

Percutaneous endoscopic discectomy: surgical technique and preliminary results compared to microsurgical discectomy

H. MICHAEL MAYER, M.D., AND MARIO BROCK, M.D.

Department of Neurosurgery, Universitätsklinikum Steglitz, Freie Universität Berlin, Berlin, Germany

✓ Percutaneous endoscopic discectomy is a new technique for removing "contained" lumbar disc herniations (those in which the outer border of the annulus fibrosus is intact) and small "noncontained" lumbar disc herniations (those at the level of the disc space and occupying less than one-third of the sagittal diameter of the spinal canal) through a posterolateral approach with the aid of specially developed instruments. The technique combines rigid straight, angled, and flexible forceps with automated high-power suction shaver and cutter systems. Access can thus be gained to the dorsal parts of the intervertebral space where the disc herniation is located. Percutaneous endoscopic discectomy is monitored using an endoscope angled to 70° coupled with a television and video unit and is performed with the patient under local anesthesia and an anesthesiologist available if needed. Its indication is restricted to discogenic root compression with a minor neurological deficit.

Two groups of patients with contained or small noncontained disc herniations were treated by either percutaneous endoscopic discectomy (20 cases) or microdiscectomy (20 cases). Both groups were investigated in a prospective randomized study in order to compare the efficacy of the two methods. The disc herniations were located at L2-3 (one patient), L3-4 (two patients), or L4-5 (37 patients). There were no significant differences between the two groups concerning age and sex distribution, preoperative evolution of complaints, prior conservative therapy, patient's occupation, preoperative disability, and clinical symptomatology. Two years after percutaneous endoscopic discectomy, sciatica had disappeared in 80% (16 of 20 patients), low-back pain in 47% (nine of 19 patients), sensory deficits in 92.3% (12 of 13 patients), and motor deficits in the one patient affected. Two years after microdiscectomy, sciatica had disappeared in 65% (13 of 20 patients), low-back pain in 25% (five of 20 patients), sensory deficits in 68.8% (11 of 16 patients), and motor deficits in all patients so affected. Only 72.2% of the patients in the microdiscectomy group had returned to their previous occupation versus 95% in the percutaneous endoscopic discectomy group. Percutaneous endoscopic discectomy appears to offer an alternative to microdiscectomy for patients with "contained" and small subligamentous lumbar disc herniations.

KEY WORDS • percutaneous discectomy • lumbar disc herniation • endoscopy • microdiscectomy

SINCE its first description by Dandy⁶ in 1929, the removal of a herniated lumbar disc ("disc surgery") has evolved considerably with advances in indication criteria, surgical technique, and instrumentation. The surgical treatment of lumbar disc herniations constitutes a substantial proportion of spine operations and has been improved by the development of less invasive techniques.^{3,11,22,67-70} However, reducing lumbar disc surgery to a mere "nerve root decompression procedure" falls short of the standards set by modern surgical philosophy, since failure not only arises from persisting or recurring neurological symptoms but also from anatomical and biomechanical disturbances caused by the surgical approach itself.^{2,15,23,34,60}

In 1975, Hijikata, *et al.*,²⁶ proposed a method for the removal of disc material through a percutaneous posterolateral approach. The method was termed "percutaneous nucleotomy." More recently, procedures covered by the term "percutaneous discectomy" have been introduced into the clinical armamentarium with varying degrees of success.^{19,25,27,29,30,32,33,39,40,51,54-56,58,59} The common goal is removal of nucleus pulposus through a posterolateral approach; however, uncertainty remains about the indications for these percutaneous procedures.^{5,14,29,65}

This paper describes the pathophysiological rationale, the surgical technique, and the indication criteria for percutaneous endoscopic discectomy, a technique that

Percutaneous endoscopic discectomy

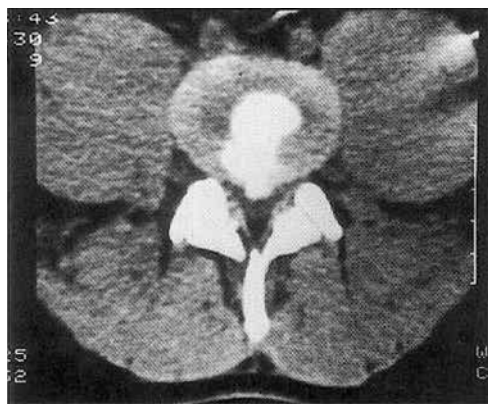


FIG. 1. Postdiscography computerized tomography scan showing a typical "contained" disc herniation located in the midline at L4-5.

has been routinely applied in our department since 1987. The results of a prospective randomized study on two series of patients with comparable indication criteria treated at our institution by either percutaneous endoscopic discectomy or microdiscectomy are also presented.

