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Percutaneous Lumbar Diskectomy Using a New Aspiration Probe

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The introduction of chymopapain and chemonucleolysis raised hopes that a relatively noninvasive treatment for herniated lumbar disk had been developed. However, injection of chymopapain into the lumbar nucleus pulposus is not an innocuous procedure. Hypersensitivity to the drug is a major problem; the current anaphylaxis rate is estimated to be about 1% and even higher among women patients [1]. Recent reports of transverse myelitis and subsequent paraplegia associated with chymopapain injection have raised serious questions about its use in young and otherwise healthy persons.

Percutaneous lumbar diskectomy has been offered as a relatively noninvasive means of disk decompression involving removal of the disk by mechanical rather than enzymatic action. Previous attempts at percutaneous diskectomy, although yielding preliminary results comparable to those of chymopapain, have required insertion of relatively large cannulas (≥ 6 mm diam) into the disk space, which has raised concern about possible nerve injury on introduction of the cannula [2–4]. In addition, the disk material had to be removed with a modified pituitary forceps, which was tedious and time-consuming. For these reasons, acceptance of the procedure has been slow.

We report a percutaneous diskectomy using a new automated disk-aspiration probe. The probe's small size (2 mm diam) minimizes the risk of nerve root injury while its automated action allows rapid removal of disk material.

Technique

The patient is placed in the right lateral decutibus position. Using fluoroscopy, a lateral view of the patient's spine is obtained and the L4–L5 disk interspace identified. An entry point for the probe is selected on the skin about 10 cm from the midline as identified by the spinous processes. The patient is then prepped, draped, and given local anesthesia. A 25-cm-long, 18-gauge hubless stainless steel sheath with a central trocar is aimed obliquely toward the posterior margin of the intervertebral disk as seen on the lateral view. The patient is monitored continously. If he experiences radicular pain, the sheath is redirected. When the sheath is correctly positioned against the disk in the lateral view, its position is confirmed in the anteroposterior view. The trocar is then removed, and a 2.5-mm cannula with an inner blunt-ended sleeve is placed over the hubless sheath. This cannula and sleeve are advanced to the disk while the patient is again monitored for radicular pain. When the cannula appears to be in the correct position, the sleeve and 18-gauge hubless sheath are removed, leaving the 2.5-mm cannula against the anulus of the disk. A 22-gauge needle is then inserted into the center of the disk through the large cannula to confirm that the trajectory of the cannula will bring the final instrument into the center of the disk. The needle is removed, and a hole is cut into the anulus with a 2-mm circular saw placed through the 2.5-mm cannula. This step is performed with the fluoroscopic beam directly perpendicular to the path of the cannula to ensure that the cannula abuts the anulus and that the saw will not be advanced beyond the confines of the disk. After the hole has been cut in the anulus, the aspiration probe is placed into the disk space.

The Nucleotome probe (patent pending; developed in conjunction with Medical Instrument Development Labs., San Leandro, CA) has a 8-inch (20.3-cm), 2-mm-diameter needle attached to it (fig. 1). The needle has a rounded, closed end with a single side port near its distal end (fig. 2). The aspiration probe works as follows: A cannula with its distal end sharpened to a surgical blade is fitted through the center of the outer needle. Suction is applied through the inner cannula, aspirating the nucleus pulposus into the port of the needle. The sharpened end of the inner cannula is then pneumatically driven across the port, thus cutting off the disk material. This material, suspended in saline that has reached the port by flowing distad between the inner cannula and the walls of the outer needle, is then aspirated through the inner cannula to a

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collection bottle. The cutting instrument operates at up to 300 cycles/min, enabling rapid aspiration of large amounts of material.

