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L1-2 Disc Herniations : Clinical Characteristics and Surgical Results

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Objective : Among upper lumbar disc herniations, L1-2 disc herniations are especially rare. We present the specific clinical features of L1-2 disc herniation and compared results of different surgical options.

Methods : The authors undertook a retrospective single institution review of the patients who underwent surgery for L1-2 disc herniation. Thirty patients who underwent surgery for isolated L1-2 disc herniations were included.

Results : Buttock pain was more frequent than anterior or anterolateral thigh pain. Standing and/ or walking intolerance was more common than sitting intolerance. The straight leg raising test was positive only in 15 patients (50%). Iliopsoas weakness was more frequent than quadriceps weakness. Percutaneous discectomy group demonstrated worse outcome than laminectomy group or lateral retroperitoneal approach group.

Conclusion : Standing and/or walking intolerance, positive femoral nerve stretch test, and iliopsoas weakness can be useful clues to the diagnosis of L1-2 disc herniation. Posterior approach using partial laminectomy and medial facetectomy or minimally invasive lateral retroperitoneal approach seems like a better surgical option for L1-2 disc herniation than percutaneous endoscopic discectomy.

KEY WORDS : Upper lumbar disc · Herniation · Buttock pain.

Introduction

Upper lumbar disc herniations have been known to be no more than 5% of all lumbar disc herniations[1,6,7]. Among these, L1-2 disc herniations are especially rare[6,7]. As the possibility of the caudal end of the spinal cord being located below middle of L2 vertebra is exceedingly rare[14,16], it does not seem that gentle retraction of thecal sac during posterior approach to L2-3 level will injure conus medullaris. However, many anatomical characteristics of L1-2 disc space including proximity to conus medullaris still hinder safe removal of L1-2 disc herniation. As L1-2 disc is located in the transitional zone from the spinal cord to the cauda equina[16], it can manifest various clinical features.

The authors undertook a retrospective single institution review of the patients who underwent surgery for L1-2 disc herniation. The aims of this study are to find out peculiar clinical characteristics of L1-2 disc herniation and to establish standard surgical options. This study represents the largest clinical series in the literature to date of patients who underwent surgery for L1-2 disc herniations.

Materials and Methods

Between January 2001 and December 2003, 12,696patients underwent surgery for lumbar disc herniations in our hospital. Of the 12,696patients, only eighty-six patients (0.68%) had symptomatic L1-2 disc herniations. Of these 86patients, the patients who had symptomatic disc herniations or spinal stenosis at other levels (56patients) were excluded in this study. Thirty patients fulfilled the inclusion criteria of our study. The demographic and clinical characteristics of 30patients are presented in table 1. The patients' medical records and radiographic studies were thoroughly reviewed, and their age, sex, duration of symptoms, neurological deficits, radiographic findings, intraoperative findings, and visual an-

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Table 1. Demographic and clinical characteristics of 30patients who underwent surgery for L1-2 disc herniation

Parameters	Values
Mean age in yrs ± SD (range)	52.53 ± 15.9(25–75)
Sex	
Male (%)	21(70)
Female (%)	9(30)
Mean duration of admission (days) ± SD	8.7 ± 14.1
Mean duration of surgery (min) ± SD	92.2 ± 52.2
Mean duration of follow-up (months) ± SD	19.5 ± 11.2
Mean duration of symptoms (months) ± SD	13.1 ± 23.2
Preoperative VAS score (L*)	6.90 ± 2.55
Preoperative VAS score (B**)	7.03 ± 2.51
Postoperative VAS score (L*)	3.33 ± 1.99
Postoperative VAS score (B**)	3.80 ± 2.28

*L: Lower extremity pain, **B: Back pain

Table 2. Surgical outcomes according to the modified Macnab criteria

Type of operation	Good prognosis group		Poor prognosis group	
	Excellent	Good	Fair	Poor
LRA*(5patients)	1(20%)	4(80%)	0(0%)	0(0%)
Laminectomy**(11patients)	4(36.4%)	6(54.5%)	1(9.09%)	0(0%)
PELD*** (14patients)	2(14.3%)	4(28.6%)	2(14.3%)	6(42.9%)
Total (30patients)	7(23.3%)	14(46.7%)	3(10%)	6(20%)

