Endoscopic posterior decompression of lumbar canal stenosis

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ABSTRACT

Lumbar canal stenosis (LCS) is quite common. Surgery is indicated when patient fails to improve after conservative treatment. Endoscopic technique can be used in LCS and lateral recess stenosis. It can be performed in degenerative canal stenosis or with disc bulges. Bilateral severe bony canal stenosis and unstable spine are the contraindications. This procedure should be avoided in patients with a history of trauma. Detailed history and thorough physical examination should be performed to find out exact level of pathology responsible for symptoms. Patient's symptoms must correlate with radiological findings. Magnetic resonance imaging is the investigation of choice because of its superior visualization of soft-tissue. Computed tomography scan does give a more accurate and detailed picture of the bony anatomy. Although the operative time and the complication rate could be more in the initial learning curve, the results of endoscopic decompression are comparable with conventional open procedures with the additional benefit of decreased complications and lower morbidity, when sufficient experience is gained. Complications in endoscopic surgery for LCS could be dural tears, hematomas and root and facet injury. This procedure is also associated with limitations such as steep learning curve and the contra lateral decompression may not be as good as ipsilateral side. Some of the limitations of this technique can be overcome by attending live operative workshop, practice on models and hands on cadaveric dissection. Conversion to an open procedure may be required when there is disorientation, management of dural tear and for control of bleeding.

Key words: Endoscopic surgical procedure, endoscopy, lumbar disc disease, spinal canal, spinal endoscopy, spinal stenosis, surgical endoscopy

INTRODUCTION

Lumbar canal stenosis (LCS) is quite common. Endoscopic techniques are being used increasingly for spine and brain pathologies.[1-3] Although the role of surgery using minimally invasive techniques in lumbar disc remains unclear in the Cochrane review,[4] there are reports of good results of endoscopic decompression in LCS.[5-7] Bilateral decompression through unilateral fenestration can be performed for lumbar spinal stenosis with good clinical results.[6] Bilateral decompression with a unilateral approach can increase the area of the dural tube up to 408.0% (range: 211-774%).[7] Better visualization of the lesion, reduced morbidity, short hospital stay and ultimately lower cost are some of the advantages of endoscopic technique over the

conventional open technique. Although the size of skin incision can be comparable in the endoscopic technique and open approach, main advantages of endoscopic procedure are minimal muscle dissection, better visualization and removal of contralateral compressive pathologies. In addition, spinal endoscopy allows observers and operating room staff to be more involved and it is better for teaching purpose. Although open technique of lumbar decompression also has comparable long-term results, early results in terms of less tissue trauma and reduced pain are some of the advantages of endoscopic technique. Spinal endoscopy, on the other hand, carries additional risks and the surgeon must be prepared to convert to an open procedure. Although the learning curve for spinal endoscopy is steep, spine surgeon can achieve better outcomes and reduced morbidity after adequate training and experience.

This review includes all articles published in PubMed and Google in last 20 years. It is based on the thorough search on the topic up to February 2013 and personal experience of more than 200 endoscopic surgeries for LCS performed by the senior author. Present article is aimed to review the indications, steps of surgical procedure and results

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of treatment and complication avoidance in endoscopic management of LCS.

INDICATIONS OF SURGERY

LCS is a degenerative disease of the lumbar vertebrae, discs and ligamentum flavum. The natural history of LCS is highly important because the symptoms do not necessarily worsen with progressive degeneration; therefore, an observation therapy is adopted for the treatment of this condition. Surgery should not be performed solely on the basis of radiological findings, careful evaluation of neurological symptoms is necessary.

Surgery is indicated for those who do not improve with medications. Drugs used for the treatment include non-steroidal or steroidal anti-inflammatory drugs. Short courses of oral cortisone and epidural steroid injections can also be used. Surgery is indicated if there is severe or progressive weakness or loss of bowel or bladder function.

Bony over growth, ligamentum flavum hypertrophy and disc prolapsed can contribute to canal stenosis. Canal stenosis secondary to all the factors, combination of lesions or any of these pathologies can be managed by endoscopic technique. It can be performed in degenerative canal stenosis or with disc bulges. Endoscopic technique can be used effectively in LCS and lateral recess stenosis.[7-10] Endoscopic technique can be used to decompress the entire length of the nerve root from the spinal canal to the extraforaminal zone while preserving the posterior elements in foraminal stenosis.[11] Bilateral severe bony canal stenosis and unstable spine are contraindications for endoscopic decompression in LCS. This procedure should be avoided in patients with a history of trauma.

