Transforaminal Percutaneous Endoscopic Lumbar Discectomy

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Background: In this study we analyzed and presented our experience of performing transforaminal percutaneous endoscopic lumbar discectomy (TPELD).

Methods: A retrospective study of 142 TPELD was conducted on 134 consecutive patients from 2001 through 2005. The inclusion criteria for patients were those who had leg pain with or without low back pain and magnetic resonance imaging (MRI) that revealed soft contained or noncontained but contiguous lumbar disc herniation (LDH). All patients failed at least 6 weeks of conservative treatment or could not tolerate it.

Results: The patients had an average age of 38 years. The mean follow-up period was 8 months. The outcomes were evaluated using the modified MacNab criteria. The percentage of successful outcomes (excellent or good) was 89%. Among the remainder of the patients, six (4.5%) had open surgery later. Moreover, eight patients (6%) sustained temporary dysesthesia over the proximal lower limb of the operated side. No major neurovascular injuries or deaths occurred.

Conclusions: In experienced hands, TPELD is minimally invasive, safe and effective for treating soft contained or noncontained but contiguous LDH.

(Chang Gung Med J 2007;30:226-34)

Key words: lumbar disc herniation, transforaminal percutaneous endoscopic lumbar discectomy

Lumbar disc herniation (LDH) is a common cause of low back pain and sciatica. The number of patients with LDH is increasing with the aging population. However, epidemiological studies have demonstrated that intervertebral disc disease is also increasing among all the populations including the young. This phenomenon may be due to the lack of physical activity, sedentary lifestyle and increasing car and air travel. Approximately 70-85% of people have experienced at least one episode of low back pain with or without leg pain during their lives, and it is the second most common reason for doctor visits.(1)

For patients with LDH who do not achieve satisfactory recovery following conservative treatment, surgical intervention should be considered. Currently, there are numerous surgical interventions for LDH. They can be classified as posterior open discectomies and percutaneous techniques. Posterior open discectomies may include microdiscectomy, microendoscopic discectomy, hemilaminectomy with discectomy, among which microdiscectomy remains the standard surgery for LDH. Meanwhile, percutaneous techniques include chemonucleolysis,(2-6) nucleoplasty,(7,8) intradiscal electrothermal therapy (IDET).(9,10) Percutaneous laser discectomy(11-15) and transforaminal percutaneous endoscopic lumbar discectomy (TPELD). All of the percutaneous techniques except for TPELD are performed using blind methods. Meanwhile, the intraoperative procedure of

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Received: Mar. 24, 2006; Accepted: Nov. 14, 2006
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TPELD is performed under endoscopic vision.

Since the success of microsurgery for LDH was reported in 1960s,[16] microdiscectomy has become the standard contemporary surgical treatment for LDH. During this procedure, the open posterior transcanal approach makes paraspinal muscle stripping, as well as lamina, facet joint, ligamentum flavum partial excision and nerve root manipulation inevitable. Kambin and Gellman introduced the percutaneous arthroscopic posterolateral extracanal approach for treating LDH.[17] This posterolateral endoscopic technique is less invasive than the standard posterior approach microdiscectomy. To ensure the safety of the neural structures, real time conscious patient interaction during the procedure is crucial. This procedure strictly proceeds under local anesthesia and conscious sedation. Owing to its low level of invasiveness, postoperative back pain is minimal and patients generally enjoy faster functional recovery.

Since the preliminary study of Kambin and Gellman,[17] the techniques and equipment used for TPELD have been evolving continuously. The changes may include shifting the target of discectomy, using automated suction devices, changing articulating instruments, cutters, shavers and rongeurs, using radiofrequency bipolar coagulators, or using Holmium yttrium-aluminum-garnet (Ho:YAG) lasers.[18-20] Investigations on TPELD are underway worldwide. In this study, we report our experience of TPELD in treating LDH.

METHODS

Patient population

From September 2001 through July 2005, 134 consecutive patients underwent 142 TPELD at the Keelung Chang Gung Memorial Hospital. Eight patients received two TPELD on different occasions. The patient inclusion criteria were leg pain with or without low back pain and MRI revealing soft contained or noncontained but contiguous lumbar disc herniation. All patients failed at least 6 weeks of conservative treatment or could not tolerate it. Patients with calcified discs, spinal stenosis, segmental instability, or cauda equina syndrome were excluded. Nineteen TPELD were two disc operations and one TPELD was a three disc operation. The sample contained a total of 163 discs. Table 1 lists the locations of the discs that were treated.

