Results

Eight of the 45 patients were subsequently reoperated. In four of these, a recurrent herniated disk was found (figs. 4 and 5) confirming the CT interpretation in three of the four. In the fourth patient no herniated disk was apparent on the enhancement study (fig. 6). In the other four reoperated



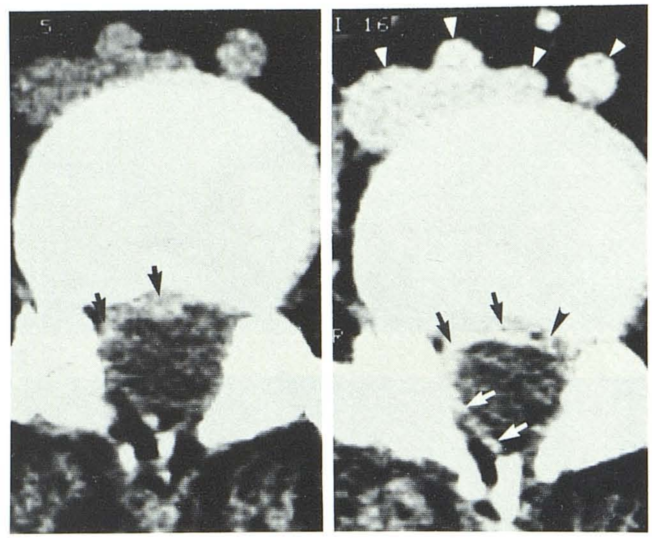
A B

Fig. 7.—Characteristic scar enhancement: corroboration by surgery. **A**, Preinfusion. Soft-tissue density (*arrow*) in right recess and anterior canal was considered fairly characteristic of scar. **B**, Postinfusion. Diffuse and homogeneous enhancement of scar is apparent (*arrows*). Recurrent radiculopathy and positive myelogram suggested recurrent herniation, but reoperation disclosed scar only, corresponding to appearance on enhancement study.



A B

Fig. 8.—Typical scar enhancement. **A**, Preenhancement scan 7 months after diskectomy at L4–L5 shows bulging density apparently continuous with anulus (*arrow*). **B**, After enhancement. Unequivocal enhancement of density extending to anulus (*arrow*) indicates it is entirely scar.



A B

Fig. 9.—Enhancement of scar, thecal sac, and vessels. **A**, Preinfusion scan shows soft-tissue mass in right anterior canal (*arrows*) and in recess. **B**, Postinfusion scan shows enhancement of scar (*black arrows*), left side of vascular plexus (*black arrowhead*), and dural wall (*white arrows*). Enhancement of iliac vessels (*white arrowheads*) anterior to vertebral body verifies intravascular contrast material.

patients, scar only was found, consistent with the CT enhancement studies in each case (fig. 7). Of the 37 patients who were not reoperated, CT enhancement findings were interpreted as recurrent herniated disk in four and scar in the other 33.

In most of the cases that were reoperated, the myelographic and clinical findings carried as much or more weight than did the enhancement studies in arriving at the decision to reoperate. Thus, in each of the four cases where the CT enhancement studies had correctly predicted scar, the surgeon had hoped that he would find a recurrent disk or disk fragments. However, as confidence in enhancement accuracy increased, the CT findings played a more decisive role in determining the type of treatment. Our observations on the enhancement of the various tissues in and around the spinal canal merit description.

Extradural Scars (Fibrosis)

In the homogeneous hypertrophic scar, enhancement is fairly uniform (figs. 8 and 9). If the fibrous tissue consists of multiple strands or bands or contains the nerve root, the enhanced mass will not be uniform but will contain unenhanced areas of fat or of a nerve root (figs. 10–14). These unenhanced areas should not be mistaken for disk or disk fragments within the enhanced scar.

Enhancement does not appear to be related to the age of the scar. Two of the oldest extradural scars were 10 and 13 years old, and yet their enhancement was quite considerable. Sometimes the enhanced scar appeared somewhat larger than on the preenhancement film. In part this was due to fibrous strands that were so thin that they could not be appreciated readily before enhancement. However, more often this was due to concomitant enhancement of the vessels of epidural plexus, which merge with the scar, thus producing a larger enhanced mass than anticipated (figs. 9 and 10).

Recurrent Herniated Disk

Most often a herniation recurs through the same focal segment of the anulus as the original herniation. The recurrent herniation will then be anterior to the scar from the original diskectomy. Consequently, a band of enhancing scar tissue posterior to the enhanced recurrent herniation (figs. 4 and 5) is fairly characteristic.

If a recurrent herniated disk emerges from a segment of the anulus other than the original herniation site, it is less likely to be as intimately associated with the scar (fig. 15). Moreover, such a herniation can be expected to produce symptoms and radiculopathy somewhat different from the original herniation.

Nonenhancing tissue (fat or nerve root) within an enhancing scar might be mistaken for a recurrent herniated disk. With