Clinical Material and Methods

Patient Selection

Between April 8 and December 11, 1987, 40 patients with proven lumbar disc herniations were randomly assigned to one of two groups of 20 patients each and treated either by percutaneous endoscopic discectomy or by microdiscectomy using a standardized technique.³ All patients included in the study had clinical symptoms due to discogenic lumbar nerve root compression. All had radicular symptoms such as a positive straight-leg raising test, sciatica, sensory disturbances, mild motor weakness (Grade III/IV),⁵⁷ and/or reflex differences. Conservative therapy had been unsuccessful in all patients. The morphology of disc herniation causing the clinical symptoms was termed "contained" when the outer border of the anulus fibrosus was still intact. The extrusion of nucleus pulposus under the posterior longitudinal ligament but still at the level of the disc space and occupying not more than one-third of the sagittal diameter of the spinal canal was termed small "non-contained" disc herniation. Only patients with these types of disc pathology were entered into the study. The following imaging techniques were used to classify morphology of disc herniation: magnetic resonance (MR) imaging, spinal computerized tomography (CT), discography, postdiscography CT, and myelography.^{1,4,20,21,24} At least three of these imaging techniques were performed for each patient. The loss of integrity of the anulus fibrosus could best be demonstrated by postdiscography CT⁵³ (Fig. 1).

Patients with severe motor deficits, conus or cauda equina syndrome, or rapidly progressing neurological symptoms were excluded from the study, as were all patients with signs of segmental instability or previous

TABLE 1
Preoperative data in 40 patients treated for lumbar disc herniation

Parameter	Procedure	
	Percutaneous Endoscopic Discectomy	Microdiscectomy
no. of cases	20	20
sex (M:F)	12:8	14:6
age (yrs)*	39.8 ± 10.4	42.7 ± 10
male	41 ± 7.7	43.2 ± 11.7
female	37.9 ± 13.9	41.5 ± 4.9
range	12-55	19-63
mean symptom duration (mos)	6.9	7.3
Mean disability duration (wks)	10.4	10.4

* Mean values are expressed ± standard deviation.

surgery at the same site, pregnant women, and all patients with psychogenic aggravation and/or worker's compensation claims. Patients with large "non-contained" disc herniations extending cranially or caudally to the level of the disc space were excluded, as were patients with any form of sequestered disc, spinal stenosis, or spondylolisthesis. Patients with associated malformations, tumors, or posttraumatic root compression were also excluded.

Case Material

Percutaneous Endoscopic Discectomy. This group consisted of 20 patients (12 male and eight female) ranging in age from 12 to 55 years, with an average of 39.8 years (mean age 41 years for males and 37.9 years for females) (Table 1). Preoperative symptoms had lasted from 14 days to more than 12 months, averaging 6.9 months. The mean duration of preoperative disability was 10.4 weeks, most patients having been unable to work for 1 to 3 months.

Nineteen of the 20 patients complained of low-back pain, constant in 18 and stress-dependent in one. All patients had irritation of one or two lumbar nerve roots. Radicular pain was constant in 19 patients, while one had sciatica only during the straight-leg raising test; this test was positive in all cases. Pain corresponded to the L-5 nerve root in 15 patients and to the L-2, L-3, L-4, or S-1 nerve root in seven patients. Two patients had bilateral sciatica. A total of 13 patients had preoperative sensory disturbances: hypesthesia was present in seven and paresthesia or dysesthesia in six. The affected segment was L-5 in nine cases, S-1 in one case, and L-5 and S-1 in three cases. Only one patient presented with paresis (Grade IV) of the extensor hallucis longus muscle (L-5). Ten patients had weakened reflexes in the affected leg.

Microdiscectomy. The 20 patients treated with microdiscectomy consisted of 14 male and six female patients. The mean age was 42.7 years (43.2 years for males and 41.5 years for females) with a range from 19 to 63 years (Table 1). Symptoms had lasted an average of 7.3 months, ranging from 2 weeks to more than 1

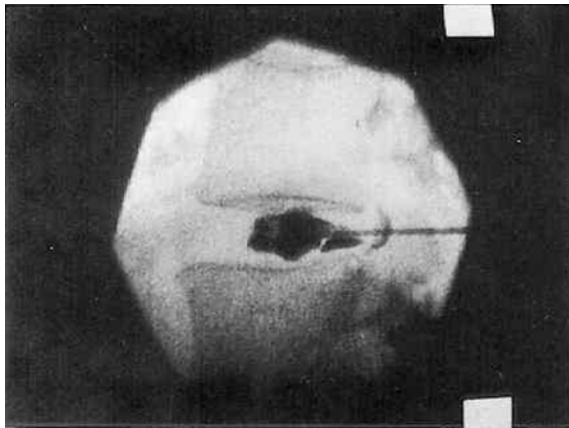


FIG. 2. Discogram demonstrating a disc protrusion with accumulation of contrast medium in the outer annulus fibrosus. No epidural or subligamentous leakage of contrast medium is seen.

TABLE 2
Clinical scoring system*

Symptom	Score		
	2	1	0
low-back pain	none	stress-dependent	permanent
sciatica	none	stress-dependent (Lasègue, Bragard)	permanent
sensory deficit	none	dysesthesia/ paresthesia	hypesthesia/ anesthesia
motor deficits†	none	Grade IV	Grade III
reflex differences	none	1 reflex	2 reflexes

* Modified from the system of Suezawa and Schreiber.⁶⁴ The total score is calculated by adding the score from each symptom, for a maximum of 10 and a minimum of 0. A total score of 9 to 10 indicates an excellent condition, 7 to 8 good, 6 to 7 moderate, 5 or less poor.