Table 1. Location of the Herniation

Level	No. of disc	%
L5-S1	37	23
L4-5	106	65
L3-4	13	8
L2-3	7	4

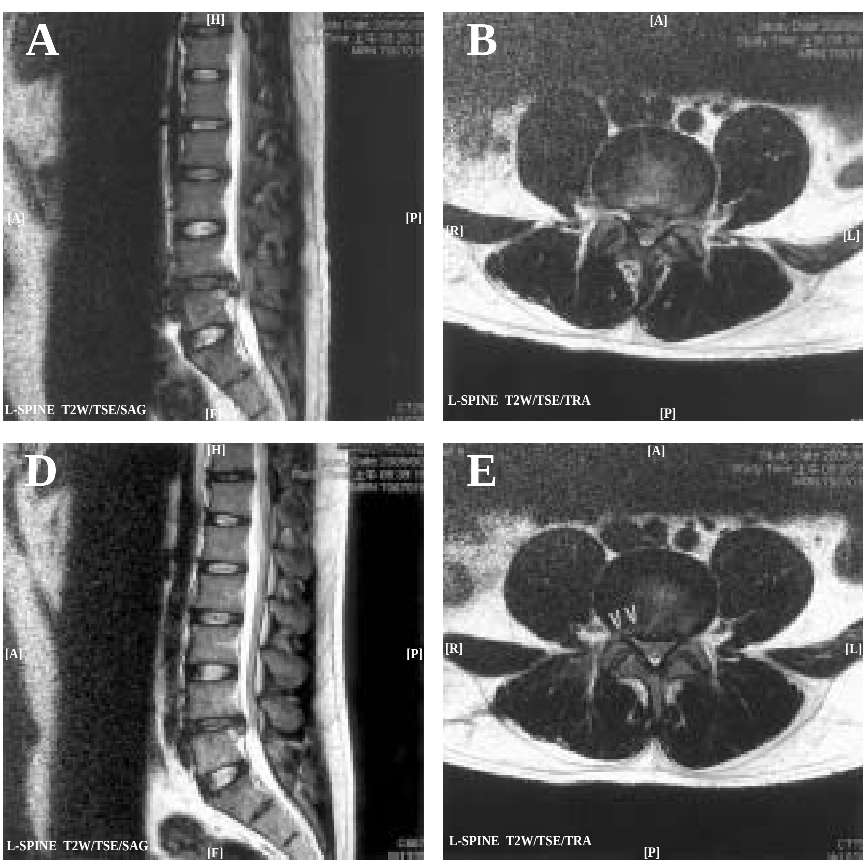
Abbreviations: L: lumbar spine; S: sacral spine.

Surgical technique

This procedure was performed under local anesthesia. The patients were positioned prone with their backs mildly flexed. Following skin preparation and draping, the midline and target disc levels were marked using fluoroscopic localization. The skin entry point was approximately 8-14 cm from the midline for each patient. Following skin entry, subcutaneous tissue and muscles along the trajectory were infiltrated with local anesthetics, and an 18-gauge spinal needle was inserted under fluoroscopic guidance. For the anatomical differences and to avoid dura or nerve injury, ideally in L5-S1, L4-5 or L3-4 TPELD the tip of the needle was positioned at the medial pedicular line in the anteroposterior projection and at the posterior vertebral line in the lateral projection just before penetrating the annulus fibrosus of the intervertebral disc. In a L1-2 or L2-3 disc procedure, before entering the intervertebral disc the tip of the needle targeted the midpedicular or lateropedicular line in the anteroposterior projection and at the posterior vertebral line in the lateral projection. Lidocaine infiltration at the epidural space was performed to minimize the pain associated with the insertion of cannula and endoscope. The spinal needle was then inserted into the nucleus pulposus. Provocative discography with 1-3 mL water-soluble contrast medium was routinely performed. For each patient, the pain response, end resistance, and epidural leakage of the contrast medium were recorded. The spinal needle was then replaced with guide wire. A 1-cm skin stab wound was made, and a cannulated dilator was slid over the guide wire and into the intervertebral foramen. The guide wire was then replaced with a spinal needle and the annulus fibrosus was infiltrated with lidocaine before penetration by the dilator. After the tip of the dilator passed through the annulus fibrosus, a beveled working cannula was slid over the dilator. Initially, the beveled end of the working cannula was positioned half in the disc and half inside the epidural space. The dilator was then withdrawn and the endoscope was inserted. Clear endoscopic vision was obtained under constant pressurized saline irrigation. The working cannula was rotated to direct the beveled side to the working field and to protect the exiting nerve root. The epidural space was examined first. Bleeding was stopped using a radiofrequency bipolar coagulator, and any fragments in the working field were removed. The annular opening generally had to be enlarged using a Ho:YAG laser. The discectomy was started manually. Using the fluoroscopic guide, the discectomy was only limited to the posterior third of the disc, specifically in the subannular region. To prevent postoperative discogenic pain, the middle and anterior parts of the disc were preserved. The degenerated and herniated disc fragments were removed using grasping forceps and a side-firing Ho:YAG laser. The protrusion discs generally contained parent continuous basal fragments, which were typically large and incarcerated between the annular fissure. When the parent fragment was pulled out together with its offending epidural protruding part (adhering to the nerve root or dural sac), the patient experienced significant and transient low back or leg pain. Thus, the pulling must be gentle to avoid patient discomfort. Once this key fragment was removed, the patient's radicular pain immediately resolved. This predicted good and rapid recovery of symptoms (Fig. 1).