INVESTIGATIONS

Detailed history and thorough physical examination should be performed in all cases to find out exact level of pathology responsible for symptoms of the patients. It is possible that the disease may look more extensive radiologically. Patient's symptoms must correlate with radiological findings. Various parameters such as anteroposterior diameter, cross-sectional area of the spinal canal can be used for central stenosis. For lateral stenosis height and depth of the lateral recess and for foraminal stenosis the foraminal diameter can be used. Different studies used different measurement for the diagnosis of LCS.[12]

X-ray films at flexion and extension can be used to evaluate any instability. Magnetic resonance imaging (MRI) currently represents the "gold standard"

in the evaluation of lumbar stenosis. It allows the visualization of the disc, neural elements, ligaments and thecal sac in a non-invasive manner. Although MRI is good for the evaluation of sequestered lumbar disc herniation, it has its limitations, especially in detection of fragment lying dorsal to thecal sac or the root.[13] Computed tomography (CT) scanning does give a more accurate and detailed picture of the bony anatomy, but is less sensitive in estimating the degree of compromise by the soft-tissue elements and is not usually adequate as a stand-alone imaging modality. Computerized tomographic myelography and computerized tomographic discography can help in accurately orientation of the diseased disc and nerve root before the endoscopic procedure and can decrease the possibility of nerve damage.[14] Myelography is no longer routinely necessary; although, it can be useful in selected cases, when MRI is contraindicated. Electrophysiological testing is rarely contributory, unless a diagnosis of peripheral neuropathy is being considered.

PROCEDURE

Surgery is performed in the prone position on a radiolucent table usually under general anesthesia. The skin incision is made after confirming level under image guidance. Surgeon stands on the more symptomatic side or on the left side if the compression is equal on both sides. Incision is given about 1-2 cm away from midline. Single incision usually suffices for two level pathologies. More than one incision can be used if pathology extends more than 2 vertebral levels.

All types of endoscopic spine surgeries utilize dilatation technology to create surgical access through subcutaneous fat, fascia and muscle rather than cutting in order to minimize tissue trauma. The operative sheath is placed at the desired ligamentum flavum and lamina. Soft-tissues on the lamina, facet joint and ligamentum flavum are removed [Figure 1]. Burrs, trephines and rongeurs can be used for the resection of bone. An ultrasonic bone curette can be used for bone resection.[15] Part of superior and inferior lamina along with the medial facet is removed. Removal of base of the spinous process, osteophytes of the opposite facet and under cutting of the opposite side lamina can be performed using same incision [Figure 2].

There is an increased risk of dural tear in a high degree LCS. Ligamentum flavum is left intact to protect dura matter until all the bony resection. Such procedures should be done after achieving sufficient experience to decrease complications.[7,8,16] Part of the offending disc is removed.

Various systems such as Destandau (Karl Storz GmbH and Co KG Tuttlingen Germany), EasyGO (Karl Storz GmbH and Co KG Tuttlingen Germany), SMART (Karl Storz GmbH and Co KG Tuttlingen Germany) etc., are available commercially.[17-19] All these systems are effective and safe.

This technique can be combined with transforaminal approach and lumbar interbody fusion in selected patients with instability of lesser than grade II listhesis.[20] The combination of interspinous process implant fusion and endoscopic decompression can be used for decompression and stabilization of the spine.[21] There is no valid evidence from randomized controlled trials on the effectiveness of transforaminal endoscopic surgery for LCS.[22]
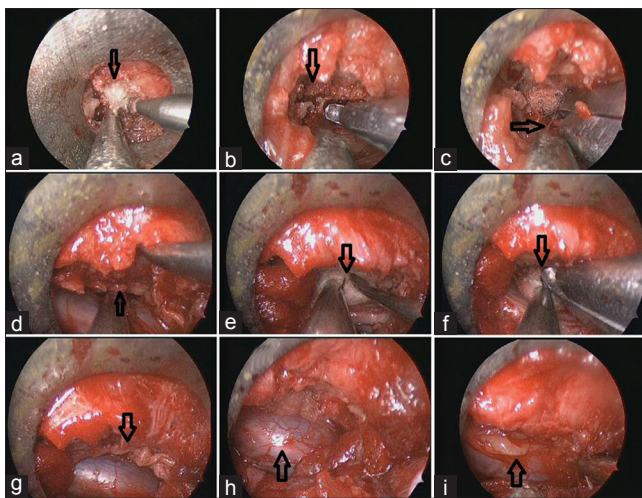