*LRA : Lateral retroperitoneal approach, **Uni- or bilateral partial laminectomy and medial facetectomy with discectomy. In one case, bilateral partial laminectomy and medial facetectomy without discectomy was performed using unilateral approach. ***PELD : Percutaneous endoscopic laser assisted discectomy

alogue scale(VAS) scores were recorded. The following items were also included in the review of the patients' medical records : lower extremity weakness, sensory disturbance, locations of pain, deep tendon reflex, Babinski sign, ankle clonus, bowel and bladder dysfunction, sexual dysfunction, limitation at straight leg raising(SLR) test, femoral nerve stretch test(FNST), and specific conditions aggravating pain. Two blinded observers telephoned to all of 30patients to define their final outcomes and to supplement medical records. They could talk over the telephone with 27 of 30patients. The patients' outcomes were assessed using modified Macnab criteria. Good prognosis group was defined as the patients who showed excellent or good outcome, and poor prognosis as the patients showing fair or poor outcome. On preoperative magnetic resonance (MR) imaging or computerized tomography(CT) scan, we measured the area of spinal canal and protruded disc material at maximal compressive level with an aid of PiView program (Infinitt Co., Ltd, Seoul, Korea). The occupying ratio of disc (area of disc/area of spinal canal × 100, %) was calculated. The levels of termination of the spinal cord were divided into 5 zones (Fig. 1). Fourteen patients underwent percutaneous endoscopic laser assisted discectomy(PELD); eleven patients, partial laminectomy and discectomy; and five patients, lateral retroperitoneal approach(LRA) (Table 2). We preferred LRA in patients with severely calcified disc or a disc herniation in association with a bony spur compressing the thecal sac. Posterior approach was performed on patients who had soft disc herniation with mottled calcification. The authors chose posterior approach or PELD in patients with soft disc herniations without calcification. The surgical procedure was selected depending upon surgeon's preference in such a circumstance.

Table 3. Specific conditions that aggravate the symptoms of the patients

Specific conditions	No. of patients (%)
Lying on patients' back	8(26.7%)
Stand still*	9(30.0%)
Walking	15(50.0%)
Changing position	5(16.7%)
Rise up	3(10.0%)
Lean forward	1(3.33%)
Turn over in sleeping	1(3.33%)
Sitting	5(16.7%)

*Three of nine patients (10.0%) could not so much as step on the ground because of excruciating leg pain