RESULTS

Most patients were discharged on the day of surgery or on the following day. The average patient age was 38 years (range, 22-71 years). The sample included 78 males and 56 females. The mean follow-up period was 8 months (range, 3-36 months). Most of the discs operated on (65%) were L4-5 discs (Table 1).



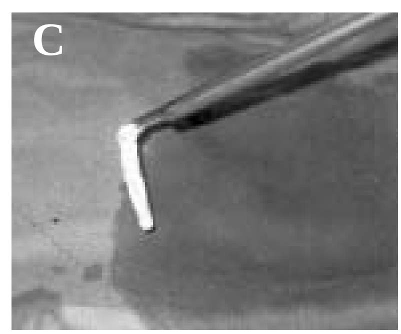


Fig. 1 The subject, a 32-year-old male, presented with low back pain and intractable bilateral sciatica lasting 2 months. The symptoms subsided immediately and markedly following right L4-5 TPELD. (A) and (B) Preoperative sagittal and axial T2-weighted MRI demonstrated L4-5 central extruding disc. (C) The intraoperative picture revealed that the extruding disc and its intradiscal parent fragment was pulled out en bloc with rongeur protruding from the working channel of the endoscope. (D) and (E) Postoperative sagittal and axial T2-weighted MRI demonstrated removal of extruding disc. Arrowheads showed the trajectory of the endoscope.

Based on the modified MacNab criteria, 89% of patients achieved excellent (28%) or good (61%) outcomes after surgery (Table 2). The percentage of successful outcomes (excellent or good) was 89%. Among the remaining patients, namely those with fair (7%) or poor (4%) outcomes, six (4%) later underwent additional surgery. One patient experienced recurrent LDH 4 months after TPELD. Moreover, eight patients (6%) sustained temporary dysesthesia over the proximal lower limb of the operated side during the early days of the TPELD. All of these symptoms recovered within 3 months of surgery. No dural tears or infections occurred, nor were there any major neurovascular injuries or deaths encountered. The complications came from postoperative dysesthesia and comprised just 5.9% of the sample.

DISCUSSION

Essentially, there is no LDH regarding its location, size, containment (contained or noncontained disc), softness (noncalcified or calcified disc) or migration that cannot be removed via posterior open discectomy. In contrast, the standard indications for TPELD are limited to soft (noncalcified) and contained LDH which caused discogenic leg pain that failed to respond to conservative treatment. The continuity of the hernia with the disc space but not its size is the key determinant of the indications for TPELD. Given the advanced technical skills and special instruments, such as flexible and steerable tools, the indications could be extended to include LDH that are extruding and even migrating but still contiguous disc fragments. In the early stage of our TPELD, we only operated on the LDH patients that had contained herniation. After gaining experience, the indications were then extended to include almost all kinds of soft LDH except for those that were noncontained and incontiguous.