Figure 1: Endoscopic management of lumbar canal stenosis showing (a) drilling of the lamina and base of spinous process, (arrow down), (b) removal of thinned out lamina (arrow down), and (c) medial facet joint (arrow to right), (d) visualization of opposite side ligamentum flavum (arrow up), (e) cotton patty (arrow down) being used to separate thecal sac from ligamentum flavum, (f) which is being removed by Kerrison punch (arrow down), (g) Opposite side (arrow down) and (h and i) whole thecal sac (arrow up) well decompressed
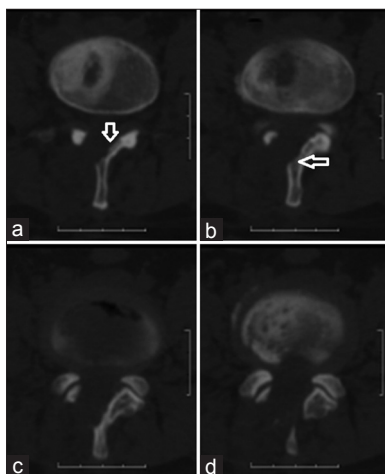

Figure 2: "Post-operative computed tomography scan (a-d) bilateral" with "Post-operative computed tomography scan (a-d) showing bilateral"

RESULTS OF SURGERY

The outcome of endoscopic treatment was good in most reported series. The results of endoscopic decompression were good with 70.8% patients without any significant leg pain and 22.2% occasional pain.[5] These results were comparable with conventional procedures. The complication rate was low in the endoscopic group.[5] Wada *et al.* also reported improvement in the mean Japanese Orthopaedic Association (JOA) score from 17.0 before operation to 23.3 after surgery.[7] The clinical results were excellent in Xu *et al.* series with 65.6% and 34.4% patients had excellent and good pain relief respectively according to the Macnab scale.[6] Endoscopic technique can be as effectively as an open technique with the additional benefit of decreased complications and morbidity.[23]

Bilateral decompression with a unilateral approach can increase the area of the dural tube up to 408.0% after the surgery (range: 211-774%).[7] Guiot *et al.* used one of the four procedures (unilateral microendoscopic laminotomy, bilateral microendoscopic laminotomy, unilateral open laminotomy and bilateral open laminotomy) in cadavers. CT was performed before and after each procedure to establish the extent of decompression of the spinal canal. Measurements of the midsagittal, interpedicular and decompression diameters were recorded. Satisfactory decompression of the spinal canal was achieved in all the four procedures. The exiting nerve roots were well-visualized when any one of these techniques was used. Complications, including dural tears and facet complex instability, were also same in all the procedures.[23]

The operative time was short (mean 70 min, range, 50-100 min for single level) and the blood loss was also less (mean 150 ml, range, 50-350 ml) in the endoscopic technique.[6] The result of endoscopic decompression is usually poor if back pain is out of proportion to the leg symptoms, such patients should be investigated for instability.

Case 1 description
Forty five years male presented with history of pain and numbness in both lower limbs, more on the right side. This pain increased on walking and used to get relieved by rest. MRI scans revealed canal stenosis at L4-5 level [Figure 3]. Canal compromise was due to disc bulge and ligamentum flavum hypertrophy. Conservative treatment did not relieve his symptoms. Endoscopic bilateral decompression was performed using right sided approach. Right sided lamina and the base of the spinous process was drilled [Figure 2]. Opposite side ligamentum flavum and under cutting of part of the lamina was performed. Patients

made a good recovery and the post-operative MRI after 2 months showed well decompressed canal [Figure 4] his leg numbness and pain disappeared completely.

Case 2 descriptions

A 47-year-old male patient presented with history of pain and numbness in both lower limbs, more on the left side, which increased on walking. It was getting partially relieved by rest. MRI scans revealed canal stenosis at L3-4 and L4-5 level [Figure 5]. There was progressive deterioration on conservative treatment. Endoscopic bilateral decompression was done using left sided approach. Left sided lamina and the base of the spinous process was drilled [Figure 6a and b]. Opposite side ligamentum flavum and under cutting of part of the lamina was performed. Patients made a good recovery and the post-operative MRI after 2 months showed decompressed lumbar canal [Figure 6c]. There was a significant relief in his leg pain and numbness.