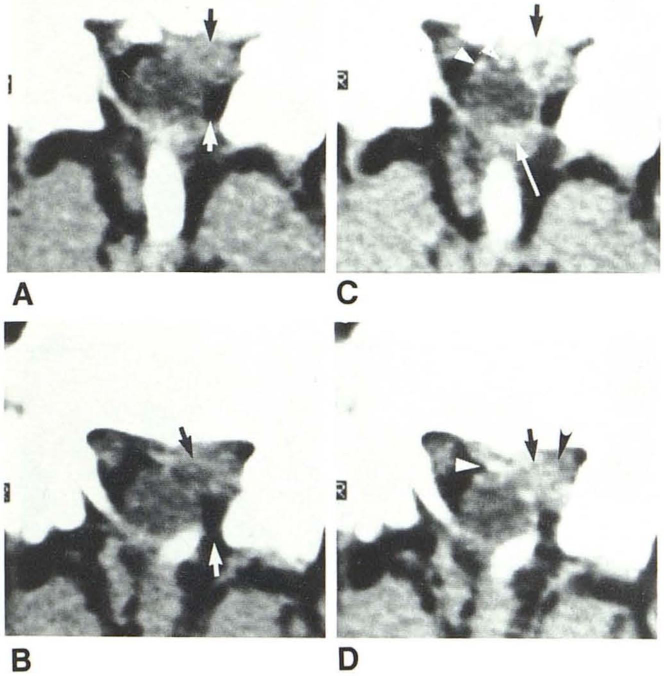


Fig. 10.—Enhancement of scar, thecal sac, and back muscles. **A** and **B**, Preinfusion scans show inhomogeneous mass densities in left recess (*black arrows*). Fat graft (*white arrows*) extends from laminectomy site into canal. **C** and **D**, Postinfusion. Enhancement of scar tissue (*black arrows*) is not homogeneous because of interspersed nonenhancing fat. Nonenhancement of nerve root (*black arrowhead*) adjacent to fibrosis. Focal linear and nodular enhancement of left side of thecal sac is apparent, extending between recess scar and laminectomy scar. Enhancement of epidural plexus vessels (*white arrowheads*). Back muscles also show some enhancement.

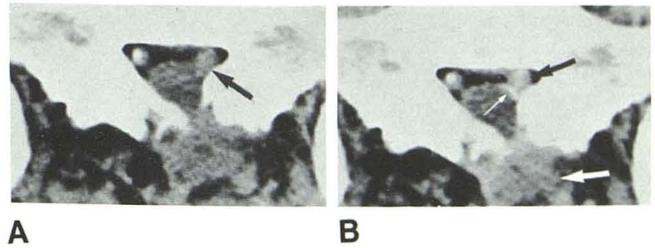


Fig. 12.—Nerve root enhancement. **A**, Preenhancement scan shows slightly denser than usual left nerve root (*arrow*). Right root contains drop of Pantopaque. **B**, After infusion. Left nerve root becomes greatly enhanced (*black arrow*), indicating it is entirely surrounded by scar. Note focal extension of scar (*small white arrow*) into adjacent thecal sac. Its appearance resembles plaque of dural fibrosis more than extradural scar. Fibrous tissue behind laminectomy (*large white arrow*) has also enhanced considerably.

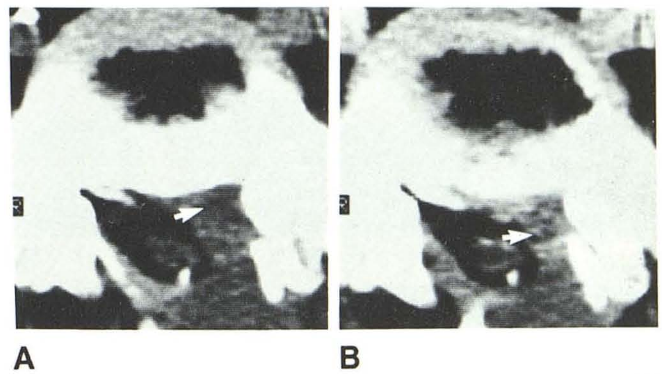


Fig. 13.—Nonenhancing epidural fat. **A**, Preenhancement CT scan. Soft tissue in left recess has low density and represents epidural fat within scar (*arrow*). **B**, After enhancement. Lucency of fat (*arrow*) presiding between enhanced tissue should not be mistaken for nonenhancing disk fragment. Disk material is usually of considerably higher density in nonenhanced CT section.

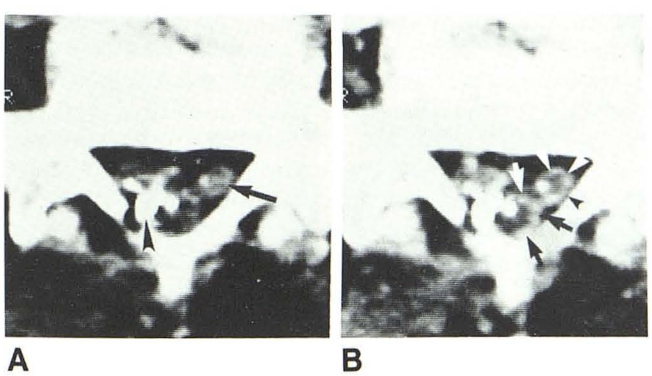


Fig. 11.—Enhancement of nerve root sleeve, dural sac, and blood vessels. **A**, Unenhanced CT scan of L5–S1 1½ years after bilateral laminectomies show left nerve root (*arrow*) with thickened sleeve containing droplet of Pantopaque. Irregular glob of Pantopaque (*arrowhead*) is in right side of sac and in emerging right roots. **B**, After intravenous enhancement. Enhancement of sleeve (*arrowheads*) and thickened sac wall (*arrows*). On right, anterior to Pantopaque, enhanced vessels and sleeve of right root are seen.

increasing experience, this interpretive error was recognized. On the other hand, failure to identify a recurrent herniated disk on enhancement studies clearly occurred in one of our cases (fig. 6). Similar failures were mentioned by Braun et al. [7] and others (personal communications). The reason for these scattered failures of enhancement studies is not clear; perhaps their review with the surgeon after reoperation will bring some clarification.

Enhancement of the Postoperative Dural Sac

In about one-half of the intravenous enhancement studies, focal enhancement of the wall of the thecal sac was noted, almost always on the side of the laminectomy. In some cases the fibrous tissue clearly extended from an enhanced extradural scar to the enhanced segment of the wall (figs. 14, 16, and 17). However, in many others, the enhancement appeared to be a focal thickening of the dura (figs. 18–20) and not related or continuous with the extradural fibrosis. It was often difficult or impossible to determine whether the sac wall enhancement was from extradural scar or intradural fibrosis. The relation between the enhanced thickened wall of the thecal sac and "arachnoiditis" makes interesting speculation. Other than a brief mention in our previous reports on the postoperative spine [3, 4] and a few CT case reports on calcified arachnoiditis, no observations have been offered on the plain (without metrizamide) CT findings in "arachnoiditis."