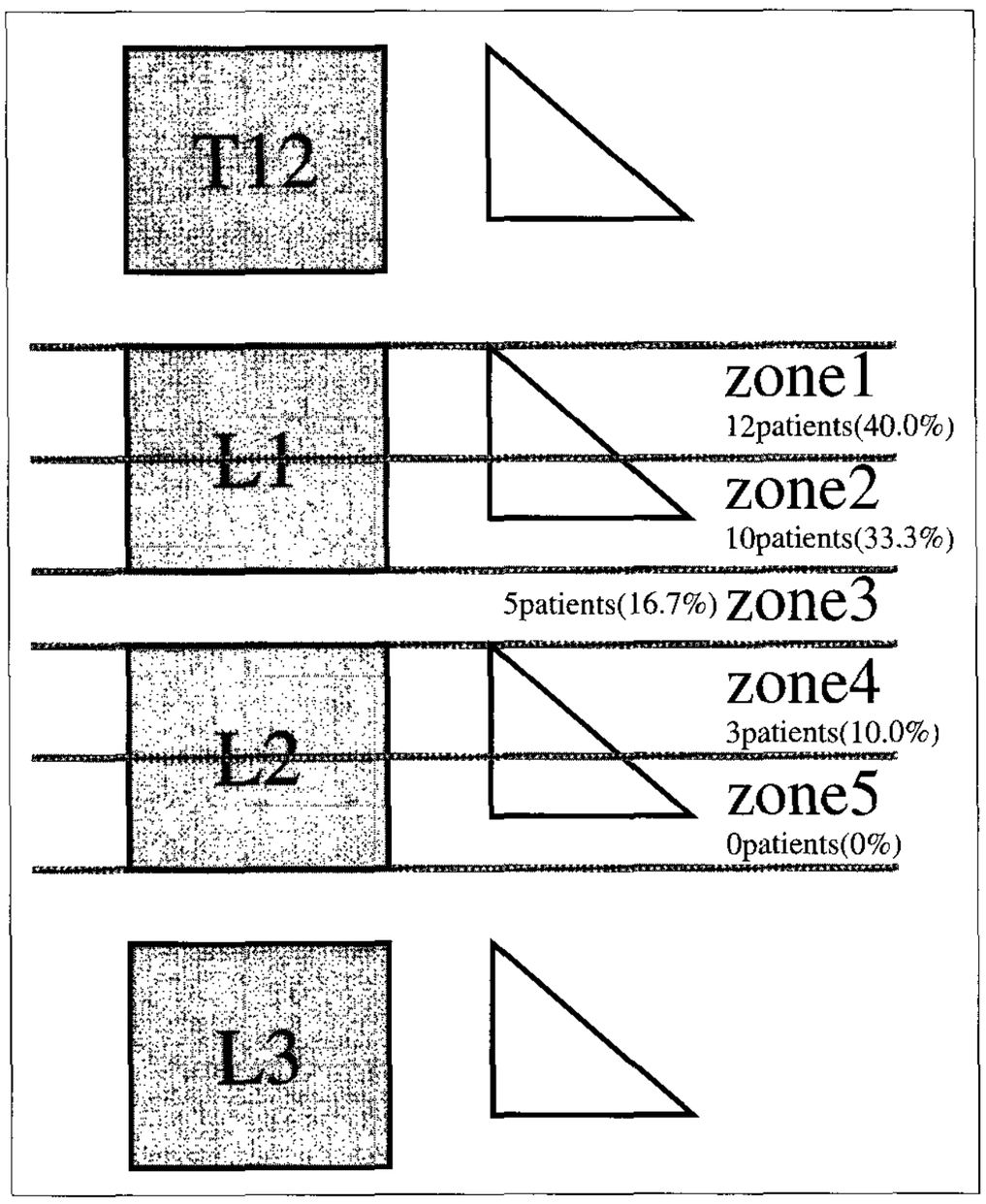

Fig. 1. A schematic drawing showing five zones and the level of conus medullaris. In order of frequency, the conus medullares were located at zone 1 (n=12), zone 2 (n=10), zone 3 (n=5), and zone 4 (n=3). No Patients had a conus medullaris below zone 4.

Surgical techniques

Lateral retroperitoneal approach

The patient was positioned in the lateral decubitus position. The authors used left-sided approach in most cases because manipulation of the liver or vena cava was more troublesome than the aorta[8]. The hips and knees were flexed slightly to relax the psoas muscle. After confirming the level of interest,

an oblique skin incision along the ribs was made. We resected some part of rib subperiosteally in some cases. If no bone graft was needed, an intercostal approach was preferred. Then, anterior abdominal muscles were divided. Blunt dissection proceeds along the transversalis fascia posterior to the kidney. The working space from skin to disc looks like a deep, narrow tunnel. However, we could safely decompress neural tissues with aids of high-resolution surgical microscope and specially designed long instruments. The psoas muscle may be displaced posteriorly by careful blunt dissection to reveal the lateral aspect of the vertebral bodies. We should pay special attention not to injure the genitofemoral nerve and the sympathetic chains at this point. As the left diaphragmatic crus extends to the second vertebral body[8,18], it should be swept partially to expose the anterolateral aspect of the disc. In some patients, partial resection of vertebral bodies was required. We usually used high-speed air drill (The Anspach Effort, Inc., US) in performing partial corpectomy. Prior to drilling, one must confirm whether the patient is in true lateral position to prevent inadvertent injury of major vessels during drilling. Depending on the amount of vertebral body resected, we also performed bone graft with or without rigid fixation using rods and screws.

