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Original Article

Minimally Invasive Lumbar Microscopic Discectomy for Treatment of Cauda Equina Syndrome, Is It Effective?

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BACKGROUND: Cauda equina syndrome (CES) is a rare but an important emergent state caused by compression of lumbosacral nerve roots. Conventionally, the treatment of CES patients was total laminectomy and discectomy. It has been reported that minimally invasive lumbar microscopic discectomy (MIS-LD) led to outcomes comparable to conventional open microdiscectomies, with fewer complications.

OBJECTIVE: This IS study aimed to assess the effectiveness of minimally invasive lumbar microscopic discectomy for treatment of huge or ruptured lumbar disc herniation (LDH) causing CES.

METHODS: This is observational retrospective case series of 12 patients treated for CES due to huge/ruptured LDH with MIS-LD. Patient's demographics and outcomes included visual analogue scale (VAS) and Medical Research Council (MRC) grading scale for low back pain (LBP), and sciatica, and lower limbs motor power assessment, respectively. Oswestry disability index (ODI) for pain and weakness as functional score. Postoperative follow up continued for 18 months to evaluate recovery of sciatica, motor weakness, urinary/bowel functions, saddle area sensory changes and sexual dysfunction.

RESULTS: All patients were males, aged 28–59 years with mean age ± standard deviation (SD) of 43.14±4.2 years. Operative time ranged from 90minutes-3hours with mean time ± SD of 132.86±35minutes. Sciatica improved immediately, urinary and bowel functions recovered completely within weeks in all patients (100%), lower extremity weakness improved after 1-3 months in 11 patients (92%), and sexual dysfunction improved from 8-10 weeks in all patients (100%). Finally, saddle area sensation returned to normal after six months in all affected patients (100%).

CONCLUSION: Minimally invasive lumbar microscopic discectomy is effective and efficient procedure for treatment of CES caused by huge/ruptured LDH with good recovery of motor power, full control of urinary, bowel and sexual functions, and normal saddle sensation, without surgical side effects.

Keywords: Cauda equina syndrome, Lumbar disc herniation, Minimally invasive discectomy.

INTRODUCTION

CES is a rare but an important emergent state caused by compression of lumbosacral nerve roots. It is considered one of the most serious and complicated spinal disorders.[1,2] Etiology of CES may be due to spine trauma, pathological spine fracture or rare spinal epidural or subdural hematoma, but massive LDH is considered the most common cause of CES.[3,4] It has been reported that CES presents only in 1-3% of LDH patients.[5]

According to Fraser et al., diagnosis of CES is made if patient has one or more of the following symptoms; saddle area dysesthesia or anesthesia (diminished or loss of sensation over the perineum, buttocks, and inner thighs, urinary or bowel sphincteric disturbances, sexual dysfunction, with either presence of sciatica and lower limbs neurological motor deficit or not.[5] Symptoms are devastating and often indicating admission of patient to the hospital for emergent spine decompression.[6]

When acute CES is suspected, the diagnostic workup for its cause must be done without delay. Once huge ruptured or massive LDH leads to symptoms referable to CES, an emergent lumbar discectomy is very crucial. Although CES is a rare surgical condition, it must be diagnosed and treated immediately and properly to provide the best opportunity of recovery and return of normal physiological functions.[7]

Conventionally, the treatment of CES patients was total laminectomy and discectomy, as the procedure of choice for surgical spine decompression.[6] More recent clinical studies have reported favorable outcomes of hemilaminectomy with discectomy for CES.[4,8] Minimally invasive techniques have started to influence the spine surgery years ago and it has been reported that MIS-LD led to comparable outcomes to conventional

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open microdiscectomies with fewer complications. However, they are often not recommended in CES due to suspected over-manipulations required through a smaller approach, longer operative time in emergency conditions and difficulty of removal of a large disc fragment.[7] Furthermore, there are high probabilities of residual deficits of lower limb(s), and bladder and/or sexual dysfunction leading to patient unsatsifaction and medico-legal issues.[9,10]

PATIENTS AND METHODS

This is a retrospective observational study of 12 patients who were treated for CES with emergent MIS-LD surgery. This study was conducted from January 2020 to December 2022 and approved by the Clinical Research Ethical Committee of 6th of October University Hospitals under approval number PRC-Me-2212047. All participants signed a written informed consent to enroll in the study.