When its position within the disk space has been confirmed, the probe is activated and gently moved back and forth within the disk space while suction is taking place. The aspiration line is monitored, and when no further material can be aspirated, the probe is rotated to change the orientation of its port before continuing. During the aspiration process, firm pressure is maintained on the cannula to ensure that it remains within the disk space. When the flow of nuclear material decreases in the aspiration line, the probe is removed and a 50-ml syringe is connected to the cannula; suction is applied. The probe may then be placed into the disk space again and more material aspirated.

Case Report

A 33-year-old man had a 1-year history of low back pain with left-leg sciatica and paresthesias in the L5–S1 distribution. Straight leg raising confirmed nerve compression on the left. Computed tomography (CT) demonstrated moderate central disk protrusion at the L4–L5 level with some posterior displacement of the left L5 nerve root (fig. 3A). After 6 weeks of unsuccessful conservative therapy, he became a candidate for chemonucleolysis. Instead, with the permission of the human experimentation committee, he agreed to undergo

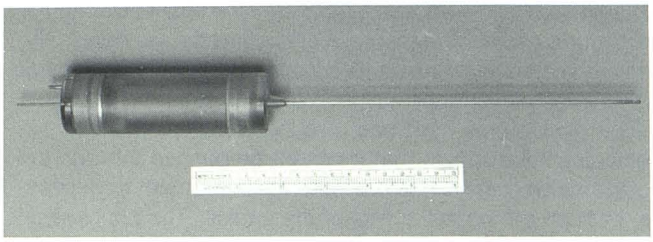

Fig. 1.—Nucleotome aspiration probe. Attached needle is 8 inches (20.3 cm) long and 2 mm in diameter. It has a rounded, closed end with a single side port near its distal end, which is inserted into intervertebral disk space.

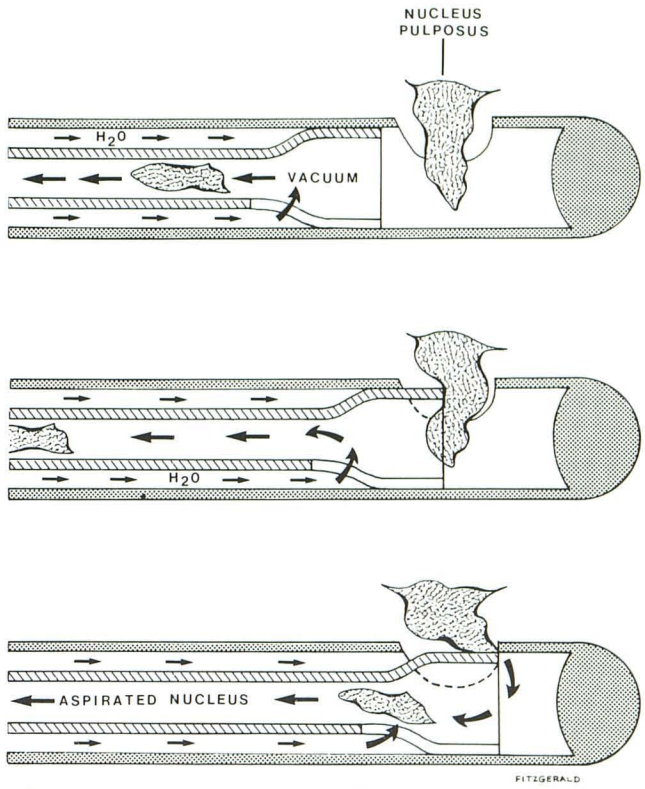

Fig. 2.—Nucleotome aspiration probe. Diagram of distal end of needle in longitudinal section. Cutting sleeve within needle slices off any material sucked into port. Water for irrigation flows around cutting sleeve and is aspirated with disk material into center of hollow sleeve.

