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Automated percutaneous lumbar discectomy

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Abstract. Lumbar spine disc disease has traditionally been treated surgically by laminectomy and manual removal of the offending disc material. Chymopapain was extensively used to decompress the disc pressure in a relatively noninvasive manner, but has been abandoned due to serious complications, including anaphylaxis and paraplegia. Onik introduced automated percutaneous discectomy in 1985. This procedure has proved safe and efficacious for treating lumbar disc disease without complications. It is performed on an out-patient basis under local anesthesia with minimal rehabilitation time. The success rate reported in a multi-institutional study with one year follow-up is approximately 75%. The majority of failures occur in patients with free fragments or spinal stenosis – both of which can be diagnosed preoperatively with good imaging examinations. Hence, the success rate can be expected to improve if preoperative imaging is relied upon to help choose appropriate patients. Over 30,000 percutaneous discectomy procedures have been performed. The only complication reported, disc infection, developed in fewer than 0.2% of cases. Automated percutaneous discectomy has the potential to treat a vast number of patients with lumbar disc disease who otherwise would have laminectomies.

Key words: Lumbar disc disease – Percutaneous discectomy – Lumbar spine

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Chymopapain raised hopes among patients and physicians that a relatively noninvasive treatment for herniated lumbar discs had been found. The associated complications – anaphylaxis, subarachnoid hemorrhage, infection, and transverse myelitis with associated paraplegia – have curtailed use of this procedure. The traditional treatment for herniated lumbar discs – surgical disc removal through a laminectomy – does benefit most patients but still poses the risk of injury to soft tissues, joints, and neural structures. Additionally, the rehabilitation period following surgery can be prolonged. Percutaneous lumbar discectomy by mechanical decompression of the disc has the beneficial effects of chymopapain use without its associated complications. In contrast to the laminectomy, there is no need for general anesthesia, no problem with epidural fibrosis, and no prolonged postsurgical rehabilitation period.

History

In 1975, Hijikata presented a technique for percutaneous nuclectomy of herniated lumbar discs [7]. In 1978, he reported good-to-excellent results in 80 patients undergoing nuclectomy through a posterolateral percutaneous approach [8]. This approach involved inserting a cannula against the anulus, making a hole in it, and then removing the disc material with long, grasping forceps. Hijikata subsequently reported his experience with this technique in 100 patients with the same positive results [5]. In 1983 Kambin and Gellman, using a similar approach, reported their results in 9 patients who were all relieved of leg pain with no reported complications [10]. In 1979 Suezawa and Jacob in Switzerland carried out percutaneous nuclectomies by means of forceps introduced into the

disc space through a long cannula similar to that used by Hijikata in Japan [22]. Between 1979 and 1985, 49 patients underwent this procedure with 70% success. Again no complications were reported. In 1981, Jacobson developed a percutaneous discectomy technique. Using a straight lateral approach, he inserted a 40 French chest tube against the lateral anulus. After incising the anulus with a number 15 blade, he used forceps to grasp and remove the nucleus pulposus. Jacobson obtained good-to-excellent results in more than 30 patients; however, neural complications have limited the use of this technique. In 1983, Friedman, using Jacobson's technique, confirmed that good results were possible but emphasized the potential risk of bowel perforation, interruption of the sympathetic chain, and vascular injury [4]. He subsequently abandoned the procedure.

In all of the previous techniques disc decompression was effected percutaneously by removing the disc material by hand with grasping forceps. Consequently, the procedures have been time-consuming, and the cannulas needed to gain access to the disc space have been large, increasing the potential for nerve injury and disc space infection. Recent papers reporting the results of the various manual techniques have confirmed that these potential problems do occur with a frequency that the authors feel is too high for a percutaneous procedure [6, 9, 11, 14, 20, 21].

In 1985 Onik described automated percutaneous discectomy, in which a reciprocating suction cutter, making up to 200 cuts per minute, separates pieces of disc material [15, 16]. This cutter allows a procedure to be completed in a reasonable time and makes possible the use of a smaller cannula (2.8 mm), thereby reducing the possibility of nerve injury. In addition, since the instrument is placed within the disc only once, the risk of a disc space infection is low.

In 1987 Onik et al. reported their results with 36 patients [17]. The procedure was successful in 31 patients, and there were no complications. This series was part of a multi-institutional study that has now been completed [19]. It reports a series of 506 discectomies performed by 18 different surgeons all over the world. The success rate for patients who met the protocol criteria ($N=327$) was 75.2%, while the success rate for those who did not meet the protocol criteria ($N=168$) was only 49.4% (11 cases were lost to follow-up). These patients have been followed for a year or more. These results have been confirmed by a separate multi-institutional study in Europe that reported a 72% success rate in over 600 patients [1].