Table 2. Outcome Based on Modified MacNab Criteria

Rating with modified MacNab criteria	Patient no.	%
Excellent	38	28
Good	82	61
Fair	9	7
Poor	5	4

In TPELD, the posterolateral approach can be used to avoid the disadvantages of posterior open discectomy that are associated with its surgical route. The TPELD approach begins at the skin entry point in the posterolateral aspect of the lower back (approximately 8-14 cm from the midline) and proceeds through the critical triangular window of the intervertebral foramen, which is bordered superolaterally by the exiting nerve root, posteriorly by the superior articular process of facet joint and caudally by the inferior pedicle. This anatomical triangular working zone for accessing the intradiscal space has been described by several authors.[18,21,22] The anatomic borders of this working zone and variations in anatomic dimensions at each lumbar level were defined by Mirkovic et al.[23] In the beginning of our TPELD, the trouble we had was the difficulty of getting the endoscope close enough and removing the centrally located or migrating LDH, thus, the patients usually ended up with fair or poor results. We found that the success of TPELD was determined mostly by the ability of the endoscope and associated instruments to safely reach the target disc hernia, which is in the posterior part of the intervertebral disc and/or the epidural space. To reach this area, the superior articular process of the facet joint is usually the obstacle. The location of the skin entry point is critical for passing the endoscope underneath the facet joint and reaching the disc hernia site. In patients with large body sizes, the ideal skin entry point is more laterally located than those with small body sizes. In addition, to reach posteriorly and medially enough to get the centrally located or migrating LDH, the location of the skin entry point should be more lateral. The location of the skin entry point is one of the most crucial key factors of a successful TPELD. During the development of our skills at TPELD, the location of the skin entry point was then moved laterally from 8-10 cm off the midline of low back in the beginning to 12-14 cm off the midline of low back.

To prevent any nerve injuries, in addition to the biplane C-arm guidance, the patient must be kept continuously awake under local anesthesia and instructed to report any pain, numbness or electrical shock sensation. Regarding the location of LDH, the posterolateral approach passing through the intervertebral foramen is more direct and facilitates easier removal of the foraminal and extraforaminal disc herniation compared with the conventional posterior open lumbar discectomy.[24]

During a conventional open lumbar discectomy, the posterior approach involves the need to detach or penetrate the paraspinal muscles, as well as removing the lower part of the superior lamina, the ligamentum flavum and the medial part of the facet joint. The reported incidence of postoperative disabling low back pain after conventional open lumbar discectomy is 11-15%.[25-29] Additionally, the destruction of these posterior structures increases the potential for segmental instability. The incidence of postdecompression spondylolisthesis has been reported to range from 2 to 10%.[30,31] Meanwhile, the incidence of postoperative progressive slippage in patients with preoperative degenerative spondylolisthesis is even higher (65%).[32] In a comparative study of the posterolateral transforaminal and posterior decompressions of the lumbar spine, a significant increase in extension and axial rotation flexibility was noted following posterior decompression.[33]

The thecal sac and nerve root are manipulated and moved aside to reach the offending disc during the posterior open lumbar discectomy. Perforations of the dura may occur with or without nerve root injury and may cause pseudomeningocele formation, cerebrospinal fluid fistula, meningitis or wound healing problems. The incidence of dura tears in the posterior open lumbar discectomy is around 4%,[34] and may reach up to 17.6% during subsequent operations.[35] Yeung and Tsou reported an incidence of 0.3% for dura tears during TPELD.[36] During posterior open discectomy, the intracanal manipulation of the nerve root and epidural space may also result in scar formation around the dura and nerve roots causing recurrent symptoms. The incidence of postoperative perineural scarring resulting in clinical failure is estimated to occur in 1 to 2% of patients undergoing posterior open lumbar discectomy.[37] In a report of 268 cases of failure of posterior open lumbar discectomy from the literature, nerve root scarring caused 12% of the failures.[38] Spangfort identified five nerve root injuries among 2504 cases that underwent posterior open discectomy.[37] There has not yet been a report of any intracanal or foraminal adhesions following TPELD or iatrogenic nerve root injury during the procedure in the literature.