† Graded according to the system described by Seddon.⁵⁷

year. The duration of preoperative disability averaged 10.4 weeks, identical to that of the patients with percutaneous endoscopic discectomy. The majority of the patients had been unable to work for 2 weeks to 3 months.

All 20 patients had constant low-back pain and sciatica. The sciatica corresponded to the L-5 dermatome in 18 patients, to L-4 in two, and to S-1 in eight. Sixteen patients had preoperative sensory disturbances; 12 had hypesthesia and four paresthesia. The affected segment was L-5 in seven cases, S-1 in two, and L-5 and S-1 in seven. Four patients had weakness of the extensor hallucis longus muscle (two Grade III and two Grade IV) and five had weakened reflexes in the affected leg.

Symptom Scoring System. In both groups, the symptoms were transformed into a scoring system modified from the system developed in 1987 by Suezawa and Schreiber,⁶⁴ with scores ranging from 0 to 10 (Table 2). In the percutaneous endoscopic discectomy group, the preoperative score averaged 4.45 ± 0.99 (\pm standard

deviation) (4.58 for males and 4.25 for females). The microdiscectomy patients reached a mean value of 4.2 ± 0.98 (4.36 for males and 3.8 for females) before the operation. There were no preoperative statistical differences between the groups relating to the evolution of complaints, conservative therapy, clinical symptoms, diagnostic methods, or level and morphology of disc herniation.

All patients were evaluated preoperatively and 2 years following surgery by an independent observer not involved in the surgical procedure. Neurological symptoms as well as the subjective personal estimation of the surgical result by the patient were recorded.

Statistical Analysis

Statistical analysis was performed using the McNemar Test for qualitative paired variables, the Wilcoxon test for quantitative paired and unpaired variables, and the chi-squared test for quantitative unpaired variables.

Surgical Technique

Percutaneous endoscopic discectomy is performed in the operating theater under sterile conditions. The patient is placed on a radiolucent operating table in a prone, comfortable position with a 30° flexion of the hip and knee joints. The procedure is performed with the patient under local anesthesia, and an anesthesiologist is available if needed. All patients receive a single intravenous injection of antibiotic prophylaxis (third-generation cephalosporin) 20 minutes before the operation.

The surgical approach is as described by Day⁸ and Nazarian.⁴⁶ The midline and the projection of the disc space to be treated are marked on the skin. The disc is approached from the symptomatic side. Under fluoroscopic control, the tip of a No. 18 cannula* is advanced to the center of the disc which has been locally anesthetized with 1% lidocaine, by entering the skin at a point between 9 and 11 cm from the midline. Discography with a water-soluble contrast medium (Solustrast 250 M) is performed to confirm the indication for percutaneous endoscopic discectomy (Fig. 2). The procedure is terminated if the contrast medium leaks into the epidural space or reveals a subligamentous prolapse occupying more than one-third of the sagittal diameter of the spinal canal. Following discography, a guidewire (400 mm long and 0.8 mm in diameter) is advanced through the cannula until the tip reaches the center of the disc; the cannula is then removed. With the wire as a guide, a blunt tapered trocar (Fig. 3, 3) is advanced to the posterolateral border of the annulus fibrosus through a stab incision. The trocar, in turn, serves as a guide for the introduction of the working cannula (outer diameter 5 mm) (Fig. 3, 4). The location of the central opening of the working cannula at the posterolateral border of the intervertebral space is controlled by fluoroscopy. A second, contralateral approach is per-

* Cannula manufactured by Aesculap AG, Tuttlingen, Germany.

Percutaneous endoscopic discectomy

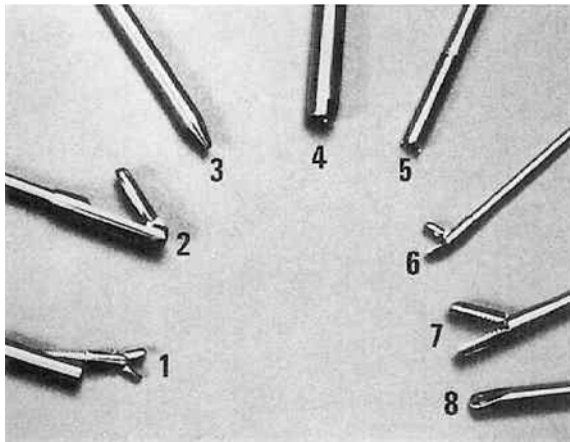


FIG. 3. Photograph of instruments used during percutaneous endoscopic discectomy: 1 = flexible forceps; 2 = reverse-opening forceps; 3 = blunt trocar; 4 = working cannula; 5 = anulus fibrosus trephine; 6 = angled forceps; 7 = straight forceps; 8 = shaver.

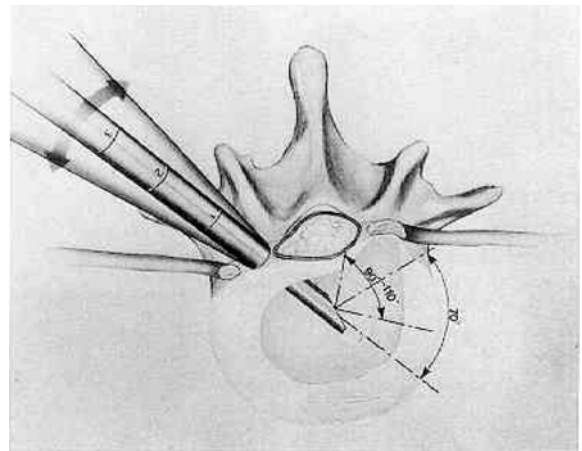


FIG. 4. Schematic representation of an endoscope angled to 70° and introduced into the disc through a posterolateral approach.