Our study includes five myelographically corroborated cases of arachnoiditis: one in a nonoperated patient and four

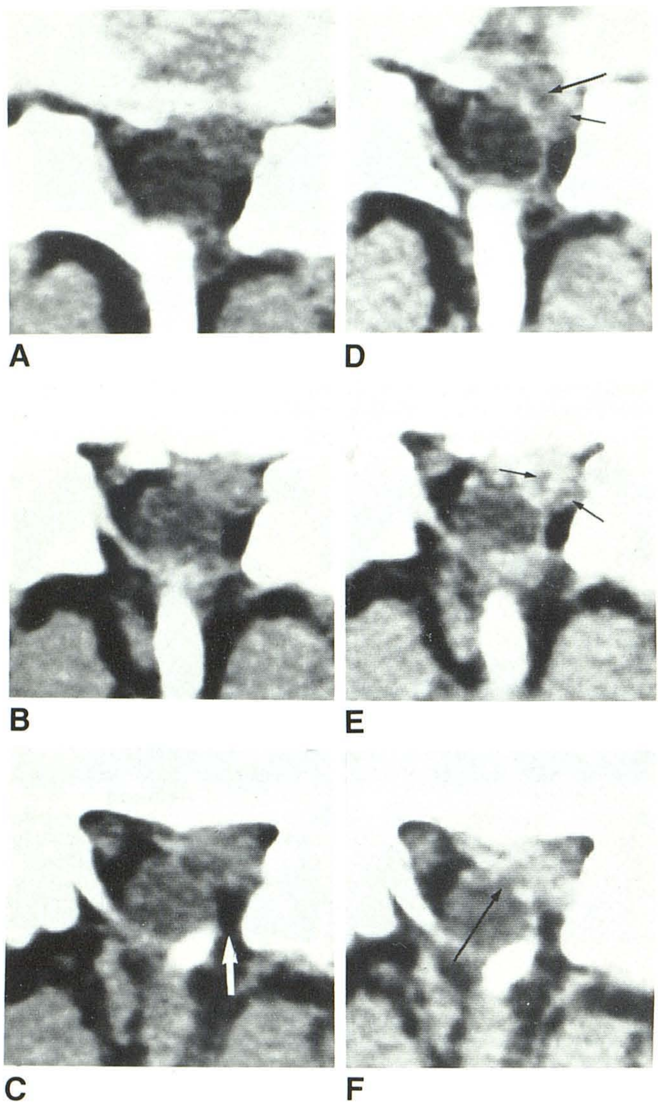


Fig. 14.—Inhomogeneous enhancement of scar (reprinted from [6]). **A–C**, Three consecutive CT sections. Tissue mass (*arrow*) filling left side of canal anterior to thecal sac is quite inhomogeneous, containing numerous low-density areas, which are epidural fat. **D–F**, After intravenous contrast. Scar enhances but is quite inhomogeneous, containing nonenhanced fat (*arrows*). Nonenhanced areas could be mistaken for disk fragments. Fat graft (*arrow*, **C**) had been placed at laminectomy site extending anteriorly to recess. Perhaps its expected role in reducing the degree of scarring explains inhomogeneous scar. Focal enhancement of left side of sac and plexus vessels to right of scar give enhanced mass somewhat larger appearance than before enhancement.

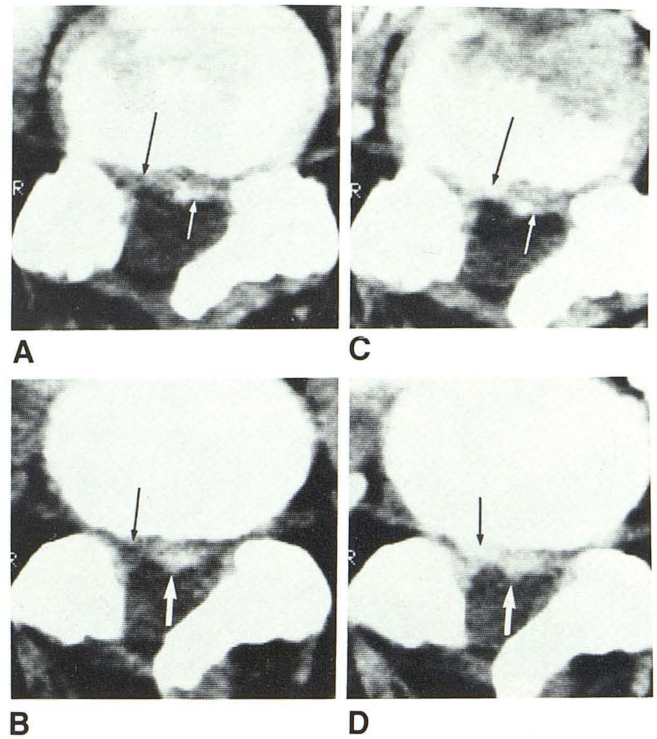


Fig. 15.—Scar and recurrent disk herniation: enhancement study. **A** and **B**, Before enhancement. Two adjacent sections show dense soft-tissue mass (*white arrows*), which could be either recurrent herniated disk or hypertrophic scar. Less dense soft tissue (*black arrows*) in right recess seems more like scar. **C** and **D**, Postenhancement scans clearly reveal enhancement of scar (*black arrows*) on right side, while more dense soft tissue centrally does not enhance (*white arrows*). This confirms recurrent disk herniation.