During the early days of TPELD, the procedure targeted the center of the disc. Central debulking was performed with the aim of achieving indirect decompression of the protruding disc. Nowadays, the target has shifted to the posterior part of the disc underlying the offending protruding part, and even the epidural extruding fragments, are targeted fragmentectomy. The foraminal and intracanal space can both be decompressed during the same procedure. The superior articular processes of the facet joint are usually the obstacle of the access to the extruding fragments, particularly in cases with central or large subarticular disc herniation. For complete removal of the epidural disc fragments, adequate epidural exploration using resection of the anterolateral part of the superior articular process and ligamentum flavum is necessary. This task can be accomplished with the help of a reamer or Ho:YAG laser. Flexible bipolar radiofrequency electrodes can be used for hemostasis, tissue modulation and probing the epidural space.

During the posterior open lumbar discectomy, the intradiscal space is difficult to visualized clearly even under a microscope and the discal tissue inside cannot be treated properly or safely (cannot be shrunk or modulated via laser or radiofrequency). Additionally, the opening of the annulotomy during the posterior open lumbar discectomy is within the spinal canal. As the degeneration of the operated disc continues following the open discectomy, subsequent fragmented pieces of disc material may rupture through the annular opening into the confined intracanal epidural space, compress the nerves and cause recurrent symptoms. The reported recurrence rate of posterior open discectomy is 5-11%.[25,39-49] In contrast, the annular opening in TPELD is in the posterolateral annulus (outside the confined intraspinal canal), which is a relatively "open space" compared with the spinal canal. The natural axial width and intact fibers of the posterolateral annulus combined with its inherent contractibility may minimize the incidence of reherniation via this surgically induced annular opening. The anatomical position of the facet joints also inhibits excessive transmission of external forces to the posterolateral boundary of the annulus fibrosus, thus limiting expulsion of nuclear tissue through the posterolateral annular opening. Additionally, the intradiscal part of the disc tissue is shrunk and tightened using laser or radiofrequency in TPELD (thermodiskoplasty). The collagenous tissue is shrunk and annular nerve receptors are desiccated.

Thus, the risk of subsequent sequestration of the disc material following TPELD may be reduced. If such sequestration does occur, the disc fragments in this relatively large space may be less compressed and more tolerated. In the reports by Yeung and Tsou, repeat surgery for recurrent herniation was performed in two out of 307 patients that underwent general LDH (0.65%)[36] and six out of 219 patients that underwent intracanal noncontained LDH (2.7%)[50] treated with TPELD. In our study, one patient had recurrent disc herniation (0.7%) at 4 months after TPELD. This patient received a second TPELD and achieved good postoperative outcome.

TPELD is performed under local anesthesia. Most patients are discharged on the day of surgery or the day following surgery. Patients generally are able to walk unassisted immediately after surgery, but have some soreness of the back or buttock area on the operated side. Temporary weakness of the proximal lower limbs on the operated side owing to anesthetic infiltration was noted in most patients. However, postoperative wound pain was generally minor.

Although the reported outcomes of TPELD are generally good, this technique requires numerous endoscopic techniques, and thus has a steep learning curve. The most challenging part of this technique is safely and less painfully placing the endoscope under fluoroscopic guidance into the target disc through the small intervertebral foramen. Particularly for the centrally located or noncontained disc herniations, adequate intradiscal and epidural exploration might be difficult and many techniques are required. The outcomes are heavily dependent on operator skills. In the hands of an experienced operator, TPELD is indicated for most spectrums of LDH, except for calcified discs or sequestration discs which are separate and migrating from the disc space. Meanwhile, the success rate of TPELD is decreased in LDH with concomitant spinal canal or lateral recess stenosis. The size of the herniation does not preclude the procedure. TPELD can be successful as long as the herniation is contiguous with the disc space. The location of herniation also does not preclude this procedure, and the different locations simply involve different levels of difficulty and thus require operators with different skill levels. The extraforaminal and foraminal disc hernia can be directly approached via TPELD. For contained subarticular and central herniation, the hernia mass is removed from the subannular space together with its intradiscal undermined contiguous part (the inside-out technique). Regarding the noncontained subarticular and central herniation, the intracanal epidural space must be explored and the extruding disc fragments sought. In this situation and concomitant foraminal stenosis, the intervertebral foramen must be enlarged by ablating the posterior medial annulus fibrosus, ligamentum flavum, and part of the superior articular process to expose the epidural space before completely removing the extruding fragments.