The patient selection protocol has now been broadened considerably, and over 2500 physicians have already been trained to perform this procedure. Over 30000 patients have now undergone the procedure with no reported complications other than a 0.2% rate of disc infection. Davis has reported a 78% success rate in 200 consecutive cases [3]. The majority of failures were due to free fragments and spinal stenosis, suggesting that good preoperative imaging and diagnosis might yield an even higher success rate.

Patient selection

The success rate of this procedure depends largely on proper patient selection. To participate in the initial multi-institutional protocol, a patient had to have sciatica confined to one leg (with leg pain greater than back pain) as the major complaint. Patients had to satisfy at least half of these criteria as well: (a) a history of paresthetic discomfort in the specific dermatomal distribution, (b) positive findings on a straight leg raising test, (c) cross-over pain or positive bow string sign, and (d) the presence of two of four possible neurologic findings (wasting, weakness, sensory alteration, and reflex alteration). In addition, computed tomographic (CT) scans or magnetic resonance (MR) images of all patients had to show a herniated nucleus pulposus in an area consistent with the specific findings. Myelography was not necessary. Patients were required to undergo at least 6 weeks of conservative therapy without success and must otherwise have been candidates for laminectomy.

Patients were excluded from the multi-institutional study if they had a history of previous lumbar surgery, previous chymopapain injections, or a workmen's compensation claim. Patients were also excluded for any other cause of back pain revealed on the CT or MRI study: severe degenerative facet disease, lateral recess stenosis, evidence of a free fragment, or other evidence of spinal stenosis.

Since the initial multi-institutional study protocol has been broadened to include other operators, the patient selection protocol has naturally been broadened. Patients originally ineligible because of mild spinal stenosis, multilevel discs, workmen's compensation claims, and prior surgery have now undergone the procedure with varying results. In general, the results in patients who do not satisfy the criteria of the original protocol have been less satisfactory, as one might expect.

We feel strongly that patients with free fragments, marked central canal stenosis, and extreme-

ly large disc protrusions should not undergo this procedure. Several of the earlier failures were secondary to the presence of free fragments that in retrospect should have been appreciated on the initial CT scan. High quality CT or MRI will aid patient selection considerably and help keep the success rate high [13].

Technique

The procedure can be performed in the radiology department or in the operating room under C-arm fluoroscopic control. Strict sterile technique is necessary. With the patient in the lateral decubitus position an entry point is chosen approximately 8 to 12 cm from the midline at the level of the herniated disc. A local anesthetic is applied to the skin at the entry point. Using a posterolateral approach identical to that used for the injection of chymopapain or for a discogram the physician places an 18 gauge needle with a removable hub into the center of the disc, traversing the lower back musculature and avoiding other retroperitoneal structures (Figs. 1 and 2). During needle placement, the patient is monitored for signs of radicular pain. If the patient experiences such pain, the needle shoud be withdrawn its full length and then redirected. The procedure is done while the patient is fully awake to avoid neural damage.

After the needle has been advanced into the center of the disc, it is imperative to obtain two right-angle views on the fluoroscope to confirm the positioning. When correct placement of the needle in the center of the disc has been confirmed, the hub on the needle is removed. Then a 2.8 mm cannula with an inner, tapered dilator is passed over the hubless needle. When the cannula reaches the anulus, its position is again confirmed radiographically in two views. The tapered dilator is removed, and the outer cannula is left in place with the needle still in the center of the disc. A circular saw or trephine is placed over the needle and through the cannula. The anulus is then incised. The trephine and the needle are removed and the cannula is left in place. Next, the nucleotome is inserted through the cannula into the disc. A depth stop around the outer cannula is brought down to the skin to mark the correct level, and the position of the nucleotome in the center of the disc is confirmed on two right-angle fluoroscopic views (Fig. 3).

The nucleotome is then activated, and nuclear material is drawn into the side port of the nucleotome by suction. An inner cutting tube slides over the port up to 200 times per minute. This inner tube cuts off bits of nuclear material, which are drawn into the port (Fig. 4). The small pieces of disc material are aspirated through the center of the tube into a collection bottle. Irrigation with saline is continuously applied to prevent disc material from clogging the tubing. The suction, irrigation, and rate of cutting are controlled by a specially designed console (Fig. 5). Aspiration of disc material continues for 10 to 40 min (the average being about 15 min), after which the nucleotome is removed and the puncture site is covered with a bandage.