Partial laminectomy and medial facetectomy

The authors usually used drill to thin the lamina until tiny shell of inner cortical bone remained and advanced laminectomy more cephalad to the upper limit of ligamentum flavum. The remaining thinned lamina was removed easily with small curette or 1mm Kerrison punch. Then, the ligamentum flavum was removed using blunt hook and Kerrison punch. Before complete removal of ligamentum flavum, we always performed medial facetectomy using drill with diamond tip. These surgical tactics might have helped us avoiding inadvertent neural injury owing to blunt tip of Kerrison punch during laminectomy. Prior to discectomy with micropituitary forceps, the author sometimes used CO_2 laser (Sharplan 20C surgical laser system, Sharplan Laser Industries, Tel Aviv, Israel) under direct microscopic guidance to decompress the disc initially. As the spot size of CO_2 laser was less than 1mm, precise and delicate approach to the disc was possible and excessive nerve root retractions could be avoided.

Percutaneous endoscopic laser assisted discectomy

The patient was positioned prone under local anesthesia. The skin entry points were determined on the basis of the preoperative CT or MR image. Although some individual variations exist, it is safer not to exceed 9cm from midline. The authors usually used Yeung Endoscopic Spine System (YESS, RICHARD WOLF, Knittlingen, Germany), side-firing Holmium yttrium-aluminum-garnet (Ho : YAG) laser (VersaPulse Power Suite Holmium and Dual Wavelength Surgical Lasers, Lumenis, Inc., New York, USA) and a bipolar radiofrequency electrode (Ellman Surgitron Dual 4MHz radiofrequency unit, RICHARD WOLF, Knittlingen, Germany).

Statistical analysis

The Fisher's exact test was used to compare the results of different surgical options. To compare the mean age and the sex ratio of 30patients with those of 12,666patients who underwent surgery for lumbar disc herniations excluding L1-2 level, independent t-test and chi-square test were used respectively. A p-value of 0.05 or less was considered significant. All statistical analyses were conducted with the SPSS software package (ver 11.5, SPSS, Chicago, Illinois).

Results

There were 21men and 9women, ranging in age from 25 to 75years, with a mean age of 52.53years. The mean age of 30patients were older in comparison with that of 12,666 patients (mean age : 45.31years) who underwent surgery for lumbar disc herniations excluding L1-2 level (Independent t-test, p=0.008). Of 12,666patients, male patients were 7,608 (60.1%) and female patients were 5,058 (39.9%). Compared with those of 30patients (male : 21patients, 70.0% and female : 9patients, 30.0%), sex ratios of two population groups were not significantly different (Chi-square test, p=0.268).

Nineteen patients (63.3%) had soft disc herniations and 11patients (36.7%) showed calcifications of the discs or bony