In most patients, the iliac crest is an obstacle to the transforaminal approach of the L5-S1 disc. The trajectory angle of the TPELD is generally too acute to reach the posterior part of the intervertebral disc or intracanal epidural space to achieve more direct targeted fragmentectomy of the subarticular or central L5-S1 LDH. Thus, the success rate of TPELD in L5-S1 LDH is lower than LDH at other levels. For moderate to severe subarticular or central L5-S1 LDH (where over 1/3 of the spinal canal is compromised by the hernia), the posterior open discectomy or transpinal interlaminar approach of percutaneous endoscopic discectomy are the first choices. For mild L5-S1 LDH (where the hernia involves less than 1/3 of the spinal canal), a small-caliber flexible endoscope (LASE, Clarus Medical System, Inc., Minneapolis, Minn) can be placed closer to the posterior part of the disc with a curved cannula. Indirect decompression of the herniation can then be achieved.

Generally, the clinical success rate of TPELD was reported to be comparable to that of conventional posterior open discectomy.[36,51-54] TPELD involves several technical challenges, such as the critical narrow access through the foraminal triangular window and the limited intradiscal and epidural working space. The published complications include infection, thrombophlebitis, dysesthesia, dural tear, vascular injury and death. The complication rate of TPELD ranges from 2.7 to 3.5%[36,50] and the 5.9% rate reported in this study is comparable to that of the posterior open discectomy. The only complication encountered in this study was the postoperative dysesthesia of the lower limb. Most of these complications occurred during the early stage of using TPELD due to the initial unfamiliarity with the procedure. Eleven patients (8.2%) did not have good or excellent recovery of symptoms due to the persistence of the disc herniation after operatio. These patients mostly underwent their operations during the early stage of our experience with TPELD and the failures were attributed to inadequate intradiscal or epidural exploration. Six of them (4.5%) received open discectomy later. To facilitate exploration, widening the operation field is needed. There have been several improvements in the equipment to help us accomplish this job. For example, the new generation endoscope has a larger working channel which allows for work with powered burrs under vision and the high-powered Ho-YAG laser allows for ablating the solid bony obstacle.

In conclusion, TPELD is less invasive than conventional posterior open discectomy. In experienced hands, TPELD is safe and comparably effective in treating contained or noncontained but contiguous LDH. To avoid the sequelae of posterior open discectomy, TPELD should be adopted as the first surgical treatment of choice for soft and contiguous LDH.