ADVANTAGES AND LIMITATIONS

Endoscopic techniques can achieve adequate decompression with reduced traumatization, improved visibility and with the positive cost benefits.[24] Although the size of skin incision can be comparable in the endoscopic technique and open approach, main advantages of endoscopic procedure are minimal muscle dissection, better visualization and removal of contralateral compressive pathologies. It was found to be as effective as an open laminotomy to decompress the spinal canal in cadaver also.[23]

This procedure is also associated with limitations such as more operating time for multiple level compressions and steep learning curve. Complication rate could be more in the initial learning curve.[9,16] Contra lateral decompression may not be as good as ipsilateral side. This procedure is less effective when back pain is out of proportion to the radicular symptoms.

COMPLICATIONS

Complications in endoscopic surgery for LCS could be dural tears, hematomas and root and facet injury. The incidences of complications are more in LCS (9.3%) as compared with disc herniation surgeries (8.1%).[9]

Although there are reports of high complications in the initial learning curve,[9,16] Xu *et al.* observed less complication.[6] Dural tears, without obvious side-effects, were encountered in two patients (6.2%) out of total 32 patients.[6] The incidence of post-operative spinal epidural hematoma may be greater (up to 33%) than
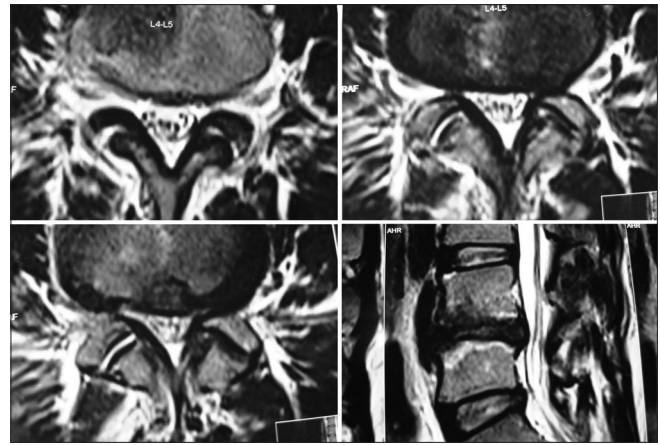

Figure 3: Pre-operative magnetic resonance imaging scans of case 1 showing disc bulge and ligamentum flavum hypertrophy producing canal stenosis
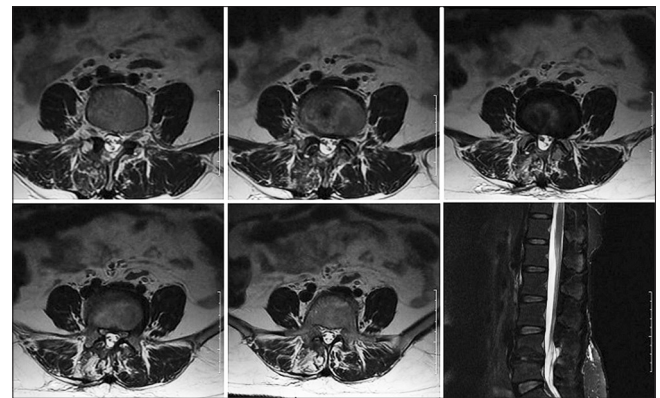

Figure 4: Post-operative magnetic resonance imaging scans of case 1 showing well decompressed canal
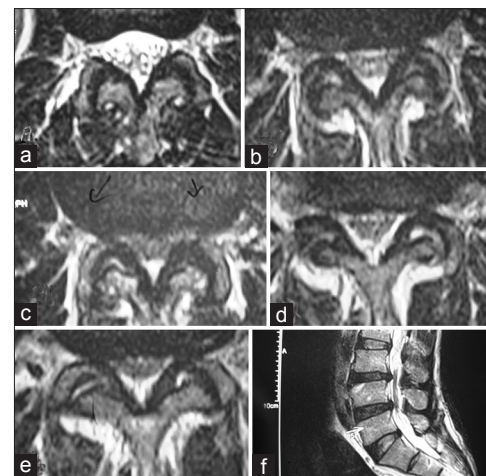

Figure 5: Pre-operative magnetic resonance imaging scans of case 2 showing canal stenosis at L3-4 and L4-5 levels

reported in the literature.[6] Although such hematomas resolve spontaneously, it can result in poor expansion of the dural sac. It can delay patient recovery and lead to a poor clinical improvement. The prevention of post-operative hematoma could avoid neurological deterioration and

prevent any delay in the recovery.[6] There is a steep learning curve in endoscopic surgery, especially for LCS. Surgeon should start performing endoscopic techniques for LCS after gaining enough experience of endoscopic surgeries of simple disc herniations.[9,16]