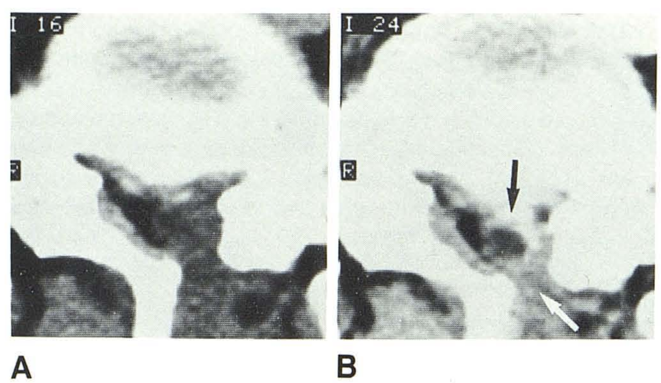


Fig. 16.—Extradural scar extending around dural sac. **A**, Unenhanced CT scan. Sac has been pulled over to left and seems to merge with scar filling left lateral part of canal. Two densities anteriorly in canal are unusually dense vessels of epidural plexus. **B**, After enhancement. Scar increases markedly in density (*black arrow*) and extends to surround about half of thecal sac, clearly outlining its border. Scar (*white arrow*) along left canal wall and laminectomy site enhances less intensely than anterior of scar and sac, probably due to presence of interspersed epidural fat within posterior scar.

in postlaminectomy patients; in each marked thickening of the wall of the sac was demonstrated on the CT studies. In the "primary" arachnoiditis (fig. 21) thick plaques of increased density were seen. Of the four cases of postoperative arachnoiditis, the fibrous thickening along the wall of the sac showed contrast enhancement in one case (fig. 22).

These findings suggest that the thickening of the wall of the thecal sac wall could represent a localized form of postlaminectomy arachnoiditis, a form without clinical or myelographic findings. Probably only when the thickening of the sac wall becomes extensive and affects the nerve roots will the myelographic changes of arachnoiditis develop. However, the cause of the diffuse dural thickening in postlaminectomy arachnoiditis is still unknown [12–14].

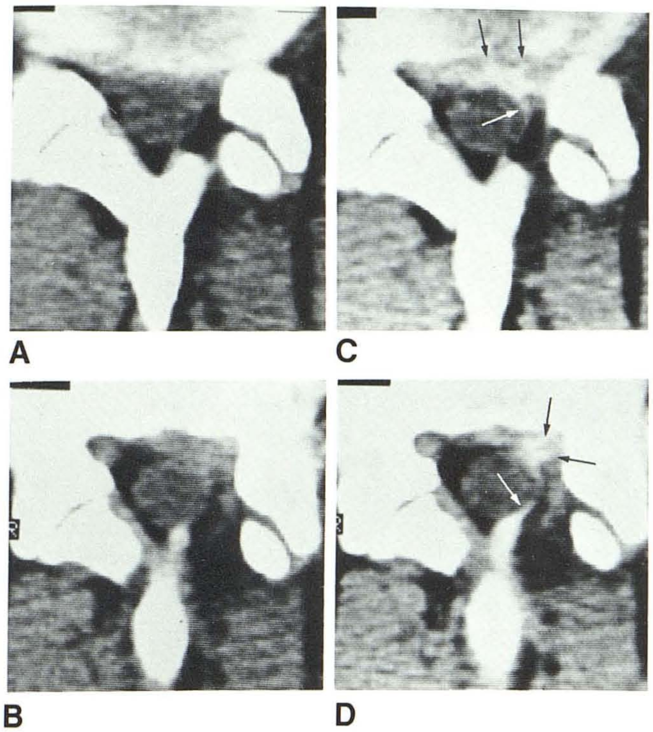


Fig. 17.—Extension of scar into anulus and nerve root. **A** and **B**, 1 year postoperatively. Preenhancement scans at L4–L5 show soft-tissue mass adjacent to anulus and filling left recess. **C** and **D**, After enhancement. CT shows enhanced mass with extension of scar tissue (*black arrows*, **C**) into irregular anulus and also into irregular left nerve root (*black arrows*, **D**). Focal enhancement of dural sac, virtually entirely on side of scar and laminectomy (*white arrows*).

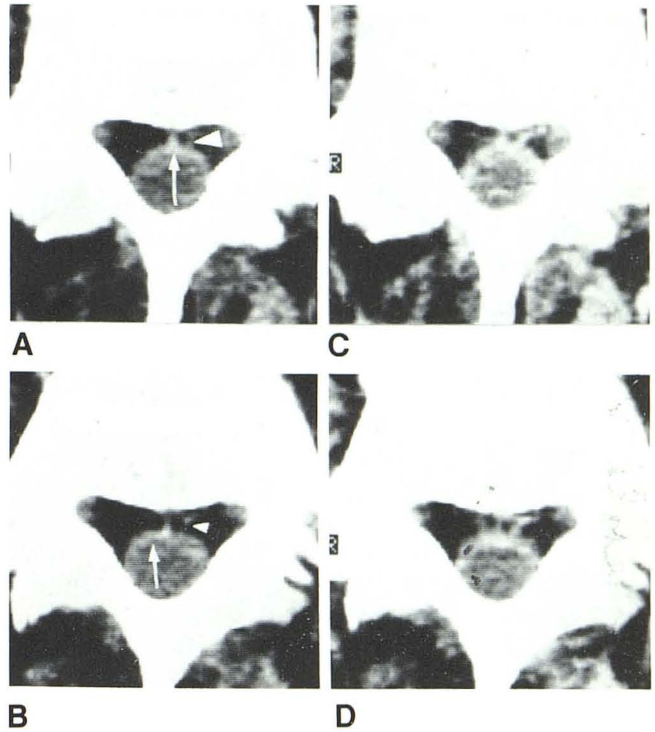


Fig. 18.—Enhancement of sac and epidural plexus vessels. **A** and **B**, Preenhancement scans of L4–L5, site of diskectomy 2 years before, show no significant epidural scar. Anterior part of thecal sac (*arrows*) appears somewhat thickened. Linear epidural plexus vessels (*arrowheads*) can also be identified. **C** and **D**, After intravenous contrast. Marked enhancement of thick-walled anterior and lateral parts of sac. Note how much thicker and more extensive enhanced scar tissue in sac becomes. Thickening of sac seems severe enough to raise question of arachnoiditis. It appears to be entirely dural thickening of thecal sac itself and not extradural scar extending around sac.