REFERENCES

1. Andersson GBJ. Epidemiological features of chronic low-back pain. Lancet 1999;354:581-5.
2. Smith L. Chemonucleolysis – personal history, trials, and tribulations. Clin Orthop 1993;287:117-24.
3. Brown MD. Update on chemonucleolysis. Spine 1996;21:62S-8S.
4. Fraser RD. Chymopapain for the treatment of intervertebral disc herniations: The final report of a double-blind study. Spine 1984;9:815-8.
5. Javid MJ. Efficacy of chymopapain chemonucleolysis: A long-term review of 105 patients. J Neurosurg 1985;62:662-6.
6. Nordby EJ, Wright PH. Efficacy of chymopapain in chemonucleolysis. Spine 1994;19:2578-83.
7. Welch WC, William C, Gerszten PC, Peter C. Alternative strategies for lumbar discectomy: intradiscal electrothermy and nucleoplasty. Neurosurg Focus 2002;13:E7.
8. Bhagia SM, Slipman CW, Nirschl M, Isaac Z, El-Abd O, Sharps LS, Garvin C. Side effects and complications after percutaneous disc decompression using coblation technology. Am J Phy Med Reh 2006;85:6-13.
9. Derby R, Eek B, Chen Y. Intradiscal Electrothermal Annuloplasty (IDET): A novel approach for treating chronic discogenic back pain. Neuromodulation 2000;3:82-8.
10. Troussier B, Lebas JF, Chirossell JP, Peoc'h M, Grand S, Leviel JL, Phelip X. Percutaneous intradiscal radiofrequency thermocoagulation. Spine 1995;20:1713-8.
11. Yunezawa T, Ononmura J, Kosaka R, Miyaji Y, Tanaka S, Watanabe H, Abe Y, Imachi K, Atumi K, Chinzei T. The system and procedure of percutaneous intradiscal laser nucleotomy. Spine 1990;15:1175-85.
12. Hellinger J. Technical aspects of the percutaneous cervical and lumbar laser disc decompression and nucleotomy. Neurol Res 1999;21:99-102.
13. Liebler WA. Percutaneous laser disc nucleotomy. Clin Orthop 1995;310:58-66.
14. Quigley MR, Shih T, Elrifai A, Maroon JC, Lesiecki ML. Percutaneous laser discectomy with the Ho:YAG laser. Lasers Surg Med 1992;12:621-4.
15. Sherk HH. Results of Percutaneous laser discectomy with lasers. Spine State Art Rev 1993;7:141.
16. Yasargil MG. Microsurgical operation of herniated lumbar disc. In: Wullenweber R, Brock M, Hamer J, Klinger M, Spoerri O, eds. Advances in neurosurgery. vol. 4. Berlin, New York: Springer-Verlag, 1977:81-94.
17. Kambin P, Gellman H. Percutaneous lateral discectomy of the lumbar spine. A preliminary report. Clin Orthop 1983;174:127-32.
18. Mathews HH. Transforaminal endoscopic microdiscectomy. Neurosurg Clin N Am 1996;7:59-63.
19. Hijikata S, Yamagishi M, Nakayma T. Percutaneous discectomy: a new treatment method for lumbar disc herniation. J Tokyo Den-ryoku Hosp 1975;5:39-44.
20. Hijikata S. Percutaneous nucleotomy. A new concept technique and 12 years' experience. Clin Orthop 1989;238:9-23.
21. Kambin P, O'Brien E, Zhou L, Schaffer JL. Arthroscopic microdiscectomy and selective fragmentectomy. Clin Orthop 1992;347:150-67.
22. Kambin P, Casey K, O'Brien E, Zhou L. Transforaminal arthroscopic decompression of lateral recess stenosis. J Neurosurg 1996;84:462-7.
23. Mirkovic SR, Schwartz DG, Glazier KD. Anatomic considerations in lumbar posterolateral percutaneous procedures. Spine 1995;20:1965-71.
24. Lew SM, Mehalic TF, Fagone KL. Transforaminal percutaneous endoscopic discectomy in the treatment of far-lateral and foraminal lumbar disc herniation. J Neurosurg (Spine 2) 2001;94:216-20.
25. DePalma AF, Rothman RH. Surgery of the lumbar spine. Clin Orthop 1969;63:162-70.
26. Hakelius A. Prognosis in sciatica. A clinical follow-up of surgical and nonsurgical treatment. Acta Orthop Scand Suppl 1970;129:1-76.
27. Hanley EN Jr, Shapiro DE. The development of low back pain after excision of a lumbar disc. J Bone Joint Surg Am 1989;71:719-21.
28. Salenius P, Laurent LE. Results of operative treatment of lumbar disc herniation. A survey of 886 patients. Acta Orthop Scand 1977;48:630-4.
29. Weber H. Lumbar disc herniation. A controlled, prospective study with ten years of observation. Spine 1983;8:131-40.