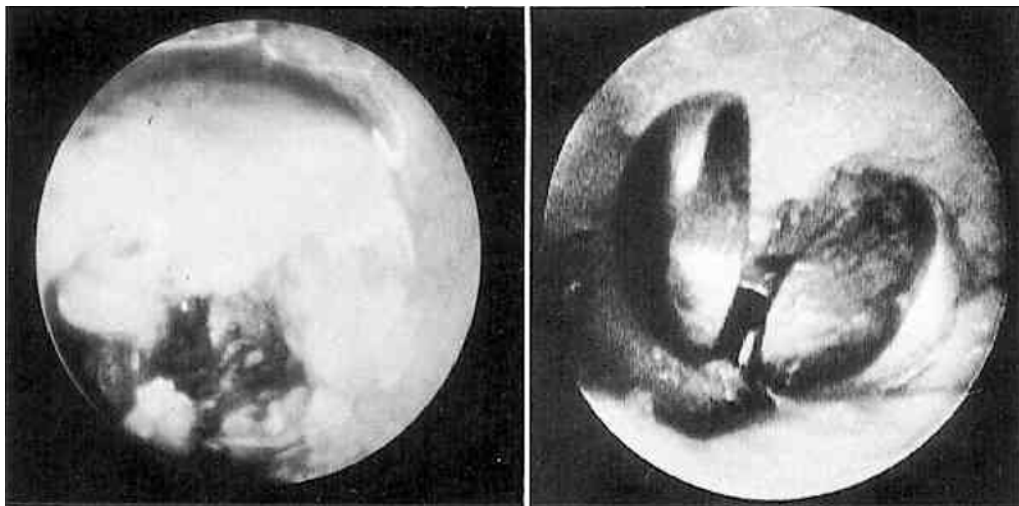


FIG. 5. *Left:* Endoscopic view of a partially removed nucleus pulposus. The dorsal aspect of the nucleus pulposus is seen at the top. *Right:* Endoscopic view of the forceps being introduced into the disc space from the opposite side (bilateral approach). The dorsal aspect of the nucleus pulposus is seen at the top.

formed in patients with medial disc herniation and bilateral symptoms.

Following introduction of the working cannula, the trocar is removed and the disc is entered by cutting a circular window in the anulus fibrosus with the aid of a trephine (Fig. 3, 5). Rigid forceps are introduced through the working cannula to remove a small amount of nucleus pulposus from the center of the disc in order to create a cavity before introducing the endoscope (Fig. 3, 6 and 7). This step can be accelerated by using automated cutters connected to a high-power suction device (Fig. 3, 8).†

† Lipektom suction device manufactured by Aesculap AG, Tuttlingen, Germany.

Endoscopy of the disc is performed with a rigid endoscope angled to 70° and coupled with a television and video unit. The cavity created within the disc is inspected (Figs. 4 and 5 *left*), and the posterior, herniated part of the nucleus pulposus can be removed using reverse-opening forceps as well as flexible forceps (Fig. 3, 1 and 2). A bilateral approach is used for continuous endoscopy during removal of disc herniations located in the midline (Fig. 5 *right*). The combination of endoscopy ("discoscopy") and fluoroscopy ensures the safe control of tip location for all instruments within the intervertebral space and the effective removal of nucleus pulposus. The operation is concluded when no further disc material can be removed. After the working cannula has been removed, the stab incision is closed with a single suture.

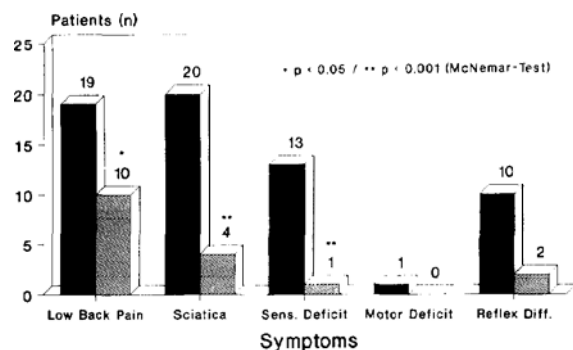


FIG. 6. Summary of symptoms in 20 patients undergoing percutaneous endoscopic discectomy. *Black bars* denote symptoms before the operation; *cross-hatched bars* denote symptoms at the 2-year follow-up examination. Sens. = sensory; Diff. = differences.

Results

Percutaneous Endoscopic Discectomy

The mean time for percutaneous endoscopic discectomy was 40.7 ± 11.3 minutes. The x-ray exposure for the entire procedure was 1.3 ± 0.8 minutes. The total amount of nucleus pulposus removed from the disc space averaged 4.3 ± 1.2 gm. The procedure was performed at the L4-5 level in 18 patients, at L3-4 and L2-3 in one, and at L3-4 in one.