COMPLICATION AVOIDANCE

Bleeding

Bleeding can occur in endoscopic technique due to improper positioning of the patient with the increase in the resistance during the ventilation. It can also be due to light plane anesthesia. Bleeding can result from rupture of engorged epidural vessels after good decompression of thecal sac [Table 1]. Proper positioning during surgery and avoiding light plane of anesthesia could prevent annoying bleeding. Most of these bleeding stop spontaneously. Gentle pressure by surgical patties and warm saline irrigation helps in stopping such bleeding. Sometime there

may be the problem during surgery when brisk bleeding causes staining of lens tip, keeping telescope as far away as possible from the bleeding site allows proper visualization and control of bleeding. Bipolar electrocautery can be used to control bleeding. Normally compression by the sheath to the surrounding tissues helps in preventing small oozing, minor ooze may occur from adjoining operative site when more than one incision is used for multiple level compressions. Gentle gauze packing of the other operative site can prevent such bleeding. Cranial and caudal gauze packing can also prevent bleeding.

Tissue coming inside the tube

Excessive cranial or caudal angulations of the operative sheath can allow unwanted tissues (muscle, fat or ligament etc.) to come inside the tube, which may obscure visualization and proper execution of the surgery [Figure 7]. Some angulations (up to 20-30°)

Figure 6a: Post-operative reconstructed image of case 2 showing removal of left side lamina and part of base of spinous process
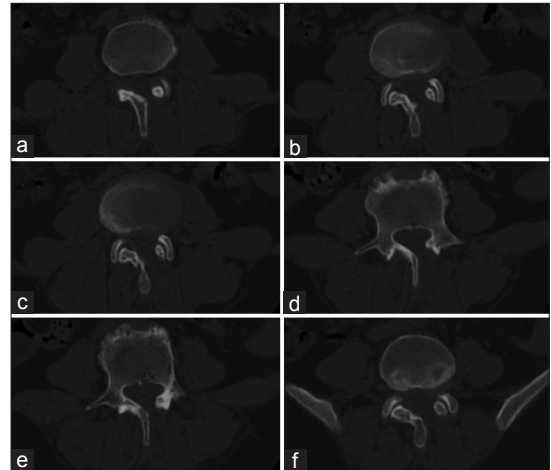

Figure 6b: Post-operative computed tomography scan images of case 2 showing removal of left side lamina and part of base of spinous process
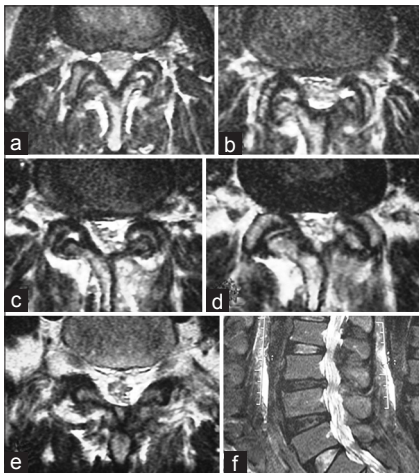

Figure 6c: Post-operative magnetic resonance imaging scans of case 2 showing well decompressed canal at L3-4 and L4-5 levels
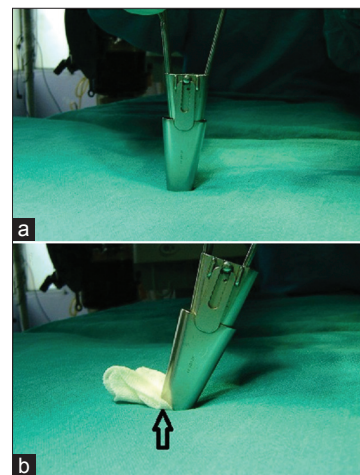

Figure 7: (a) Correct vertical position of the tube prevents bulging of unwanted tissue, (b) wrong angulations of the endoscopic assembly resulting in protrusion of tissue inside the sheath (arrow)

Table 1: Various types of complications and its avoidance in endoscopic treatment of lumbar canal stenosis