Enhancement of the Epidural Plexus Vessels

These vessels are readily enhanced during an infusion of contrast material. However, they may be incorporated into the mass of an enhancing scar and often cannot be distinguished clearly (figs. 10 and 11). In individuals who have had no surgery, epidural vessel enhancement can be used to identify the vascular nature of a soft-tissue density (fig. 23). Enhanced vessels might also help clarify an equivocal herniated disk on CT; the enhanced vessels might identify the posterior margin of an otherwise unclear disk herniation. This has already been used with some success for cervical disk herniation [15]. The marked enhancement of the aorta, the cava, and the iliac vessels was apparent on all the enhanced sections and confirmed that a large concentration of contrast material was in the circulatory system during the enhancement scans.

Laminectomy fibrosis, at or behind the site of laminectomy, enhanced with about the same intensity as extradural scars (figs. 12 and 16), and the paravertebral muscles always enhanced to a slight degree (figs. 8 and 10).

Nonenhancing Structures

The normal anulus did not enhance since it had no vascular supply. However, in a few patients, a thin rim of enhancement was seen completely outlining the circumference of the anulus (fig. 24). The reason for this uncommon finding is currently unknown.

Epidural fat and cerebrospinal fluid did not enhance. As mentioned above, when the nonenhancing fat was within or associated with a mass of enhancing scar, the CT image could simulate recurrent herniation or disk fragments.

The ligamentum flavum did not enhance or enhanced minimally under normal conditions (fig. 24). If partial ligamentum flavum resection had been done, some enhancement was possible due to fibrous tissue that had developed in and around the ligament.

The nerve roots did not enhance. Consequently, an enhancing root indicated the presence of fibrosis or scar tissue in or around the nerve sleeve (figs. 10 and 11). The thecal sac and contents ordinarily did not enhance appreciably.

Diskitis

A rare complication of disk surgery or chymopapain injection is diskitis. The infected disk becomes vascularized and swollen; if untreated, focal osteomyelitis of the adjacent vertebral bodies occurs.

In two patients with diskitis, we found that after intravenous

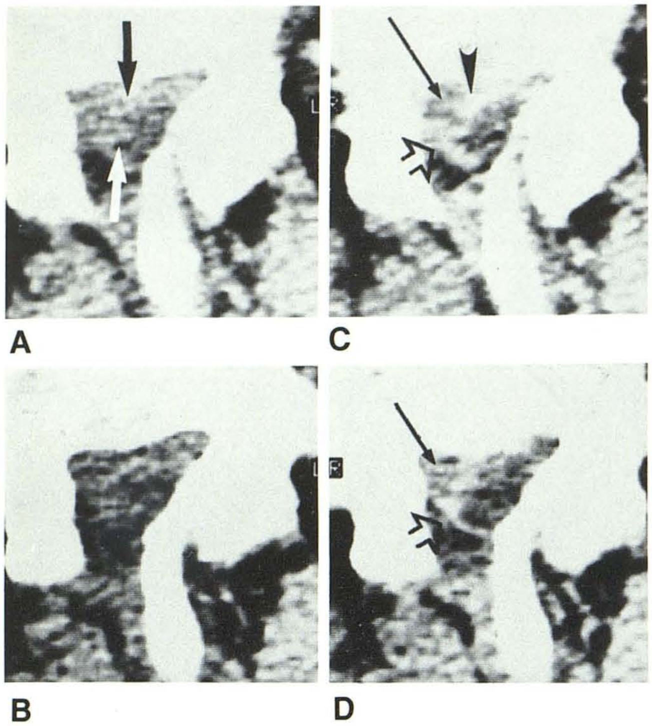


Fig. 19.—Enhancing thickened thecal sac. **A**, Before enhancement. Some extradural soft tissue is in anterior canal (*black arrow*) and on right side of thecal sac (*white arrow*), side of previous laminectomy. **B**, 4 mm caudad. Soft tissues run together and cannot be distinguished. **C** and **D**, After infusion. Anterior scar is densely enhanced (*arrowhead*). Markedly thickened enhanced band of tissue extends from anterior sac around right side of thecal sac, especially in **C** (*open arrows*). Nerve root in corner of recess is unenhanced (*solid arrows*).

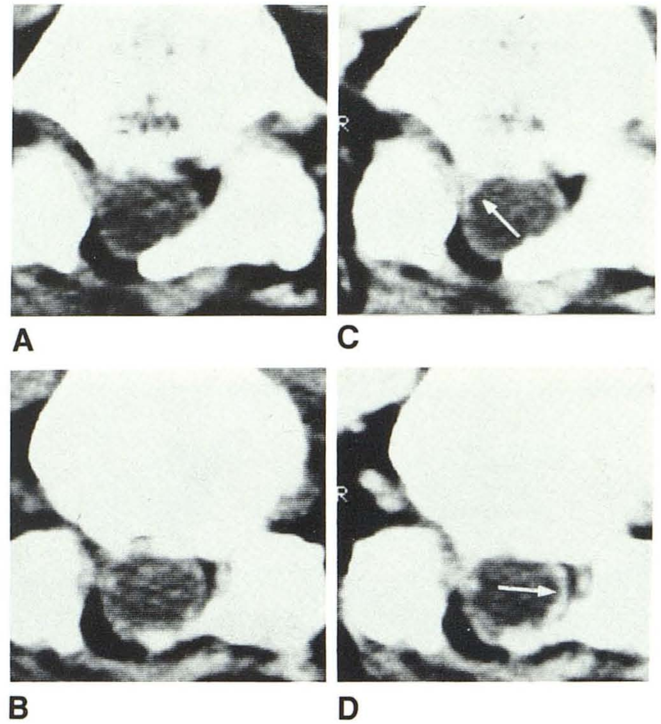


Fig. 20.—Postoperative enhancement of thecal sac; focal arachnoiditis. **A** and **B**, Before enhancement. Consecutive CT sections at L5–S1 show some increased wall density of thecal sac. Bilateral laminectomies and right diskectomy had been done 2 years before. **C** and **D**, After enhancement. Almost entire thecal sac has enhanced with focal areas of thickening (*arrows*). When thickened enhanced wall of sac has smooth and sharp outer border, it is assumed that fibrosis is within sac, indicative of arachnoiditis. If, however, focal enhanced tissue has smooth, sharp border against thecal sac it is probably fibrotic scar outside sac.