Figure 6 summarizes the preoperative and 2-year postoperative symptoms. At follow-up examination, nine of 19 patients had no low-back pain ($p < 0.05$, McNemar test). Of the remaining 10 patients, eight had stress-dependent pain and two had constant low-back pain. Two patients still had continuous radicular pain projecting into the leg. Eight patients complained of only occasional stress-dependent sciatica; however, only another two of these 10 patients were left with an intermittent radicular pain projection ($p < 0.001$, McNemar test). In the remaining six cases, pain did not show a dermatomal distribution. Of the 13 patients

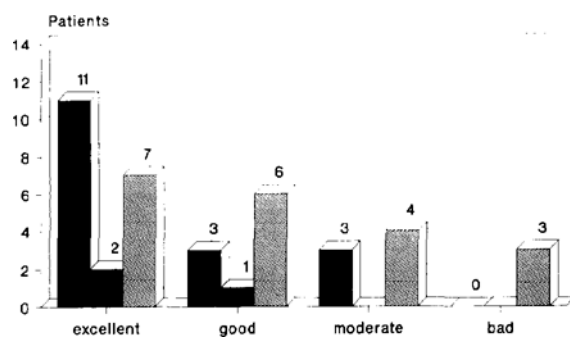


FIG. 7. Results of percutaneous endoscopic discectomy in 20 patients (*black bars*), of an operation after percutaneous endoscopic discectomy in three (*dark cross-hatched bars*), and of microdiscectomy in 20 patients (*light cross-hatched bars*), according to the clinical score (at left, see Table 2).

with preoperative sensory deficits, only one had mild S-1 paresthesia postoperatively ($p < 0.001$, McNemar test). Motor deficits had resolved in the one patient affected preoperatively. Reflex differences persisted in two of the 10 patients with this symptom before surgery. The clinical score calculated from the system described in Table 2 averaged 8.23 (9.00 for males and 7.75 for females) in the percutaneous endoscopic discectomy group at 2 years postoperatively (Table 3). The results could be classified as excellent in 13 patients, good in four, and moderate in three; no patient had a poor result (Fig. 7). These figures include three patients treated by "open" microsurgery following unsuccessful percutaneous endoscopic discectomy; two were subsequently scored as excellent and one as good.

Subjective evaluation of the surgical outcome by the patients yielded excellent results in nine cases, good in five, and moderate (satisfied) in six (Fig. 8). The three reoperated patients estimated their results as excellent (one patient) and good (two patients). Nineteen of 20 patients reported an improvement of 50% or more over their preoperative symptoms (Fig. 9); the improvement

TABLE 3

Pre- and postoperative clinical score in two treatment groups*

Factor	Total Score	
	Percutaneous Endoscopic Discectomy	Microdiscectomy
no. of cases	20	20
mean preop score	4.55 ± 0.99	4.2 ± 0.98
mean score at 2 yrs postop	$8.23 \pm 1.3^\dagger$	$7.67 \pm 1.9^\ddagger$

* Mean values are expressed \pm standard deviation.

† Statistical significance: $p < 0.001$ compared to preoperative levels (Wilcoxon test).

‡ Statistical significance: $p < 0.005$ compared to preoperative levels and to the percutaneous endoscopic discectomy group (chi-squared test).

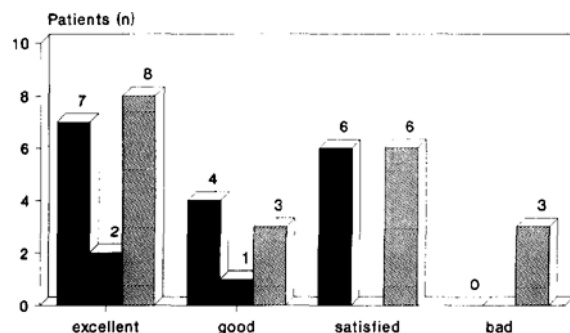


FIG. 8. Results of percutaneous endoscopic discectomy in 20 patients (*black bars*), of an operation after percutaneous endoscopic discectomy in three (*dark cross-hatched bars*), and of microdiscectomy in 20 patients (*light cross-hatched bars*), as evaluated by the patients themselves.

Percutaneous endoscopic discectomy

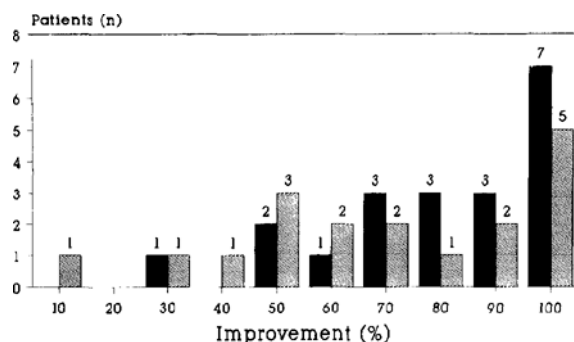


FIG. 9. Postoperative percentage improvement of preoperative symptoms as evaluated by the patients themselves. *Black bars* denote those treated with percutaneous endoscopic discectomy; *cross-hatched bars* denote those undergoing microdiscectomy.

was 100% in seven patients and 90% in three. Sixteen patients improved by at least 70% and three reported an improvement of only 30% to 50%. Their clinical result was, however, classified as moderate.