Type and causes of complications	Complication avoidance	Treatment of complication
Bleeding: Improper positioning with increase in the resistance during ventilation, light plane of anesthesia, rupture of engorged epidural vessels after the decompression, ooze from adjoining operative site when more than one incision is used for multi-level compression	Proper positioning during surgery and avoiding light plane of anesthesia Gentle packing of the other operative site Cranial and caudal gauze packing	Most of these bleeding stop spontaneously Gentle pressure by patties and warm irrigation Staining of telescope can be avoided by keeping telescope as far away as possible from the bleeding site Bipolar electrocautery
Tissue coming inside the tube: Excessive cranial or caudal angulations of the operative sheath	Keeping sheath as vertical as possible If the tube needs to be moved cranially or caudally it has to be pushed cranially or caudally respectively keeping it vertical	Unwanted tissue can be excised or displaced by suction tip Slight withdrawal of telescope
Dural tear: Initial learning curve, high canal stenosis and multilevel diseases	Keeping ligamentum flavum intact until all the bony decompression is achieved Placing patties between dura mater and ligamentum flavum or the bone Kerrison punch should be partially retracted after nibbling of the bone or excision of ligamentum flavum Proximal part of the tissue should be hold before it is completely detached and removed	Sealing the tear by fascia and tissue glue
Visual obscuration: Incorrect system assembly, damaged lenses, fogging of lenses, scope out of focus, undesired tissue may come in front of telescope	Suction of air containing excessive moisture from the operative area Proper positioning of lens (slight withdrawal from the obstructing tissue) Moving telescope cranial, caudal or to the side (away from the obstructing object)	Telescope can be removed and cleaned Warm saline irrigation Antifogging agents
Steep learning curve: Most of the endoscopic techniques are associated with steep learning curve	Learning curve can be improved by attending live operative workshops, practice on models and hands on cadaveric dissection	Avoiding difficult cases in the initial learning curve, team work

may be allowed. Keeping sheath as vertical as possible prevents entry of such tissues. If the tube needs to be moved cranially or caudally it has to be pushed cranially or caudally respectively keeping it as vertical as possible.

Dural tear

Dural tear may occur in any lumbar surgery. Incidence is high in the beginning of the learning curve, high canal stenosis and in multiple level compressions. This can be prevented by keeping ligamentum flavum intact until all the bony decompression is over. This can also be prevented by keeping surgical patties between the dura mater and ligamentum flavum or the bone. This can also be prevented by partially retracting the Kerrison punch after nibbling of the bone or excision of ligamentum flavum. Holding the proximal part of the tissue before it is completely detached and removed can prevent dural injury. Cerebrospinal fluid leak due to the dural tears can be managed by using fascia and tissue glue.

Visual obscuration

There are several causes of poor vision during surgery such as incorrect system assembly, damaged lenses, fogging of lenses and scope out of focus. Fogging of the lens and visual obscuration may occur due to excessive moisture in the media, staining of lens by blood, bone dust or any tissue etc. The lens fogging usually occurs

when there is an imbalance between the temperature of the front lens, temperature of the airway cavity and humidity of the environment. Telescope can be removed and cleaned. Warm saline irrigation can also be used to clean lens tip. Suction of air containing excessive moisture from the operative area can improve vision. Anti-fogging agents such as baby shampoo, Savlon and povidine scrub are very effective agents. Sometime undesired tissue may come in front of the lens and obscure visualization of desired structures [Figure 7]. Proper positioning of telescope (slight withdrawal from the obstructing tissue), moving telescope cranial, caudal or to the side, away from the obstructing object, can improve visualization. Obstructing tissue can be removed if indicated. Bone drilling in LCS can prolong operative time due to frequently staining of telescope tip by bone dust or saline. This problem can be partly avoided by keeping telescope as far away as possible from the drilling site and by using intermittent irrigation in between the short period of drilling. It is useful to use lower revolutions per minute to reduce staining during the drilling. Identification of proper cause and appropriate corrective method improves visualization.

Steep learning curve

This technique is associated with a steep learning curve. This learning curve can be improved by attending live

operative workshops, practice on models and hands on cadaveric dissection.[16,25]

OTHER MINIMALLY INVASIVE TECHNIQUE FOR LCS

The chimney sublaminar decompression technique for the degenerative LCS can be used, which do not require stripping of the paravertebral muscles. Excellent, good and fair outcomes were achieved in 61%, 28%, and 11% patients, respectively. No patient required any brace and there was no worsening of pre existing spondylolisthesis. The spinal canal was increased to 2- to 6.8-fold (mean 4.2 fold) of the pre-operative size.[26] Although the results of microscopic discectomy using tubular retractor have been found to be safe and effective,[27] there is no report of bilateral decompression using microscopic technique to the best of our knowledge.

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