Many patients report immediate or near immediate relief of sciatica with some continuing low back pain for several days. Postprocedure pain is uncommon but can occur. It is generally unnecessary to admit the patient for overnight observation. The initial patient trials were performed with

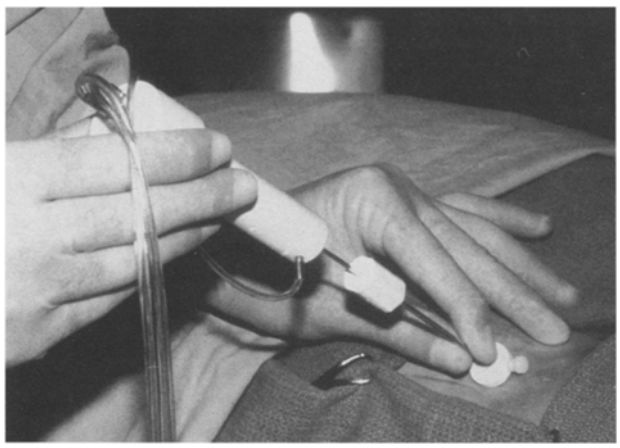

Fig. 1. Nucleotome placement in a patient. A posterolateral percutaneous approach has been used for entry. Note the depth stop at the skin level to prevent inadvertent advancement of the cannula

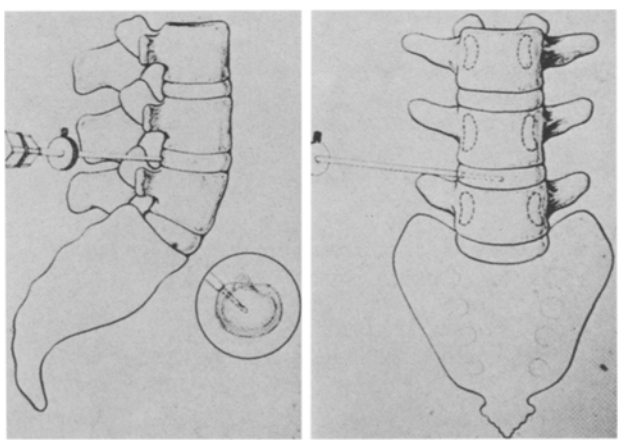

Fig. 2. An artist's drawing of the nucleotome centered in a disc

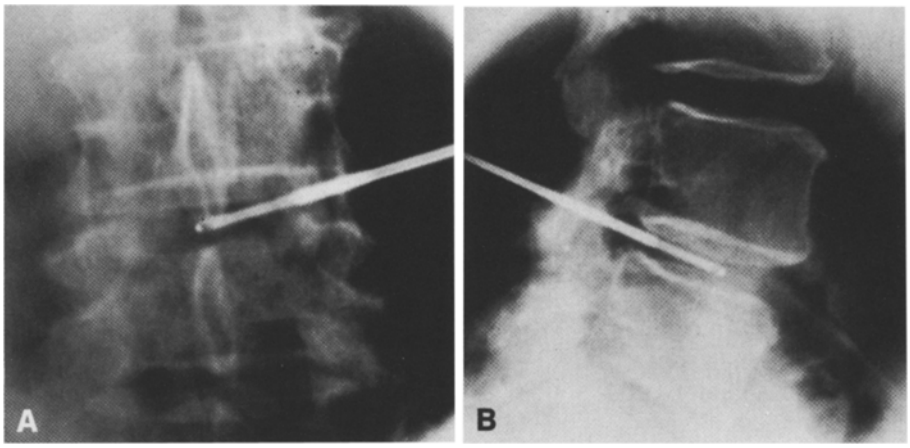

Fig. 3. An anteroposterior (**A**) and lateral (**B**) spot film obtained during a procedure showing the tip of the nucleotome centered in the L4–L5 disc