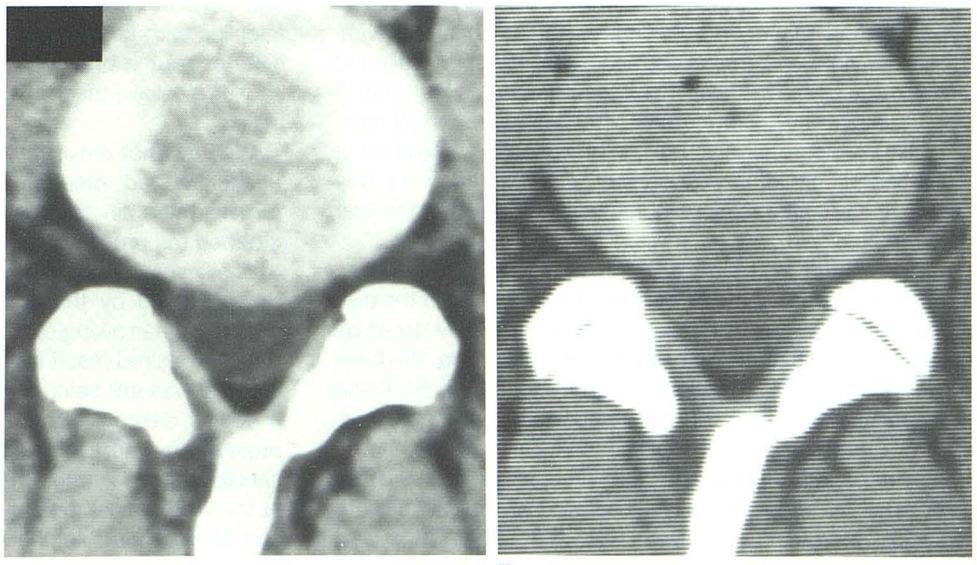

Fig. 3.—**A**, Preprocedure CT scan at L4–L5 level. Focal disk protrusion with impression on thecal sac and left L5 nerve root. **B**, Same level after percutaneous diskectomy. No disk protrusion is seen.

a percutaneous lumbar diskectomy at the L4–L5 level using the new aspiration probe.

During the procedure, he reported discomfort from lying on this side; the operation therefore was terminated while disk material was still obtainable. The probe was turned off, and the probe and cannula were removed simultaneously. Immediately after the procedure, he reported complete resolution of his sciatica with only minimal discomfort at the site where the probe had been introduced. A CT scan obtained at this time (fig. 3B) was interpreted as normal with complete resolution of the previously noted disk protrusion. The patient was discharged 5 hr after the procedure at his request. He remains symptom-free 1 month later.

Discussion

The intervertebral disk can be considered an osmotic system. Because of the breakdown of macromolecules during the fourth and fifth decades of life, the number of particles in the intervertebral disk increases and causes a concomitant rise in osmotic pressure; this in turn causes a fluid influx into the disk and raises the intradiscal pressure. Fissures develop in the anulus because of the biomechanical forces placed on it [5]. In this setting the intervertebral disk may decompress through the anulus and compress nerve roots and the thecal sac. The usual treatment is bed rest, which is intended to decrease the mechanical forces that were causing an increase in disk pressure. When conservative therapy fails, surgery may be recommended.

The current surgical approach aims at total disk removal through a partial hemilaminectomy, entailing all the risks associated with major surgery and general anesthesia. The complication rate for lumbar diskectomy has been reported as 2%–14% [6]. Chemonucleolysis is a less invasive method of treatment: In this procedure, the intradiscal pressure is decreased by percutaneous instillation of chymopapain into the intervertebral disk to dissolve it. Although its efficacy in treating herniated disk was at first questioned, subsequent studies have shown it to be highly effective [7]; however, safety problems associated with the use of chymopapain make an alternative method of disk decompression attractive.

Our method effects disk decompression mechanically without instillation of enzymes into the disk. Suction is applied to the disk during the removal process, creating a space that is then filled by more disk material. In the case reported here, the dramatic postoperative CT findings showing resolution of the patient's herniation support our belief that we were able to pull the herniated nucleus pulposus back through the tear in the anulus.