Research data included patient's demographics (age & sex), clinical presentation of patient and time between the onset of clinical presentation until surgery. Clinical symptoms and signs based on a detailed neurological history and examination were recorded and included axial LBP, sciatica, motor and/or sensory deficits, reflex changes, special clinical tests indicating nerve root tension signs as straight leg raising (SLR) test and crossed straight leg raising (XSLR) test and sphincteric dysfunction. We used VAS for axial LBP and/or sciatica as patients were educated that the worst pain marked 10 and no pain marked 0. We considered the classification of VAS as 0 degree for no pain or pain free, 1-4 degrees for mild pain, 5-8 degrees for moderate pain and 9-10 degrees for severe pain. Also, we used ODI for pain and weakness as a functional score to assess the patient's functionality, activities of daily living and quality of life. ODI is a categorical ordinal scale that consists of 10 questions related to activities of daily living. Each item is scored 0–5 (5 being the most disability) and the total is multiplied by 2% to obtain the final score (range: 0–100%). Interpretation of the final score is shown in **Table 1.**[11]

Regarding motor power examination of lower limbs, we used MRC grading system scale.[12,13] We examined specifically ankle dorsiflexion and plantar flexion, great toe extension, knee flexion and extension, and hip extension, flexion, adduction and abduction. We conducted testing each muscle immediately with testing of its contralateral counterpart to enhance the detection of any asymmetries. Muscle strength is often rated on a scale of 0/5 to 5/5 as shown in **Table 2.**[13] Regarding sensory system examination of lower limbs, we used superficial sensory examination to detect any dermatomal sensory changes and saddle area sensory deficits. Deep tendon reflexes of lower limbs were recorded especially ankle jerk reflex if it was diminished or totally absent.

Nerve root tension signs as SLR test and XSLR test were documented. SLR test is done with and patient in supine position, we raise the ipsilateral leg straightly by the ankle until pain is elicited (should occur at < 60°, as tension in nerve increases little above this angle). A positive test consists of leg pain or paresthesias in distribution of the root that become under tension. SLR primarily tenses L5 and S1, L4 less so, and more proximal roots very little. XSLR test is a SLR on the painless leg that causes contralateral leg pain with a greater degree of elevation usually required than the painful side. XSLR may correlate with a more central LDH. It is more specific but less sensitive than SLR as approximately 97% of patients undergoing disc surgery with this sign have confirmed LDH.[14,15] Sexual and sphincteric dysfunction was documented based only on the detailed history due to emergency circumstances.

Magnetic Resonance Imaging (MRI) of lumbosacral spine with MRI myelography scans were assessed for the presence of a massive/ruptured LDH, its level, direction of herniation (mostly central with predominance to one side, right or left) and free fragment sequestration or migration, and complete myelograhic block of lumbosacral spinal canal, respectively. Plain X-ray (PXR) (anteroposterior (AP), lateral and dynamic flexion and extension views) of lumbosacral spine images were assessed to rule out the overt instability and spine congenital anomalies and also to be compared with postoperative PXR to assess the extent and degree of bony work in the lamina.

Surgical procedure time, presence of intraoperative adhesions, ruptured sequestrated free fragment, bulging thecal sac and inflamed edematous nerve roots, the occurrence of intraoperative complications as unintentional dural tear, cerebrospinal fluid (CSF) leak, nerve root injury and the need for switching to open decompressive laminectomy and discectomy were documented.

The surgical technique

All patients undergoing MIS-LD for CES were prepared for surgery, intubated and ventilated after induction of general anesthesia in supine position and then placed in prone position on a spine bridge. Good surgical positioning was done and all pressure points were padded. Intraoperative C-arm fluoroscopy was used to localize the level of the accurate lumbar disc that will be addressed. After sterilization and draping of patient, skin incision was done with 2 cm length in the midline and then subcutaneous tissue and lumbosacral fascia were opened by using a dissecting scissor. The subperiosteal peeling or dissection of lumbosacral muscles from spinous process and lamina was done unilaterally on the predominant ipsilateral clinical and radiological side of LDH. After reaching the lamina, another lateral view confirmatory disc level localization was done by intraoperative C-arm fluoroscopy. A proper minimal invasive lumbosacral retractor was used for more exposure.

The surgical microscope was used from this step, then a large fenestration up to hemilaminectomy was done in the ipsilateral lamina by using 1mm ,2 mm and 3 mm

up cutting micro Kerrison rongeurs directed cranially. Hemilaminectomy was continued until the defect of ligamentum flavum was exposed which indicates insertion of flavum in the undersurface of lamina. A blunted tip micro-hook was used to elevate ligamentum flavum and flavectomy was done by the micro Kerrison rongeur directed caudally up to lamina of lower level. The retractor allowed us to move towards all four directions without more muscle violation to complete the bony work. A micro-dissector was used to dissect and expose the traversing nerve root and the underlying ruptured or massively herniated lumbar disc. The maneuverability of the cauda equina and traversing nerve root was done without undue sustained retraction but with a very delicate and gentle intermittent retraction that was done by atraumatic micro suction tip and micro-dissector until the disc fragment became apparent in the surgical working area. A disc punch forceps were used to remove the disc fragment and other disc material in a delicate manner. The surgical site was irrigated only with normal saline and haemostatic material (Gelfoam) was impeded in the working area. We did not put a closed suction drainage system in 5 cases because the oozing was very minimal. Fascia was closed with interrupted 2-0 Vicryl sutures followed with 2-0 Vicryl stitches for subcutaneous tissue, and then subcuticular skin sutures for closure of skin edges by absorbable non removable sutures.