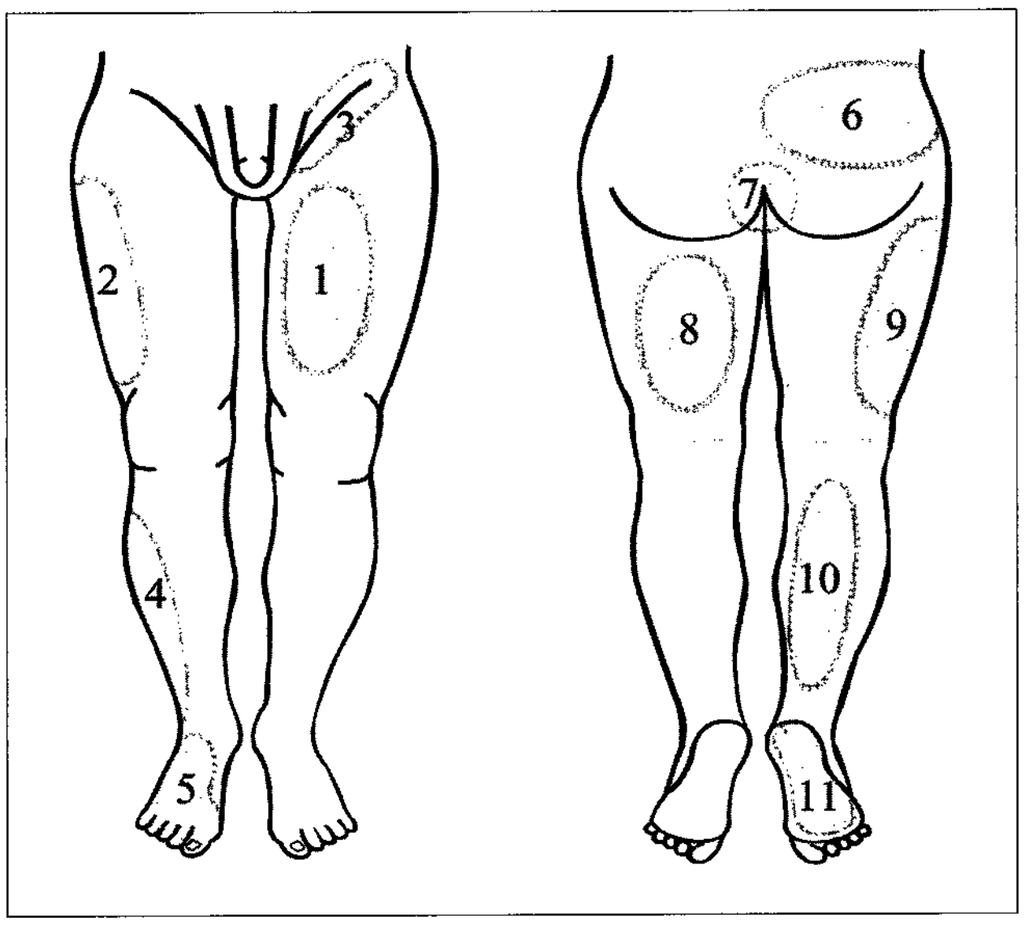

Fig. 2. Schematic drawings showing distribution of pain or sensory change in 30patients of this study. ① anterior thigh (n=10), ② anterolateral thigh (n=9), ③ inguinal (n=5), ④ anterolateral lower leg (n=2), ⑤ foot dorsum (n=5), ⑥ buttock(especially upper portion, n=21), ⑦ perianal (saddle area, n=1), ⑧ posterior thigh (n=13), ⑨ posterolateral thigh (n=1), ⑩ calf (n=9), ⑪ sole (n=1).

spurs adjacent to the discs. Over seventy percent of the patients had conus medullaris at zone 1 or 2 and no patients had a conus medullaris below zone 4 (Fig. 1). The mean occupying ratio was 40.6±9.88% (mean±SD).

The distribution of pain or sensory change was presented in figure 1. In order of frequency, the patients complained of pain on buttock (70.0%), anterior aspect of thigh (33.3%), anterolateral aspect of thigh (30.0%), inguinal area (16.7%) and foot dorsum (16.7%)(Fig. 2). Sensory disturbance was noted only in 8patients (26.7%). Of 30patients, only one patient (3.33%) showed saddle anesthesia. However, as sensory change was not described in many charts, the authors were not able to make a specific conclusion concerning sensory change. Compared with clinical features of the patients who had lumbar disc herniations below L1-2 level, some patients with L1-2 disc herniations had peculiar conditions that aggravated the symptoms of the patients (Table 3). Seven of twenty-six patients (26.9%) and five of twenty-seven patients (18.5%) showed depressed knee reflex and ankle reflex respectively. SLR test was positive in 15 of 30patients (50.0%) and FNST was positive in 11 of 17patients (64.7%). Iliopsoas weakness was found in 5 of 22patients (22.7%). Two of nineteen patients (10.5%) had quadriceps weakness and three of twenty-three patients (13.0%) showed weakness in ankle dorsiflexion. Only one patient (3.33%) complained of sexual dysfunction preoperatively. Three patients (10.0%) experienced bladder dysfunction. Bowel dysfunction was found in three patients (10.0%). The Babinski sign was not noted in any of the patients, and only one patient (3.33%) showed ankle clonus.

Twenty-one patients (70.0%) showed good prognosis at final examinations (Table 2). Compared with LRA or laminectomy group, PELD group showed worse prognosis (Fisher's exact test, p=0.04).

There were 4 complications (3patients). There was one dural tear owing to severe adhesion, which was repaired intraoperatively. The same patient also experienced pelvic bone fracture at the bone graft donor site, which did not need operative intervention. Two patients had sexual dysfunctions after PELD.