Three male patients (aged 42, 27, and 43 years) were also treated by microsurgical discectomy; two because of lack of improvement and one due to recurrence of symptoms following initial improvement. Two underwent reoperation within the first 8 days after percutaneous endoscopic discectomy because of persistent symptoms; at surgery, both patients presented subligamentous fragments. The third patient who had been free of symptoms for 1 month was operated on because of a bulging anulus which had led to recurrent symptoms. There were no complications in the present series.

Microdiscectomy

The average duration of surgery was 58.2 ± 15.2 minutes, with a mean of 12.8 ± 3 gm of tissue removed. Nineteen patients were operated on at the L4-5 and one at L3-4 level. Figure 10 summarizes the preoperative and postoperative symptoms in this group of 20 patients. Only five patients achieved complete low-back pain relief; 10 had stress-dependent and five had permanent low-back pain. Sciatica improved in 13 of 20 patients ($p < 0.001$, McNemar test); four others had stress-dependent and three had permanent pain projection into the leg. In contrast to the percutaneous endoscopic discectomy group, however, sciatica was radicular in all cases. Of 16 patients with preoperative sensory deficits, four still complained of hypesthesia and one of mild paresthesia at the L-5 and/or S-1 levels; the sensory deficit had disappeared in 11 of the 16 patients ($p < 0.001$, McNemar test). Motor deficits at follow-up review had resolved in all four with this symptom preoperatively. Only two of five still had reflex differences (Fig. 10).

The 2-year postoperative clinical score as described in Table 2 averaged 7.67 (8.23 for males and 6.2 for females) ($p < 0.001$, Wilcoxon test) (Table 3). Thus, the results could be classified as excellent in seven patients, good in six, moderate in four, and poor in

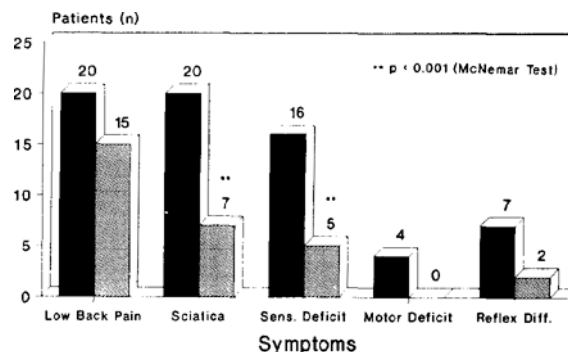


FIG. 10. Summary of symptoms in patients undergoing microdiscectomy. *Black bars* denote symptoms before the operation; *cross-hatched bars* denote symptoms at the 2-year follow-up examination. Sens. = sensory; Diff. = differences.

three (Fig. 7). One patient in the latter group underwent reoperation because of epidural scar tissue and progressive neurological symptoms 3 months following the first surgery. She subsequently developed spondylodiscitis, which was treated successfully by conservative therapy. At $2\frac{1}{2}$ years following the first surgical intervention, she was operated on for the third time and again presented with an epidural scar at L4-5, which had led to compression of L-5.

The patients' evaluation of the surgical result was more negative as compared to the percutaneous endoscopic discectomy group (Fig. 8). Eight patients regarded the result as excellent and three as good. Six patients were quite satisfied, but three (including the reoperated patient) felt that surgery had led to a poor result. Of 15 patients showing a subjective improvement of preoperative symptoms by 50% or more (Fig. 9), only five considered themselves to be completely asymptomatic. Ten patients were improved by 70% or more. Nevertheless, five patients (25%) showed only a minor (10% to 40%) improvement in symptoms or none at all.

Postoperative Disability

The duration of the postoperative disability in patients treated by percutaneous endoscopic discectomy was between 1 and 26 weeks (mean 7.7 weeks). Nineteen of 20 patients (one retired because of coxarthrosis) returned to their previous jobs. In the microdiscectomy group, disability lasted between 4 weeks and more than 1 year (mean 22.9 weeks). Only 13 (65%) of the 20 patients returned to their previous occupation; two retired for reasons unrelated to surgery and one remained without a job. However, four patients were still unable to work 1 year following surgery.

Discussion

Lumbar disc herniation can lead to nerve root compression within the spinal canal, within the intervertebral foramen (intraforaminal), or outside the spinal canal (extraforaminal). The location determines the surgical approach. In all but the extraforaminal cases,

disc herniations are removed by the "standard" interlaminar transspinal approach.^{3,11,12,15,22,45,48,67-70}

Surgery on the disc at the site where it compresses the nerve requires manipulation and sometimes segmental dissection of paraspinal muscles, removal of the yellow ligament, penetration into the spinal canal, manipulation of the nerve root, dissection and coagulation of epidural vessels, and perforation of the anulus fibrosus and the posterior longitudinal ligament before the nucleus pulposus is eventually reached. To prevent recurrent herniation through the perforated or incised anulus fibrosus, a mostly "radical" removal of nucleus pulposus is considered necessary. The indication for this "standard" procedure does not depend on either the stage or the morphological aspect of disc degeneration.