Table 1: Oswestry disability index (ODI) score[11]

Score	Interpretation
0–20%	Minimal disability: can cope with most daily activities.
21–40%	Moderate disability: pain and difficulty with sitting, lifting, and standing. Patient may be disabled from work.
41–60%	Severe disability: pain is the main problem, but other areas are affected.
61–80%	Crippled: back pain impinges on all aspects of patient's life.
81–100%	These patients are either bed-bound or else are exaggerating their symptoms.

Table 2: Medical Research Council (MRC) grading system scale[13]

Score	Interpretation
0/5	No contraction (total paralysis).
1/5	Muscle flickers or trace contraction either visible or palpable, but no movement.
2/5	Movement possible, but not against gravity (with gravity eliminated).
3/5	Movement possible against gravity, but not against resistance.
4/5	Movement possible against resistance with subdivisions: 4- (slight resistance), 4 (moderate resistance) and 4+ (good resistance).
5/5	Normal strength (against full resistance)

Postoperative follow up assessment

Clinical data immediately after surgery and in 1st postoperative day postoperative was recorded. All patients were discharged in 2nd postoperative day. Follow up was done for 18 months scheduled at 1, 4, 6, 12 weeks and then every 3 months up to 18 months in outpatient clinic, to assess recovery of sciatica, motor weakness, urinary/bowel functions, saddle area sensory changes and other presenting symptoms and signs.

Results

All patients were males with age 28 to 59 years old with mean age ± SD of 43.14±4.2 years **(Fig. 1)**. They all presented with moderate axial LBP and severe unilateral sciatica (100%). Isolated urinary incontinence occurred in two patients (16.6%), isolated bowel incontinence occurred in one patient (8.3%), while both urinary and bowel incontinence occurred in four patients (33.3%). Six patients (50%) complained of saddle area numbness but walking problems were present in all patients (100%) and ranged from limping to being on a wheel chair. Sexual dysfunction was reported in four patients (33.3%) **(Fig. 2).**

Preoperatively, axial LBP was moderate while unilateral sciatica was severe in all patients based on VAS scale. All patients were completely disabled based on ODI score as nine of them were with ODI score 100% and three of them were with ODI score 70%. All patients presented with partial foot drop as motor power examination was grade 2/5 in ankle dorsiflextion in 9 patients and grade 3/5 in ankle planter flexion in 3 patients while dorsiflexion of big toe was grade 2/5 in all patients. Other lower limb movements like hip joint abduction and extension were affected also with grade 3-4/5 in all patients. Sensory examination revealed L5 dermatomal distribution hypoesthesia in 8 patients and S1 dermatomal distribution hypoesthesia in 4 patients. Saddle area sensation was diminished in 10 patients and only two patient not affected. Deep tendon reflexes examination revealed absent ankle jerk in 4 patients and diminished in 8 patients. SLR was positive in all patients with severe limited degree of leg elevation angle not exceeding 20 degrees while XSLR was positive in 7 patients.

All patients presented to us after a period of time from

onset of symptoms that ranged from one week to two weeks. Four patients presented after two weeks (33.3%), one patient after 12 days (8.3%), one patient after 10 days (8.3%) and six patients after one week (50%).

MRI revealed massive/huge LDH with complete myelographic block in all patients (100%) indicating severe caudal compression. L4-5 disc was massively herniated in eight patients (66%) and ruptured in four of them (50%) and L5-S1 was massively herniated in four patients (34%) and ruptured in one of them (25%), with huge disc fragment migrated downward obliterating the lumbar canal in all patients (100%) **(Fig. 4a,b, and c)**.

The surgical operative time ranged from 90 minutes to 3 hours with mean operative time ± SD of 132.86 ± 35 minutes. Intraoperative complications as unintentional dural tear, CSF leakage and nerve root injury did not occur in any patient (0%). Intraoperatively, adhesions (amalgamated thecal sac with root and disc material with difficult differentiation between nerve tissue and disc material) was found in two patients (16.6%), ruptured sequestrated free fragment was found in six patients (50%), bulging thecal sac was faced in all patients (100%) and there was inflamed edematous nerve root in four patients (33%) **(Fig. 5)**. Switching to open surgery with decompressive laminectomy and discectomy did not occur in any patient (0%).