Discussion

It has been reported by several researchers that clinical features of upper lumbar disc herniations were variable and nonspecific in comparison with those of lower lumbar disc herniations[1,5-7]. It is well known that anterior or anterolateral thigh represents L2 dermatome[9,12]. However, the greatest number of patients in our study group (21patients, 70.0%) complained of buttock pain rather than anterior (10patients, 33.3%) or anterolateral (9patients, 30.0%) thigh pain. If one looked in dermatome chart closely[12], one could realize that upper buttock area was also L2 dermatome. So, any lesions compressing L2 nerve root like L1-2 disc herniation cannot only give rise to pain on inguinal area or anterolateral thigh but also give rise to pain on buttock. Substantial percentage of our patients group complained of pain on L5 or S1 dermatome also. At L1-2 disc level, intrathecal motor bundles of L5 and S1 roots are located in close proximity to the disc[17]. Several decades ago, one surgeon found out very interesting phenomenon while operating with local anesthesia on patient with cervical nerve root compression. Selective stimulation of irritated motor root reproduced the patient's presenting pain. On the other hand, selective stimulation of normal motor root provoked muscle contraction but no pain[4]. Supposing above mentioned things hold true, compressed intrathecal motor bundles of L5 and S1 roots might have caused pain on L5 and S1 dermatome. It is known that T12 or L1 vertebral body corresponds to L4, L5 and S1 myelomeres[14,16] and a lesion of the epiconus (L4 to S1 spinal cord segments) can present with symptoms and signs mimicking those of lumbar nerve root involvement and/or some forms of peripheral nerve entrapment[14]. However, as only three patients of our study group had conus medullaris below zone 3, it was less likely that pain on L5 or S1 dermatome observed in our patients represented epiconus syndrome.

It is remarkable that 15 of 30patients had preoperative VAS score of 9 or 10points. Of these 15patients, 4patients could not so much as have slept or been laying on their back for over one hour due to excruciating back or leg pain preoperatively. Three patients were admitted to our hospital via emergency room owing to severe pain. One male patient even said to the doctor, he would rather cut his leg and pricked his leg with needle in reality. Although we did not compare the severity of pain in our 30patients objectively using concrete data like VAS scores with other patients having been operated for lumbar disc herniations below L1-2 level, we can infer that the patients with L1-2 disc herniations may show a tendency to have more severe pain than that of the patients who have lumbar disc herniations below L1-2 disc level. Tokuhashi et al. reported that the patients with L1-2 disc herniation showed more severe leg pain in comparison with other patients who had disc herniations at thoracolumbar junction excluding L1-2 level[16]. There have been several reports that L2 dorsal root ganglion had a major role in innervation of lower lumbar discs in experimental animals[10,13,15]. It was reported recently that the main afferent pathways of pain from the lower intervertebral discs were through the L2 spinal nerve root and the L2 nerve root innervated from low back to buttock in human beings also[11]. Supposing L2 nerve root as a common pathway of discogenic low-back pain, we can presume that the patients with L1-2 disc herniation may have more chances to induce severe back pain in comparison with other patients having disc herniations

below L1-2 level. There is a possibility that irritated intrathecal motor bundles may cause more severe leg pain than nerve roots.

Among muscles tested in our 30patients, iliopsoas weakness was most frequent. Considering innervation patterns of muscles[12], our results were no wonder and also accorded with other reports[1,2].

Aronson et al. reported that fifty percent of the patients with upper lumbar disc herniations had an absent or depressed knee jerk and fifteen percent had an absent or depressed ankle jerk[2]. If we consider the facts that the major nerve root involved in knee jerk is L3 or L4[12] and the patients with L2-3 or L3-4 disc herniations were also included in Aronson's study[2], we will easily realize that our results were not quite different from those of Aronson's.

Of our 30patients, no patient fulfilled classic description of cauda equina syndrome[12]. However, as four patients showed one or more signs suggesting involvement of caudal nerve roots including S3, S4 and S5 (saddle anesthesia, bladder dysfunction, bowel dysfunction or sexual dysfunction), it could be interpreted in a broad sense as 13.3% of our 30patients had cauda equina syndrome.