contrast, the entire disk enhanced markedly on CT sections (fig. 25). The extension of the swollen anulus into the canal simulated a herniated disk both on nonenhanced CT studies and on myelography. This limited experience suggests that intravenous enhancement CT studies might be useful for earlier recognition of diskitis than is now possible.

Discussion

The primary determinant of a dependable intravenous enhancement study is constant and rapid intravenous infusion before and during scanning. A proper infusion permits attainment and maintenance of near-maximum enhancement of the postoperative scar or fibrous tissue. Before our use of this technique, inconstant and sometimes confusing results were seen.

For optimal comparison of pre- and postenhancement sections, both parts of the study should be done on one CT run. The GE 8800 scanner permits side-by-side viewing on the CRT, and the enhancement is readily perceived without need of comparing CT Hounsfield density units.

To obtain identical pre- and postinfusion sections for comparison, there must be no patient movement, which might cause change of position. For this reason the infusion needle should be inserted at the start and not in the middle of the study. A strong admonition to the patient against any movement of the legs or hips is also important.

With experience it is not difficult to distinguish unenhanced fat or nerve root within an enhancing scar from an unenhanced recurrent herniated disk or disk fragment. Recurrent herniated disks are bordered or partly surrounded by scar tissue. Although we failed to recognize one of four recurrent herniated disks before reoperation (fig. 6), we believe the enhancement study is generally more accurate than clinical data or myelography in distinguishing between scar and recurrent herniation.

In most failed back surgery patients, the ordinary unenhanced CT scan may show unequivocal scar formation, retraction of the sac, some form of bony spinal stenosis or bony encroachment, pseudomeningocele, facet disturbances, or nothing abnormal. It is only when there appears to be an extradural mass that more or less resembles a herniated disk that contrast enhancement distinction is needed. The hypertrophic scar is apparently far more common than actual recurrent herniation; of our 45 enhancement patients, 37 appeared to have only scar. Recognition of a recurrent herniated disk without an enhancement study may be possible if serial CT studies are available after diskectomy. An increase in extradural soft tissue is considered strong evidence of recurrent herniation, since it is well known that scar tissue alone does not increase in size over time.