Improvement of preoperative symptoms was not at the same time for all symptoms. Axial LBP improved gradually by time in all patients (100%) as it changed from severe (immediate postoperative) in five patients and moderate in seven patients to very mild LBP based on VAS scale in the first week. Sciatica improved immediately postoperatively before patient's discharge in all patients (100%) as it changed from severe sciatica to being sciatica free in nine patients and very mild sciatica in three patients based on VAS scale **(Fig. 3)**. SLR was negative in all patients with unlimited degree of leg elevation angle and XSLR was not present in all patients in the first postoperative week. Lower extremity weakness improved after 1 month in eight patients (66%) and after three months in two patients (16.6%) as they became intact in motor power with grade 5/5 and still one patient (8.3%) had a dorsiflexion weakness in big toe movement with grade 4/5 based on the MRC grading scale.

The urinary and bowel functions recovered completely within a couple of weeks in all patients (100%) as urinary incontinence improved firstly and then bowel function. Sensory examination revealed L5 and S1 dermatomal distribution normoesthesia after 4 months in all patients (100%). Sexual dysfunction improved from 8-10 weeks in all 4 patients (100%). Finally, the saddle area sensation returned to normal after six months in all 6 patients (100%) who had complained of saddle area numbness preoperatively.

The post-operative PXR lumbosacral spine was compared to the pre-operative PXR to know extent and degree of bony work in the lamina and revealed that by MIS-LD, the bony work was minimal and did not expose patients to any degree of iatrogenic spine instability **(Fig. 4d, e).**

Secondly all patients had excellent functional recovery, good quality of life and regained normal daily life activities after surgery based on the ODI score. Apart from one patient who still had a big toe dorsiflexion weakness, all patients at the 18th month of follow up were fully recovered from all the presenting symptoms and signs and regained full motor power, full control of urinary, bowel, and sexual functions.

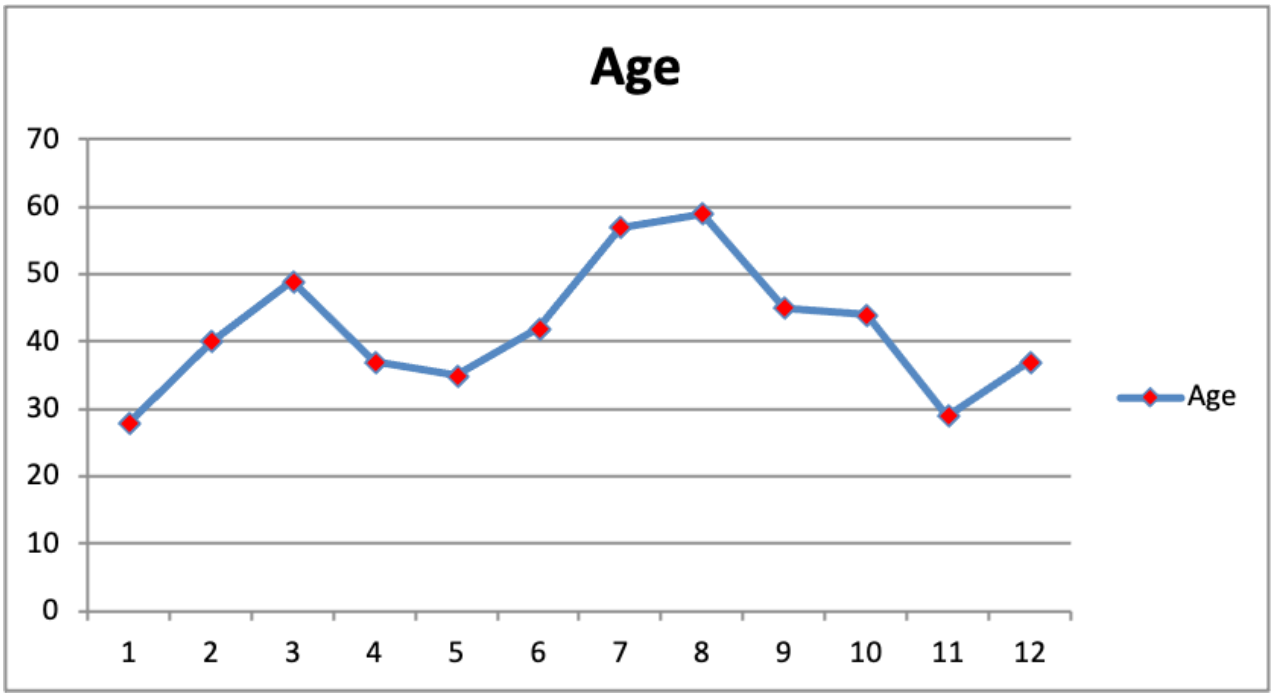

Fig 1: The age distribution of the included patients.