The SLR test is known to have over 80% of sensitivity in patients with lumbar disc herniation[3,12]. However, little has been known about the clinical significance of FNST[1,4,16]. Estridge et al. dorsiflexed the knee in two patients during operation and observed that L4-root moved caudally[4]. The mechanism of pain provoked by FNST is supposed to be caused by stretching of femoral nerve. Hence, we can infer that the patients with symptomatic upper lumbar disc herniation may have more chances to show positive FNST as compared to the patients with lower lumbar disc herniation, for the L2, L3, or L4 nerve roots are main components of the femoral nerve. However, the positive FNST is not a pathognomonic sign of upper lumbar disc herniation, as it is frequently observed in patients with diabetic neuropathy also[4]. As the FNST was not included in routine check-up lists for low-back pain patients in our hospital, we could not clarify its importance in evaluating patients with L1-2 disc herniation definitely. Considering the fact that the FNST was positive in five of eleven patients (45.5%) in whom the SLR tests were negative, the FNST could be a very useful tool to find out L1-2 disc herniation.

Sitting intolerance is one of well-known clinical features of lumbar disc herniation[12]. However, many of our patients complained of walking or standing intolerance rather than sitting intolerance. Neurogenic intermittent claudication(NIC) is known to be rare in patients with single level lumbar disc herniation[12]. However, as the spinal canal of L1 vertebra is narrowest among lumbar vertebrae and mean occupying ratio of our 30patients was over 40% (Table 3), we can presume that some of our patients who complained of severe pain during walking represented some features of NIC. It is noteworthy that nine of thirty patients (30.0%) experienced severe leg pain during standing and even three patients were not be able to step on the ground owing to excruciating leg pain. Although there were no patients who showed instability in radiographic studies preoperatively, five patients complained of severe pain at the time of changing position. There was a report that standing intolerance being observed in some patients with lumbar disc herniation might be attributable to irritation of nerve root rather than severe compression[12]. We can infer from our results that some kind of hypersensitivity of nerve roots or intrathecal motor bundles to irritation might played some role in provoking standing intolerance or pain during changing position.

Although preoperative symptom durations of our 30patients were very diverse (mean±SD, 13.1±23.2months, range : 1week~8years), it is worthy of note that preoperative symptom durations in 8patients were over 12months and even it have taken 8years to diagnose L1-2 disc herniation in one patients. These might be interpreted as the diagnosis of L1-2 disc herniation was not easy.

There have been several reports that the development of L1-2 disc herniation was related with previous back operation[1,2] or abnormal mechanics[6]. Of our 30patients, only two patients (6.67%) had histories of previous back operations. No patient showed instability or abnormality in sagittal or coronal balance. Judging from our results, it is less likely that history of previous back surgery or abnormal mechanics have significantly influenced the development of L1-2 disc herniation in this study population.

If the main pathology is located anterior portion of L1 or L2 vertebra and the physical character of the pathology is not soft, posterior approach will inevitably have substantial risk of neural injury. However, as direct anterior approach to L1-2 level is almost impossible due to various anatomical obstacles including renal arteries or veins, we will inevitably select lateral approach in such case. The authors preferred LRA in patients who had severely calcified disc or bony spurs prohibiting safe posterior approach. Thoracoabdominal approach is a well-known invasive lateral approach to the pathologies located in thoracolumbar junction. Although LRA is a modification of thoracoabdominal approach, we do not need to resect rib unless we are to use rib as graft material. If we adopt a microsurgical modification and are well acquainted with LRA, LRA for L1-2 disc herniation will not be an invasive surgery anymore. Recently, it became possible for experienced surgeons of our hospital to approach L1-2 level using less than 6cm of skin incision.