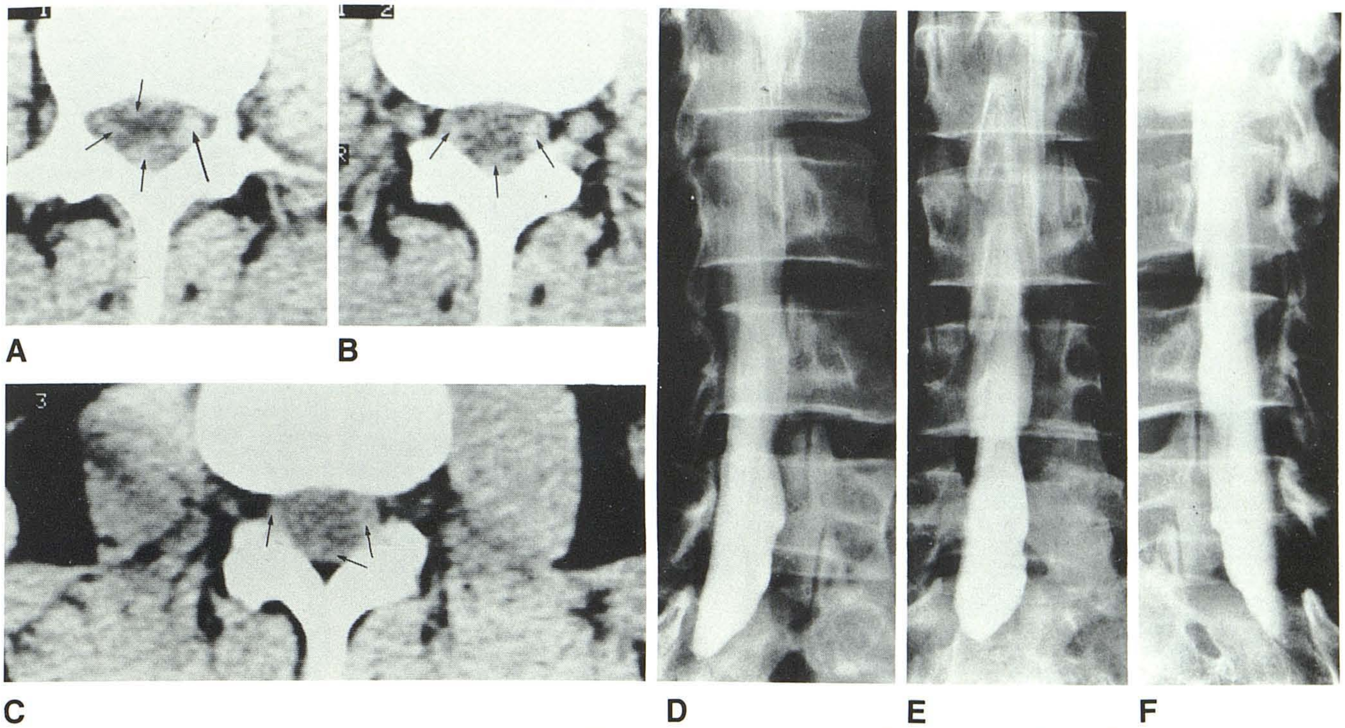


Fig. 21.—Primary arachnoiditis. Because of vague radicular signs, CT was done to rule out disk herniation in 34-year-old woman. **A–C**, Nonenhanced sections of L3–L4 show most unusual plaques of increased density within thecal sac (*arrows*), suggesting extensive dural thickening that might be consistent with chronic arachnoiditis. No disk herniation or other abnormalities were noted. **D–F**, Metrizamide myelograms show a normal-appearing sac and nerve roots above L3–L4 interspace. Below L3–L4 interspace almost no individual roots can be identified within sac, and there is no contrast filling of sleeves below L3. Sac is narrow, irregularly contoured, and even more constricted at L4–L5 interspace. Myelographic findings are consistent with arachnoiditis from L3 caudally.

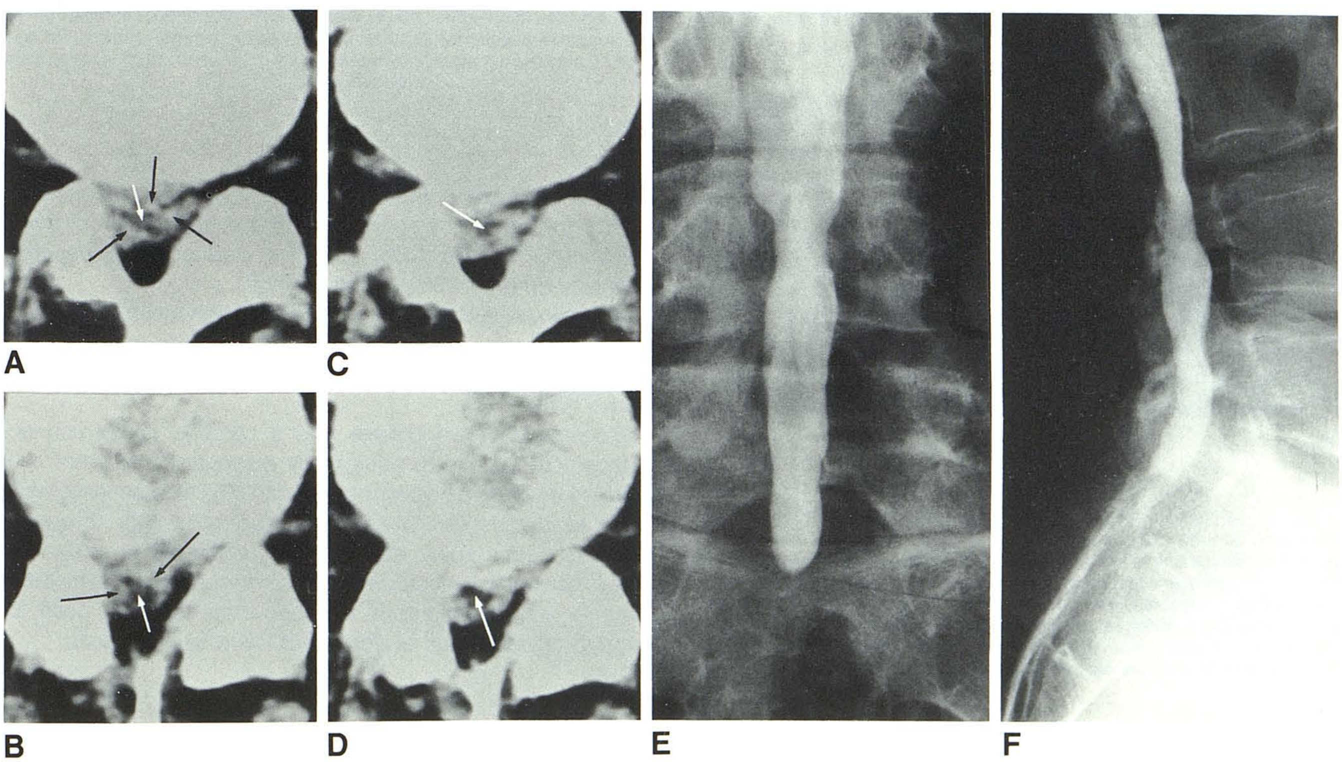


Fig. 22.—Postoperative arachnoiditis. **A** and **B**, Nonenhanced postoperative CT scans show small and somewhat irregular thecal sac (*white arrows*) surrounded almost completely by irregular thick scar tissue (*black arrows*). **C** and **D**, Enhancement sections. Scar tissue in wall of thecal sac enhances. **E** and **F**, Anteroposterior and lateral metrizamide myelograms show typical changes of postoperative arachnoiditis and scarring from L3–L4 to S1. These changes include narrowed and somewhat irregular sac with no visible emerging nerves or sleeves. Myelographic changes were limited to lower three lumbar segments.