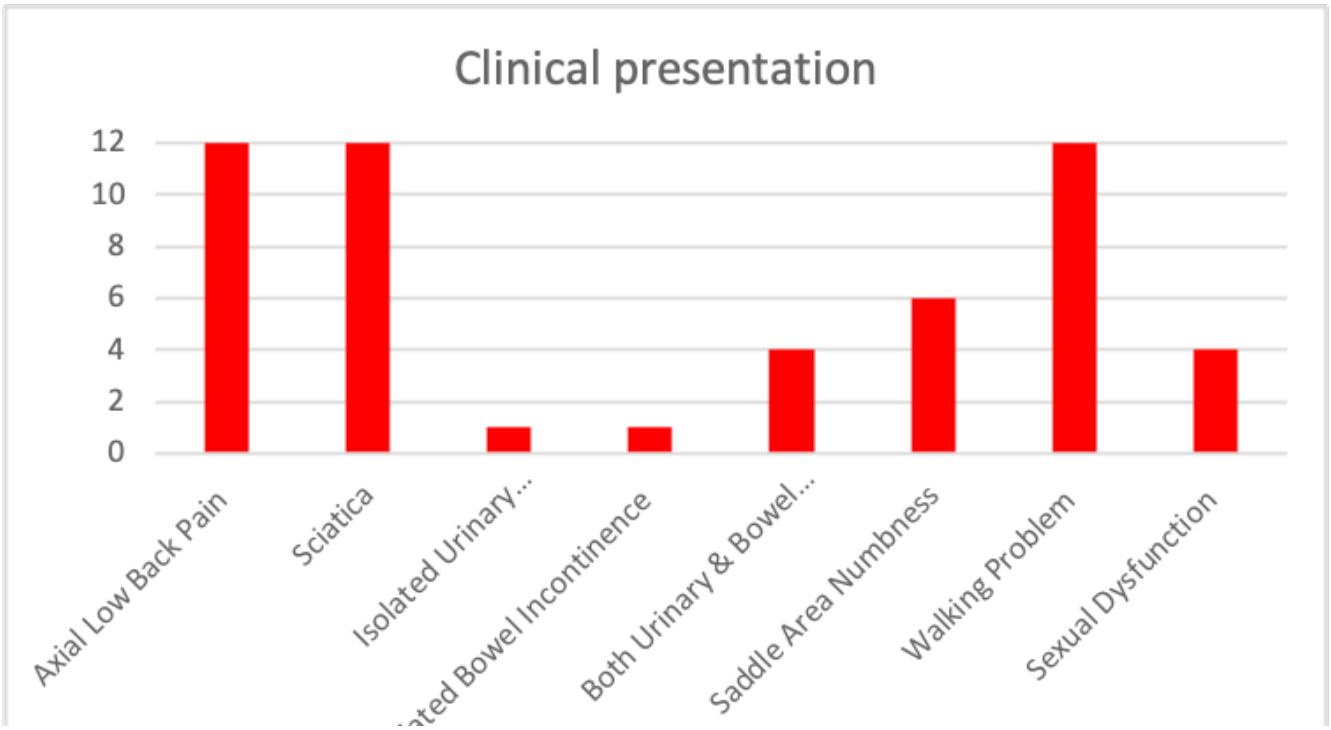

Fig 2: The clinical presentations of the included patients.