It is well known that unilateral or bilateral medial facetectomy, if created without the division of the posterior ligaments,

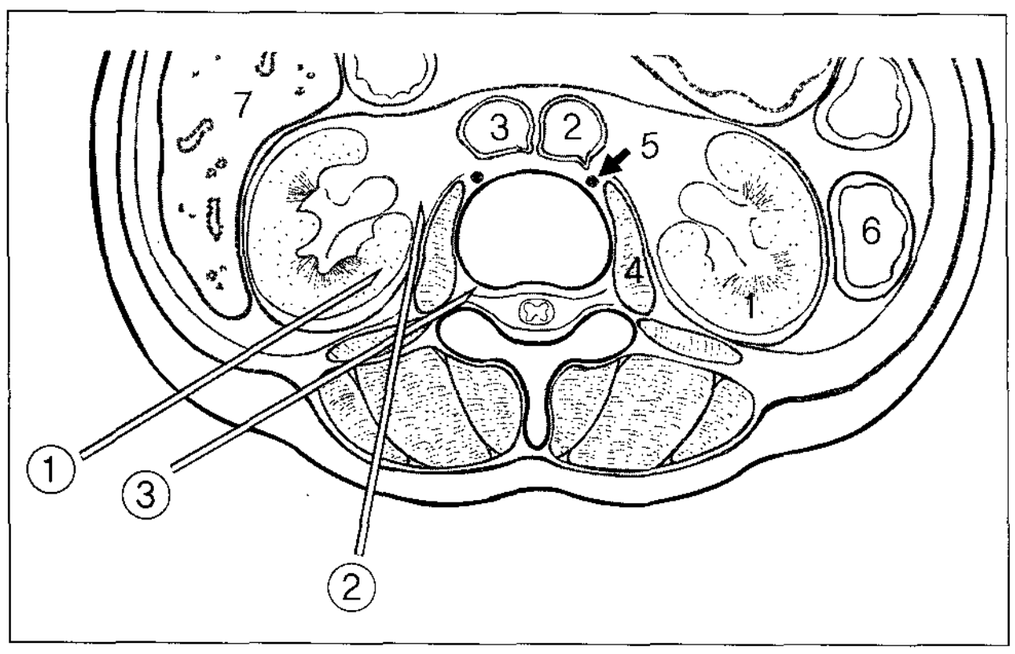

Fig. 3. Axial view of percutaneous posterolateral approach at L1-2 level. The numbers 1, 2, 3, 4, 5 and 6 indicates Kidney, Aorta, Vena cava, Psoas muscle, Sympathetic chain, Descending colon, and Liver, respectively. At L1-2 level, the kidney often restricts ample lateral entry point. In addition, as the bulk of psoas muscle at L1-2 level is smaller compared with those of lower lumbar levels, steep placement of a needle is likely to violate the peritoneal cavity. ① : Too lateral skin entry can injure kidney or liver. ② : Too medial skin entry can violate peritoneal cavity. ③ : Safe skin entry.

dose not affect any of spinal motions[10]. In eleven patients who underwent unilateral or bilateral partial laminectomy and medial facetectomy for treatment of L1-2 disc herniations of our study group, no patient showed junctional degeneration or radiolographic evidence of instability. Thanks to many technical advances and accumulation of experiences about percutaneous endoscopic discectomy, L1-2 discectomy using percutaneous posterolateral approach became feasible. As we already mentioned, the kidney restricts ample lateral entry point. So, as we go upper lumbar levels, the angle between endoscope and the patient's back becomes acuter. Compared with lower lumbar levels, psoas muscles at L1-2 level are much smaller[13]. Not only too lateral entry, but also too medial entry can cause catastrophic events (Fig. 3). Several years ago, some experienced surgeons in our hospital started L1-2 discectomy using percutaneous posterolateral approach. However, functional outcomes of the patients who underwent PELD for L1-2 disc herniation at last follow-up were very disappointing. Five of fourteen patients (35.7%) needed reoperations. Two patients having shown excellent outcomes immediately after surgery got worse later.

Conclusion

Not only anterior or anterolateral thigh pain but also buttock pain was an important clinical feature of L1-2 disc herniation. Standing and/or walking intolerance was more frequent finding than sitting intolerance. FNST can be a useful diagnostic tool to find out L1-2 disc herniation especially when the SLR test is negative. Among muscles tested, iliopsoas weakness was most frequently observed. Although PELD at L1-2 level is technically feasible, it would be better to be reserved for the patients who cannot withstand general anesthesia. In most cases of L1-2 disc herniations, posterior approach using partial laminectomy and medial facetectomy or minimally invasive LRA seems like the best surgical option.

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