It has been demonstrated that surgical results are worse in patients with mere disc protrusions as compared to those with a sequestered disc.^{35,37,47} The surgical procedure itself eliminates the influence of the initial stage of disc degeneration on the subsequent course of the disease by converting an "operated disc" into a new and mostly uniform pathological condition. This might contribute to the 2% to 17% recurrence rate reported in the literature irrespective of the technique used ("conventional" or microdiscectomy).^{2,10,23,35,41,42,45,48,60,68} while the outcome itself (excellent and good results) could be slightly improved by microsurgical techniques.^{2,3,11,12,68} Nevertheless, a great number of failures following lumbar discectomy are related directly or indirectly to the surgical approach to the disc space through the spinal canal.

Surgical Technique of Percutaneous Endoscopic Discectomy

In 1975, Hijikata, *et al.*,²⁶ described the original method of percutaneous nucleotomy through a posterolateral approach. However, this technique did not fulfill the requirements for selective discectomy since the instruments used by this author were straight and rigid and could only reach the center of the disc space. Hijikata, *et al.*,^{25,26} pointed out that the diameter of the working cannula (2.6 mm) was too small to allow removal of significant amounts of nucleus pulposus and that it was not possible to reach the herniated tissue with the instruments used. These drawbacks were partially eliminated by the instruments described by Kambin and coworkers^{30,32} in 1986 and 1987, comprising working cannulas with diameters of up to 5 mm as well as flexible forceps. However, the working range of these instruments is still limited and does not cover the dorsal part of the intervertebral space.

A methodological improvement was achieved when Suezawa and coworkers^{62,63} and Schreiber, *et al.*,⁵⁴⁻⁵⁶ described a method of percutaneous nucleotomy using a bilateral approach and continuous endoscopic control. However, the bilateral approach prolonged the operation, increased x-ray exposure, and appeared to bear a higher risk of infection.⁵⁶ These authors did not use flexible instruments.

Another technique, the automated percutaneous

lumbar discectomy, was first described in 1985 by Onik and coworkers.^{49,50} This procedure, however, neither achieves selective discectomy nor permits disc excision since it is performed with only one unidirectional instrument (the Nucleotome). The aim of this operation is to achieve "internal decompression" of the disc by removing small amounts of the central parts of the nucleus pulposus,^{7,18,49} and it is performed without endoscopic control. In addition, removing tissue from the center of the disc, thus leaving dorsal parts "entrapped" in the clefts of the anulus fibrosus, bears the risk of subsequent reherniation by way of the "wedge-effect" described in 1989 by Shepperd, *et al.*,⁵⁸ The major advantage of automated percutaneous lumbar discectomy is that it is innocuous; however, this seems to be at the same time its major hazard, since it may be tempting to "loosen" indications and to apply the method in patients who would have improved spontaneously with time⁵² or through adequate conservative treatment. These cases of spontaneous healing or improvement can result in an overestimation of the efficacy of this procedure and may explain the "inflation" of good results recently reported in series so large and assembled in such short time periods as to raise doubts about whether solid selection criteria have been applied.⁷ When solid criteria are applied, the series are necessarily modest (even in multicenter studies) and the "success rate" of automated percutaneous lumbar discectomy falls to 55%.²⁹

The surgical goal of percutaneous endoscopic discectomy is the selective removal of nucleus pulposus from the posterior one-third of the disc space under intermittent or constant visual control through a posterolateral approach. Since the disc space is entered at an angle of 50° to 60° to the sagittal plane,^{8,44,46} the removal of nucleus pulposus requires reverse-opening and flexible rongeurs, as well as automated shaver systems with high-powered suction/irrigation devices. Endoscopy with angled endoscopes (30° to 90°) visualizes the removal of nucleus pulposus and helps direct the instruments to the target area in the dorsal part of the disc space.

Indications for Percutaneous Endoscopic Discectomy

The selection criteria for percutaneous endoscopic discectomy are not well defined. However, most authors consider radicular symptoms mandatory in establishing the indication for percutaneous removal of nucleus pulposus.^{27,30,55,58,61} Patient selection for percutaneous endoscopic discectomy strongly depends on imaging findings. In addition to spinal CT and MR imaging, discography and postdiscography CT are the most reliable methods for preoperative evaluation of disc morphology.^{9,53} The differentiation between a "contained," a "noncontained," and a sequestered disc herniation is established only (but not always) by combining several imaging techniques. The combination of spinal CT with postdiscography CT is superior to MR imaging and leads to a 90% reliability in excluding a sequestered disc.^{9,53}

Percutaneous endoscopic discectomy

Results of Surgery

This prospective trial suggests that the clinical results of percutaneous endoscopic discectomy and microdiscectomy are similar in comparable groups of patients. In 1989, Hijikata²⁵ reported excellent or good results in 72% of 136 patients who underwent percutaneous nucleotomy with a follow-up period of 12 years. In the same year, Kambin and Schaffer³³ and Stern⁶¹ described clinical success with manual percutaneous discectomy in 87% and 87.5% of their patients, respectively. Although Hoppenfeld²⁷ reported successful operations in 86%, he observed that severe preoperative motor deficits in eight patients could be improved in only one. This justifies recommending the exclusion of patients with severe neurological deficits. In the series reported by Shepperd, *et al.*,⁵⁸ 81% had excellent or good results, and 14% were satisfied with the operation. Schreiber and coworkers,⁵⁵ using a clinical score comparable to the one applied in our study, reported clinical success in 72.5% of cases.