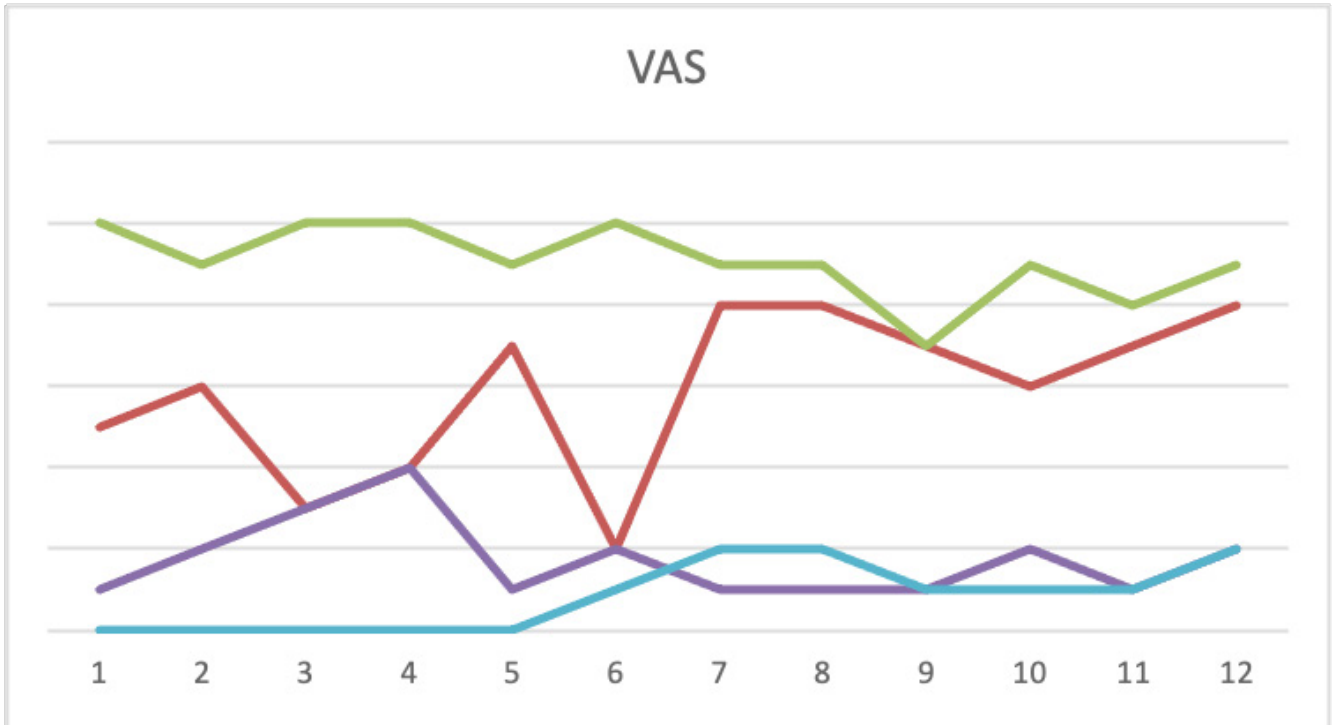

Fig 3: Visual Analogue score in study cases.

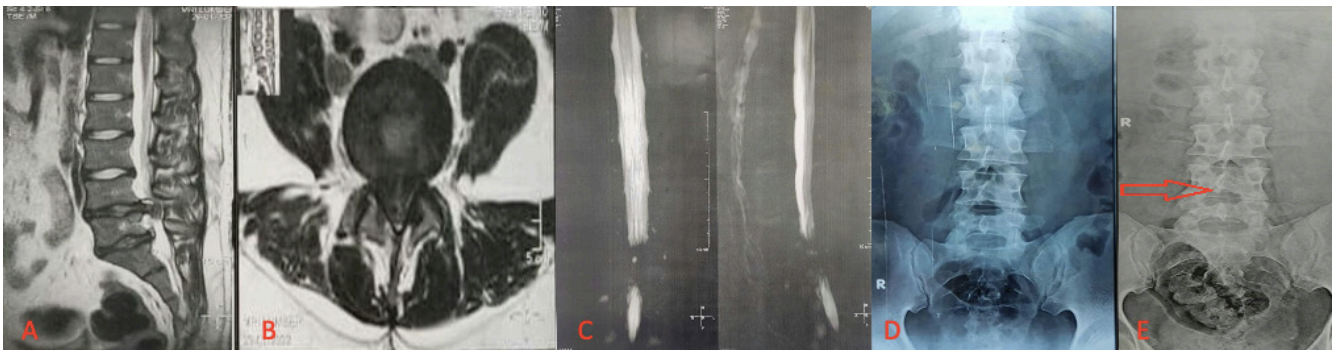

Fig 4: A) & B) MRI showing massive/huge LDH C) Myelogram showing complete myelographic block D & E) Post-operative Xray lumbosacral spine was compared to the pre-operative showing that bony work was minimal.

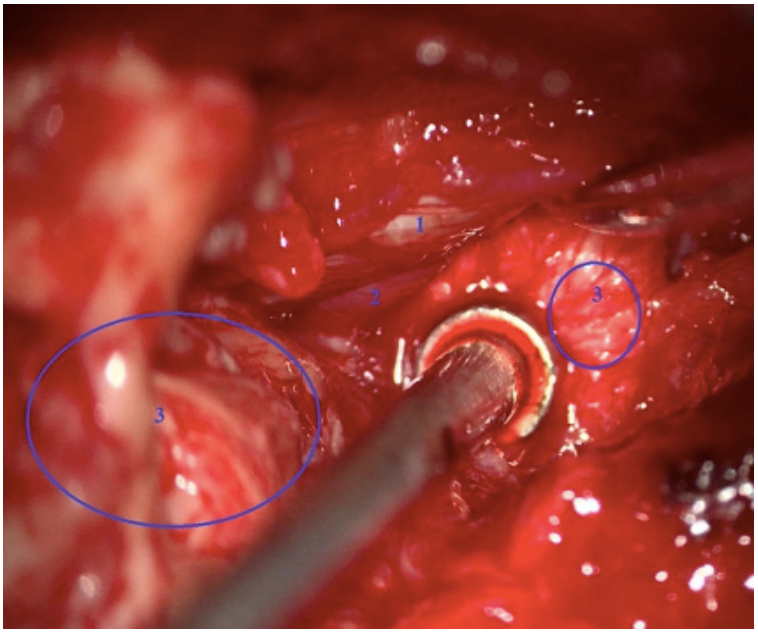

Fig 5: Intraoperatively, adhesions (amalgamated thecal sac with root and disc material with difficult differentiation between nerve tissue and disc material), ruptured sequestrated free fragment, bulging thecal sac and inflamed edematous nerve root.