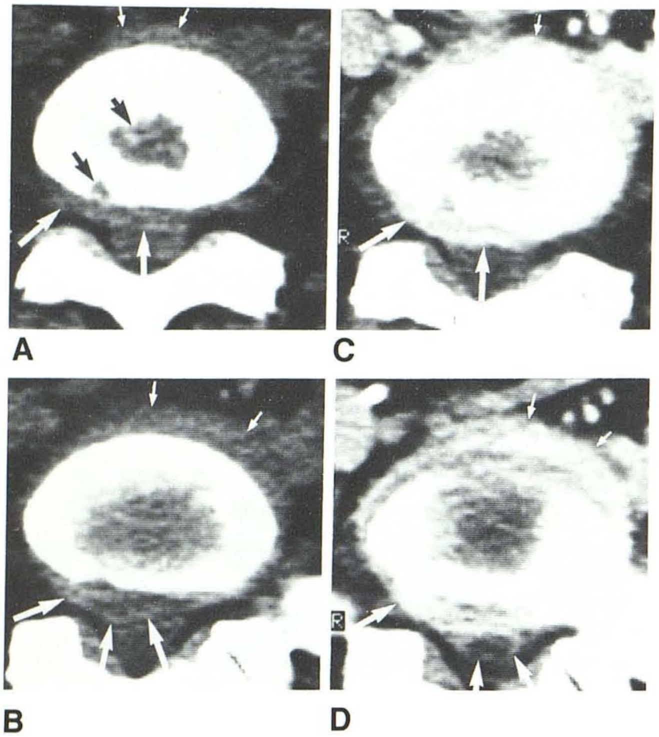


Fig. 23.—Enlarged vessel in epidural plexus. **A** and **B**, Nonenhanced sections of L4–L5. Band of soft tissue of uncertain significance is seen in **B**. Vessels of epidural plexus appear unusually prominent (*white arrows*) since narrow window was used for viewing and photographing these. **C** and **D**, After enhancement. Enhancement (*arrow*) of questionable tissue, indicating it is merely an unusually prominent vessel. Similar enhancement of other epidural vessels.

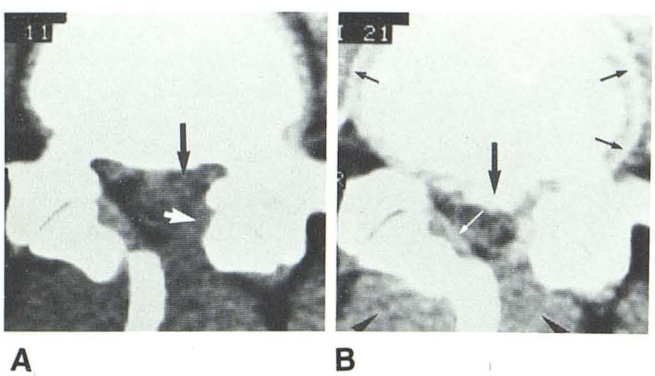


Fig. 24.—Enhancement of scar, rim of anulus, ligamentum flavum, and muscles. **A**, Unenhanced scan shows some scarring in left anterior canal (*black arrow*) and along left canal wall (*white arrow*) into laminectomy site. **B**, Enhancement shows homogeneous, densely enhanced scar (*large black arrow*), which is larger than it appeared in **A**. Also note enhanced ligamentum flavum (*white arrow*), enhanced muscles (*arrowheads*), and enhanced border of anulus (*small black arrows*). In most cases ligamentum flavum does not enhance appreciably. Enhanced border of anulus was seen in only a few patients, and its significance is uncertain.

The interesting problem of arachnoiditis is raised by the incidental enhancement of focal segments of the wall of the sac in the postoperative enhancement CT studies. The thick bands of enhancing tissue in or around the periphery of the sac possibly are related to chronic adhesive arachnoiditis. Although the latter condition can be suspected from these thick enhancing plaques, definitive diagnosis still depends primarily on the myelographic findings.

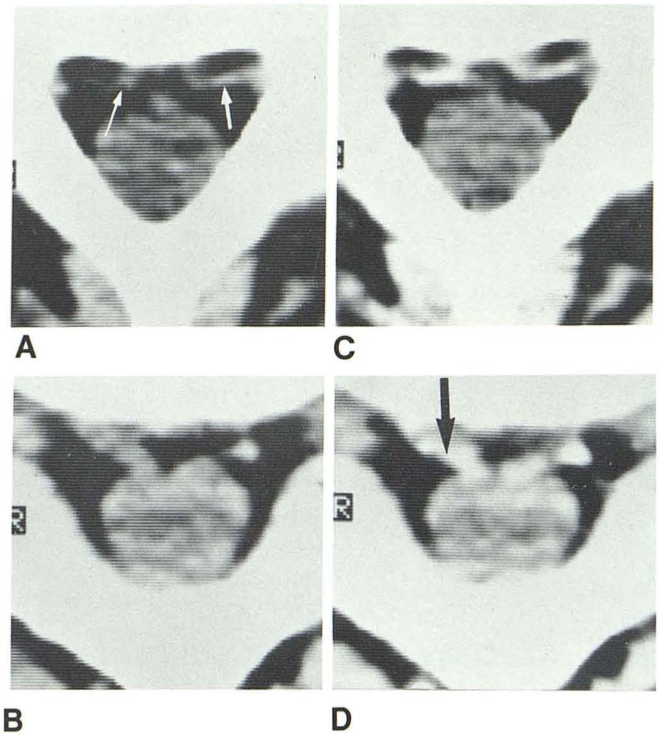


Fig. 25.—Postchymopapain pyogenic diskitis. Backache and right radiculopathy occurred a few days after chymopapain injection at L5–S1. **A** and **B**, Consecutive preenhancement slices at L5–S1. Soft-tissue mass (*large white arrows*) projecting from anulus into canal centrally and somewhat to right had been considered herniated disk on scan at another hospital. Anulus is bulging anteriorly also (*small white arrows*). **C** and **D**, After intravenous contrast. Marked enhancement of entire anulus. Part within canal impinges on anterior and right side of thecal sac. Bone window scans showed that central lucency in **A** (*black arrows*) was focal area of osteomyelitis.

An unexpected role for intravenous enhancement CT became apparent in two cases of diskitis; the inflamed disk enhanced intensely (fig. 25) in contrast to a normal intervertebral disk.

To conclude, we believe that a carefully performed enhancement CT study will usually distinguish recurrent disk herniation from a hypertrophic scar. More experience with such studies is clearly needed, since only eight of our 45 patients had surgical confirmation of the abnormality. We hope corroborative studies will be forthcoming from other centers and investigators, because there is a real need for more precision in the evaluation of failed back surgery.

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