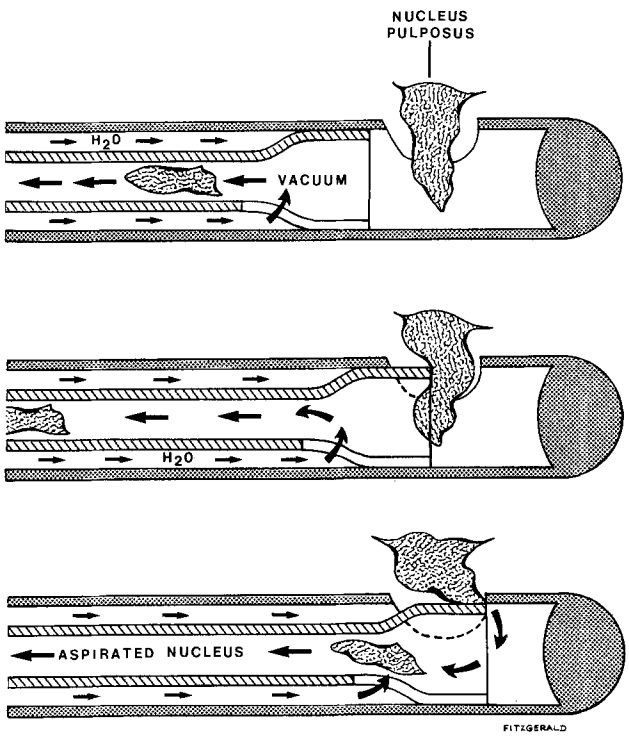

Fig. 4. An artist's drawing of the tip of the nucleotome showing how disc material is aspirated into the side port, cut off by the inner cutting sleeve, and irrigated up the center of the instrument

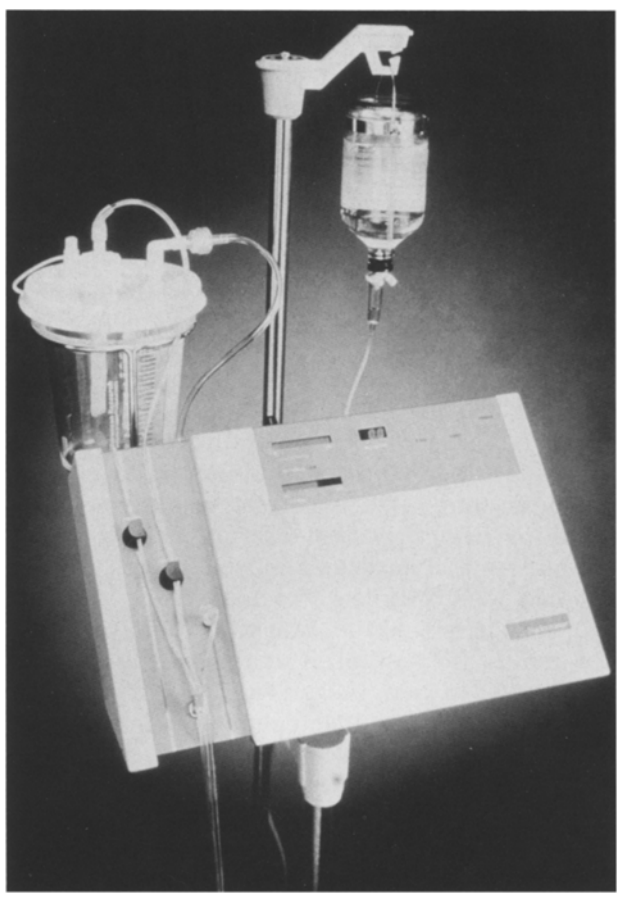

Fig. 5. The console (Surgical Dynamics, San Leandro, CA) controls the rate of cutting, amount of aspiration, and irrigation. The disc material is aspirated through the nucleotome into the collection bottle on the left

disc protrusions at the L4–L5 level; however, the development of a curved cannula allows fairly easy access to the L5–S1 level with excellent results [18]. Some workers have reported multiple level disc aspirations in selected cases [2].

Conclusion

Automated percutaneous lumbar discectomy has now been performed in over 30000 patients with a success rate of approximately 75%. This outpatient procedure is performed with the patient under local anesthesia in a radiology suite or an operating room equipped with C-arm fluoroscopy. To date no complications have been reported; however, the

nucleotome will indiscriminately cut any structure in its path, such as the aorta, nerve roots, and muscle. Close radiographic monitoring is therefore necessary to ensure placement of the nucleotome in the center of the disc. Infection and nerve root damage are potential complications. Nerve root damage from placement of the instrument can be averted by having the patient report radicular pain and then repositioning the needle. Infection can be avoided by strict adherence to sterile technique. This procedure should totally replace chymopapain injection and has the potential for replacing many surgical laminectomy procedures [12], thereby decreasing hospital costs, patient morbidity, and postsurgical rehabilitation time.

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