DISCUSSION

CES is a rare serious urgent neurosurgical spine condition that was firstly described by Mixter and Barr in 1934.[16,17] Traditionally, a wide-open lumbar decompression by full laminectomy and discectomy was believed to achieve optimal decompression of spinal canal with the least complications in CES.[18,19] It was thought that this approach will reduce the risk of intraoperative complications as unintentional dural tears and nerve root injury.[20] However, there are possible drawbacks of open decompressive spine surgery as the relatively extensive trauma to paraspinal muscles and/or soft tissue, posterior ligamentous complex and facet joints. These injuries can be associated with greater risk of postoperative complications such as surgical site infection, epidural adhesions or fibrosis, severe postoperative LBP and iatrogenic future spine instability.[21,22]

Since the size of LDH causing CES are usually huge, their surgical removal may be more difficult and challenging. The rate of CSF leakage can be more frequent with full laminectomy and ligamentum flavectomy. This may result from pressure by LDH over the thecal sac. Additionally, nerve root injury can occur due to over-retraction or poor visualization.[7]

Generally minimal invasive microdiscectomy (MID) has advantages of decreased blood loss, less tissue trauma, conservation of posterior tension ligamentous and bony bands, less postoperative axial LBP, shorter functional recovery and lower infection rates.[21,23-26] Moreover, there is certainty that the small working channel which is done in MID surgery limits or avoids CSF leaks from becoming symptomatic compared to open laminectomy, which may need further procedures to deal with it.[27] Due to these factors, when performed safely in CES, MID surgery has some clear advantages over open full laminectomy surgery.[7]

However, there are some worries about using MID as the procedure of choice in emergent condition like CES. These worries may come from a false belief that MID has a longer operative time when compared to open full

laminectomy. Besides, the small working tubular channel was believed to interfere with removal of a huge disc fragment leading to either excessive undue thecal sac and/or nerve root retraction or inadequate decompression of cauda equina nerve roots.[7]

Shih et al. performed a retrospective series of four patients (1 male and 3 females) who presented with CES and were operated with MID. Their study showed that operative length times were comparable to reported operative length for open laminectomies, and the bladder symptoms recovery and motor recovery was 100%. They concluded that MID can be used effectively in treating a large ruptured or sequestered lumbar disc fragment that can present with manifestations of CES. Their study was analogous to our study in absence of complications, no switch to open surgery and bladder symptoms recovery rate but not in motor symptoms recovery rate as we have approximately 86% motor symptoms recovery rate.[7]

In addition, Khashan et al, conducted a comparative study between MID and open full laminectomy for treatment of CES (12 patients each, 18 males and 6 females). They concluded that MID is effective and safe procedure for treatment of CES when compared to open full laminectomy and discectomy. Also, they found that while laminectomy may still be considered as the safest surgical procedure for treatment of CES, MID might also provide more favorable results when compared to open surgery especially regarding LBP improvement.[28]

In addition, further minimally invasive surgical techniques other than MIS-LD had been done as a treatment for CES and it was an effective treatment. One of these was discussed in the clinical study by Krishnan et al., who performed a retrospective series of 15 patients (13 males and 2 females) with CES who were operated upon by percutaneous transforaminal endoscopic lumbar discectomy (PTELD), and they found that urinary manifestations improvement was 100% and lower limb motor affection improvement was 80%. Their study was similar to our study in gender distribution of patients, as we expected that CES are more common in males, bladder symptoms recovery rate, absence of complications and no switch to open surgery. Also, the motor function did not improve in all of their patients.[3]

Another example is Yankang et al. who conducted a retrospective comparative study between full endoscopic lumbar discectomy versus laminectomy for CES in 43 patients (21 patients for endoscopy and 22 patients for laminectomy), and they concluded that CES clinical improvement was similar with both techniques in short-term and intermediate-term follow-up. However, endoscopic treatment was valuable in reducing intraoperative bleeding, operative time, and hospital stay when compared to open laminectomy.[6]

From all the above-mentioned clinical studies we can realize that MIS-LD surgery and other minimally invasive surgical techniques can be used as procedure of choice in treatment of CES with the same outcome of open total laminectomy but with minimal or no complications.