Maroon, *et al.*,⁴⁰ and Davis and Onik⁷ reported automated percutaneous lumbar discectomy to be successful (excellent and good results) in 70% and 77.5%, respectively. However, a recent multicenter analysis by Kahanovitz, *et al.*,²⁹ of automated percutaneous lumbar discectomy could not confirm these success rates; in that study, only 55% of the patients were able to return to work following the procedure and 64% of these patients retained low-back pain, 56% sciatica, 44% sensory deficits, and 12% motor deficits. One reason for such modest results could be that selection criteria were not well defined. This multicenter study, like other series,^{7,29,40,49} lacked a clear definition of clinical and morphological criteria for patient selection.

In our opinion, the patient's personal estimation of the result of percutaneous endoscopic discectomy is the most reliable and significant criterion for success or failure of the method. Although some patients in our series still had low-back pain, sciatica, or mild neurological deficits at follow-up review, none evaluated the result as "poor." In a second series of 40 patients treated by percutaneous endoscopic discectomy, we analyzed the time course of the relief of symptoms; within 24 hours, 77.5% of the patients had complete relief of sciatica and 82.2% were without sensory deficits. These had risen to 82.5% and 89.3% by the day of discharge (unpublished data). This immediate indication of success, together with the low incidence of postoperative morbidity, exerts a positive influence on the patient's rehabilitation behavior and personal estimation of the result.

Percutaneous Endoscopic Discectomy vs. Microdiscectomy

The comparison of percutaneous and open surgical techniques poses some problems. On the one hand, there are virtually no prospective or retrospective studies that compare and selectively analyze patients with a "contained" or slight subligamentous disc herniation. On the other hand, criteria for defining "success" or "failure" are inhomogeneous and prevent exact comparison. A success rate of 83% after microdiscectomy

was reported in 1989 by Landolt, *et al.*,³⁶ patients with a sequestered disc had the best results. Thomas and Afshar⁶⁶ reported satisfactory results in more than 91% of cases, with a mean follow-up period of 2.5 years; however, radicular symptoms were still present in 33% of the patients. If one considers not only an improvement in clinical symptoms but also return to a previous occupation, the success rate of microdiscectomy decreases to roughly 70%.¹⁰ This is in line with our own results and reflects at least in part the sociomedical situation in Germany where loss of income due to disability is generously covered by legal insurance.

Postoperative disability lasted significantly longer after microdiscectomy than after percutaneous discectomy (22.9 vs. 7.7 weeks). The high mean disability period of 22.9 weeks following microdiscectomy was due to the fact that four of the 20 patients were still without work 12 months after the procedure. Most of the patients were unable to work for 2 to 6 months.

Procedure Failures

Three patients who had undergone percutaneous endoscopic discectomy were subsequently treated by microdiscectomy because of residual or recurrent symptoms. In these patients, the percutaneous procedure did not seem to have a disadvantageous influence on the outcome of subsequent open surgery since the result was excellent in two and good in the third.

We have gained clinical experience with more than 110 cases and have on several occasions found a small subligamentous fragment in patients in whom percutaneous endoscopic discectomy was unsuccessful. In our two patients with subligamentous fragments, there was evidence that removal of nucleus pulposus from the posterior part of the disc space was insufficient. In both cases, the central part of the disc space was nearly empty at the time of the second operation, and the sequestra were, at least in part, trapped in the fibers of the outer annulus fibrosus. It appears to be essential not only to perforate the annulus fibrosus but to remove the nucleus pulposus adequately from the region where it herniates through the annulus and compromises the nerve root.³⁸ This means that the surgical target area is essentially the same as in open microdiscectomy. The second finding on reoperation was a bulging annulus in one patient; there was evidence that too much nucleus pulposus had been removed from the center of the disc. This patient showed a nearly 50% decrease in disc height within one month postoperatively, which probably led to the bulging of the annulus, a phenomenon known from conventional discectomy or chemonucleolysis.³¹

Complications

There were no complications during or following percutaneous endoscopic discectomy in the present series. However, it has been reported recently that the overall complication rate for this kind of surgical procedure averages 2.6%;⁴³ it is thus comparable to the rates described for other endoscopic procedures.^{13,16,17,28} Besides complications due to the approach such as

nerve root or vascular injury, postoperative infections mainly contribute to this complication rate.⁴³

Conclusions

If patient selection follows the criteria described in this paper, 10% to 15% of all patients submitted to surgical treatment for disc herniation are candidates for percutaneous endoscopic discectomy. Our results show that the clinical results are comparable, and in some respects, superior to those of microdiscectomy. Percutaneous endoscopic discectomy is performed with the patient under local anesthesia, it involves less tissue trauma and no risk of epidural scarring, the hospitalization time is shorter, and the postoperative morbidity is lower than for microdiscectomy. The results of the present study justify the assumption that percutaneous endoscopic discectomy can be a surgical alternative for patients with "contained" or slight subligamentous lumbar disc herniations.

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Address reprint requests to: H. Michael Mayer, M.D., Department of Orthopedic Surgery, Freie Universität Berlin, Clayallee 229, 1000 Berlin 33, Germany.