Although our procedure does not pose the life-threatening risk of anaphylaxis, the introduction of a cannula into the disk space raises the possibility that a peripheral nerve could be injured at the point where it exits the neuroforamina. We have instituted a number of precautions to minimize the likelihood of this occurring: First (and most important), the entire procedure is performed under local anesthesia. Therefore, if the patient experiences radicular pain at any point during the introduction of the cannula, its position can be modified to avoid the exiting nerve. In addition, we use a small (18-gauge) needle to find the correct path to the disk space; even if this needle were to strike a peripheral nerve, the probability of a permanent injury would be extremely small. This has been borne out by the few injuries that have occurred during the instillation of chymopapain, which also is done with an 18-gauge needle. Moreover, we lead the 2.5 mm cannula to the disk space with a blunt-ended trocar, which tends to push structures aside rather than slicing through tissue. Finally, we have minimized the size of the outer cannula to 2.5 mm. This is one-third the size of the cannula used by Sadahisa et al. [2] and Kambin and Gellman [3] in their combined series of over 130 percutaneous diskectomies performed by hand, in which—following the precautions we have outlined—they have not experienced a nerve injury. The reduced size of our system should make the likelihood of this type of injury even more remote.

Great care has been taken in the design of both the procedure and the instrument to ensure that the device cannot leave the safe confines of the disk space. When the cannula is in the disk space, the instrument is essentially isolated from any of the structures surrounding the spine (e.g., the nerves and blood vessels). The procedure is not begun until radiologic confirmation is obtained that the cannula and instrument are correctly positioned within the disk space. We now use a special sleeve that is bolted to the cannula at skin level; this acts as a marker to indicate if the cannula has been withdrawn from the disk space. During the procedure, constant pressure is applied to the cannula in the direction of the disk space to ensure that the cannula is not withdrawn inadvertently.

The Nucleotome itself has a round blunt tip. Cadaver experiments have shown that it cannot be pushed through the anulus inadvertently. This prevents the instrument from passing through the opposite wall of the anulus. The principle on which the device operates prevents aspiration of any material too large to be sucked into its small side port. The firm structure of the anulus prevents it from being deformed into the port of the Nucleotome or cut by the device. This has been confirmed by experiments using cadaveric specimens and porcine disk specimens [8]. Finally, the instrument is supplied with positive control via a foot pedal so that immediate cessation of its activity can be accomplished if necessary. We believe the procedure will prove safe in future clinical trials.

We have not arrived at a standard end point for the operation. We had intended to continue disk removal until no further material could be aspirated; however, when we stopped the procedure (because of the patient's discomfort), a significant amount of material had already been removed, as evidenced by the amount of material in the aspiration bottle, the narrowing of the patient's disk space, and the fact that the desired result had been achieved. Nevertheless, disk material was still being aspirated without signs of abatement. It seems desirable from a biomechanical standpoint not to remove any more disk than necessary. Further experience should indicate whether resolution of the patient's symptoms at the time of operation and CT-scan resolution of the herniation are reproducible phenomena that can be used as indicators for termination of the operation.

In selecting patients for this procedure, we recommend use of the criteria outlined by McCulloch [9] for the selection of patients for chymopapain injection. We intend to treat with percutaneous diskectomy only patients whose predominant symptom is sciatica and who have physical findings and a CT scan consistent with a herniated disk. We will exclude any patients who have had previous surgery or chymopapain injection or who are receiving workmen's compensation. Even with these strict criteria, we expect there will be treatment failures in patients who have a free extruded fragment and will require traditional surgery.

At present the procedure is limited to the L4–L5 level because the iliac crest limits access to the L5–S1 interspace. This fact was particularly true with the large cannulas used previously. Our instrument, however, has the capability of being bent to a 90° angle while still operating effectively. This should allow use of curved cannulas to approach the L5–S1 level. We conclude that percutaneous lumbar diskectomy is a viable alternative to chymopapain injection and/or surgery in the treatment of selected cases of herniated lumbar disk.

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