There is a controversy regarding the relative importance of timing of surgery from onset of symptoms as a prognostic factor affecting outcome in CES. The role of urgent surgery in improving the outcome of CES is still debatable as some studies documented good outcome from emergency spine decompression while others have reported no difference. Based on the belief that the chance of neurological deficit improvement may already have been lost at the time of hospital admission and also removal of huge and central LDH is more difficult than usual lumbar discectomy and may require a wide-ranging exposure, these factors may support the claim that spine decompression surgery when done on emergency bases as in CES may even increase the morbidity.[29-31]

In our study we noticed that despite all patients presented late from their symptoms onset (1-2weeks) and we operated upon them on emergency bases after very rapid preparation within 8 hours, all of them except one patient, were fully recovered from all presenting symptoms and signs including motor, sensory, urinary and bowel symptoms.

This issue was discussed by Qureshi and Sell, who studied the effect of the time of surgery on the surgical outcome in CES patients treated by surgical decompression. They documented that severity of urinary incontinence at presentation was the main principle factor of outcome and there was no statistically significant difference in outcome between their groups of patients as regards the duration of time from onset of symptoms to surgery (even <24, or 24–48 and >48 hours).[19] In addition to the above mentioned study, Dhatt et al. performed a case series of 50 patients to study clinical outcome of delayed spinal decompression in CES and reported no statistically significant difference in delayed surgical time between the improved and non-improved groups. They noticed delayed spinal decompression had a solid association with the time taken for urinary incontinence improvement but did not significantly affect the final outcome.[32]

Kumar, et al, did a systematic review and meta analysis of 22 studies with 852 cases about the outcomes of CES due to LDH after surgery and factors affecting it, and reported that since CES is uncommon urgent syndrome, there have not been several studies that could sufficiently associate clinical outcomes with preoperative patient-related factors. It is not practically doable to get cohorts of patients with similar factors to study the effect of each on the outcome. Thus, most of CES related studies are retrospective, with fewer patients and a lower level of evidence. Also, they reported that the least improvement was seen in sensory impairment, with a mean of 53.3% and 43.3% of patients having persistent sensory dysfunction and urinary sphincteric affection, respectively at final follow-up. They concluded that the most important factor affecting the clinical outcome is the time from onset to

surgery as spine decompression within 48 hours was associated with good results.[33] Korse et al., who studied the long-term outcome of urinary, bowel and sexual functions after spinal surgery for CES, documented that a younger age at presentation was associated with a higher incidence of sexual dysfunction in the follow-up.[34] Kennedy, et al. who studied the determinants of clinical outcome in CES, documented many items associated with bad prognosis including late spine decompression, complete saddle area anesthesia, and considerable urinary or fecal incontinence at presentation.[35]

In our study, we have assessed bladder dysfunction subjectively by asking the patients about sphincteric dysfunction preoperatively and occurrence of improvement postoperatively, without any evidence of documented investigations as pre-voiding and post-voiding pelviabdominal ultrasonography or cystometry. The rational was that we did not want to delay that emergent surgery hopefully to do the best for our patients. Kumar, et al, in their systematic review and meta analysis found that most studies documented bladder function by questioning the patients to assess urinary incontinence improvement.[33]

Limitations

There are three limitations in this study, but our results are still reliable and valid in spite of these limitations. First, our sample size is relatively small as CES is very rare condition, so a larger sample size is needed to validate the significant relations between outcomes and the surgical approach. Second, the assessment of bladder dysfunction by standard objective investigations like pre-voiding and post-voiding pelviabdominal ultrasonography and urodynamic studies should be done in every suspected CES patient to be more confident when judging the bladder dysfunction and improvement. Finally, a randomized comparative study between open full laminectomy approach versus minimally invasive approach for patients with CES is needed to validate the safety for such approach.

Conclusions

MIS-LD is effective and efficient emergent procedure for treatment of CES caused by huge/ruptured LDH with good recovery of motor power, full recovery of urinary, bowel and sexual functions, normal saddle area sensation, good quality of life and normal daily life activities without surgical side effects.

Abbreviations

AP: Anteroposterior.
CES: Cauda equina syndrome.
CSF: Cerebrospinal fluid.
LBP: Low back pain sciatica.
LDH: Lumbar disc herniation.
MID: Minimal invasive microdiscectomy.
MIS-LD: Minimally invasive lumbar microscopic discectomy.
MRC: Medical Research Council.
MRI: Magnetic resonance imaging.
ODI: Oswestry disability index.
PTELD: Percutaneous transforaminal endoscopic lumbar discectomy.
PXR: Plain X-ray.
SD: Standard deviation.
SLR: Straight leg raising.
VAS: Visual analogue scale.
XSLR: Crossed straight leg raising.

Disclosure

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