30. Lee CK. Lumbar spinal instability (olisthesis) after extensive posterior spinal decompression. Spine 1983;8:429-33.
31. Shenkins HA, Hash CJ. Spondylolisthesis after multiple bilateral laminectomies and facetectomies for lumbar spondylosis. Follow-up review. J Neurosurg 1979;50:45-7.
32. Johnsson KE, Willner S, Johnsson K. Postoperative instability after decompression for lumbar spinal stenosis. Spine 1986;11:107-10.
33. Osman SG, Nibu K, Panjabi MM, Marsolais E, Chaudhary R. Transforaminal and posterior decompressions of the lumbar spine. A comparative study of stability and intervertebral foramen area. Spine 1997;22:1690-5.
34. Jones AA, Stambough JL, Balderston RA, Rothman RH, Booth RE Jr. Long-term results of lumbar spine surgery complicated by unintended incidental durotomy. Spine 1989;14:443.
35. Stolke D, Sollmann W, Seifert V. Intra and postoperative complications in lumbar disc surgery. Spine 1989;14:56-9.
36. Yeung AT, Tsou PM. Posterolateral endoscopic excision for lumbar disc herniation: surgical technique, outcome, and complications in 307 consecutive cases. Spine 2002;27:722-31.
37. Spangfort EV. The lumbar disc herniation: A computer-aided analysis of 2,504 operations. Acta Orthop Scand Supp 1972;142:1-95.
38. Frymoyer JW, Hanley EN Jr, Howe J, Kuhlmann D, Matteri RE. A comparison of radiographic findings in fusion and nonfusion patients, ten or more years following lumbar disc surgery. Spine 1979;4:435-40.
39. Cinotti G, Roysam GS, Eisenstein SM, Postacchini F. Ipsilateral recurrent lumbar disc herniation. A prospective controlled study. J Bone Joint Surg Br 1998;80:825-32.
40. Connolly ES. Surgery for recurrent lumbar disc herniation. Clin Neurosurg 1992;39:211-6.
41. Ebeling U, Kalbarcyk H, Reulen HJ. Microsurgical reoperation following lumbar disc surgery. Timing, surgical findings, and outcome in 92 patients. J Neurosurg 1989;70:397-404.
42. Ebeling U, Reichenberg W, Reulen HJ. Results of microsurgical lumbar discectomy. Review of 485 patients. Acta Neurochir Wien 1986;81:45-52.
43. Fandino J, Botana C, Viladrich A, Gomez-Bueno J. Reoperation after lumbar disc surgery: Results in 130 cases. Acta Neurochir Wien 1993;122:102-4.
44. Herron L. Recurrent lumbar disc herniation: results of repeat laminectomy and discectomy. J Spinal Disord 1994;7:161-6.
45. Jackson RK. The long-term effects of wide laminectomy for lumbar disc excision: a review of 130 patients. J Bone Joint Surg Br 1971;53:609-16.
46. Law JD, Lehman RAW, Kirsch WM. Reoperation after lumbar intervertebral disc surgery. J Neurosurg 1978;48:259-63.
47. O'Sullivan MG, Connolly AE, Buckley TF. Recurrent lumbar disc protrusion. Br J Neurosurg 1990;4:319-25.
48. Ozgen S, Naderi S, Ozek MM, Pamir MN. Findings and outcome of revision lumbar disc surgery. J Spinal Disord 1999;12:287-92.
49. Suk KS, Lee HM, Moon SH, Kim NH. Recurrent lumbar disc herniation: Results of operative management. Spine 2001;26:672-6.
50. Tsou PM, Yeung AT. Transforaminal endoscopic decompression for radiculopathy secondary to intracanal noncontained lumbar disc herniations: outcome and technique. The Spine J 2002;2:41-8.
51. Hermantin FU, Peters T, Quartararo L, Kambin P. A prospective, randomized study comparing the results of open discectomy with those of video-assisted arthroscopic microdiscectomy. J Bone Joint Surg Am 1999;81:958-65.
52. Mayer HM, Brock M. Percutaneous endoscopic lumbar discectomy (PELD). Neurosurg Rev 1993;16:115-20.
53. Yeung AT. The evolution of percutaneous spinal endoscopy and discectomy: state of the art. Mt Sinai J Med 2000;67:327-32.
54. Schaffer J, Kambin P. Percutaneous posterolateral lumbar discectomy and compression with 6.9 millimeter cannula: analysis of operative failures and complications. J Bone Joint Surg 1991;73A:882.

穿脊椎間孔經皮內視鏡腰椎椎間盤切除手術

昝文清

背 景： 分析報告我們執行穿脊椎間孔經皮內視鏡腰椎椎間盤切除手術的經驗。

方 法： 自 2001 至 2005 年，有 134 位患者經核磁共振掃描證實爲內含性或非內含性但未分離之腰椎椎間盤突出，引起下肢疼痛有或未合併下背痛，且經保守治療失敗，接受142回穿脊椎間孔經皮內視鏡腰椎椎間盤切除手術。

結 果： 平均年齡爲 38 歲，術後追蹤平均 8 個月。以 modified MacNab criteria 評估結果，89% 獲得成功，4% 後來接受傳統開放式腰椎椎間盤切除手術，6% 發生術後手術側下肢短暫性感覺異常，沒有嚴重神經血管傷害或死亡案例發生。

結 論： 在有經驗的醫師手上，以穿脊椎間孔經皮內視鏡腰椎椎間盤切除手術治療內含性或非內含性但未分離之腰椎椎間盤突出，具備有微創、安全並有效的特性。
(長庚醫誌 2007;30:226-34)

關鍵詞：腰椎椎間盤突出，穿脊椎間孔經皮內視鏡腰椎椎間盤切除手術

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受文日期：民國95年3月24日；接受刊載：民國95年11月14日
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