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Effectiveness of ultrasonic bone scalpel in cervical myelopathy: A case series

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Abstract
Study design: Retrospective case study
Aims and Objectives: To know functional outcome and safety of cervical laminectomy done by ultrasonic bone scalpel.
Introduction: Cervical spondylotic compressive myelopathy is managed by laminectomy done with either conventional methods by using Kerrison rongeur, high speed drill or ultrasonic bone scalpel in selected patients in whom risk of post-operative cervical kyphosis is minimal. Conventional methods having theoretically more risk of dural injury, neural damage, thermal injuries while ultrasonic bone scalpel provides easy way of doing laminectomy with shorter duration of time.
Methodology: This study comprises total 44 patients operated by single surgeon between January 2016 to February 2020. All patient operated by using ultrasonic bone scalpel. Clinical parameter including demographics, affected spinal levels, symptoms, intra and post-operative complications were noted. Patients had pre- and post-operative assessment with modified Japanese Orthopedic Association score (JOA), nurick grading and visual analogue score. Minimal follow up was 10 months with regular interval assessments.
Results: This study includes 44 patients with minimum 10 month follow ups. Laminectomy made at total 163 levels. Average time taken for removal of single lamina was 3.7±0.6 min. Expected blood loss occur during surgery was 131.3±23.9 ml and average length of hospital stays was 6.5±0.87 days. Mean canal compression rate was 42.6±8.9%. Mean pre-op mJOA score is 9.2±2.82 and average post-op mJOA score is 14±3.81. Recovery rate in our study is 59.7±29.2%. There is one case of dural tear and deep infection, 2 cases of C5 nerve palsy, 3 cases of delayed wound healing.
Conclusion: Cervical laminectomy is frequently used approach for cervical spondylotic myelopathy. Laminectomy done by using ultrasonic bone scalpel which is safe, rapid and having less complications like dural injury, thermal injury, neurological deterioration, blood loss and also decreases hospital admission days. To prevent dural injury, put ultrasonic blade as horizontal to dura, don't put blade at single point for long time and constant irrigation help to prevent thermal injury. Pre-operative identification of calcified dura and leaving thin inner cortex which is subsequently break by twisting of osteotome may help to reduce dural injury.

Keywords: cervical, myelopathy, high speed drill, ultrasonic bone scalpel

Introduction

Cervical myelopathy is a degenerative condition caused by compression on spinal cord in cervical region that is characterized by loss of motor and sensory functions with gait imbalance. Main etiology of this myelopathy is degenerative cervical spondylosis, ossification of posterior longitudinal ligament (OPLL) and ossified ligamentum flavum (OLF) [1]. Severe compression of spinal cord with severe symptoms usually requires surgical treatment because conservative management is of no benefits [2]. There are several surgical approaches for compressive myelopathy describe in literature including anterior decompression [3], posterior circumferential decompression [2], posterior laminectomy and posterior laminoplasty [1, 4]. Each technique has their own merits and demerits. Posterior laminectomy and laminoplasty provide indirect decompression by shifting spinal cord posteriorly which should be done in multilevel and severe cervical myelopathy patients where direct decompression is risky. These procedures are associated with inferior neurologic improvement and various complications especially when there is associated OPLL and OLF [5, 6]. Several techniques have been described for cervical laminectomy. In conventional methods (CM), Kerrison rongeur is use for removing lamina piecemeal or make through on both sides of lamina and then removing lamina en block with use of nibbler or Leksell rongeur. There have been several complications with this technique like dural and mechanical injuries [7, 8]. These complications will occur while inserting footplate of rongeur under laminae which causes narrowing of canal which is already compromised [9]. Then Hirabayashi describe technique of cervical laminectomy by using High speed burr (HSB) [10]. Several complications have been occurred such as dural injury, bleeding, thermal and neural injury [11]. Heat generated by tip of burr may cause damage to neighboring neural tissue and may ended up in osteonecrosis [13]. Dural injury may lead to CSF fistula, meningitis, arachnoiditis, epidural abscess, pseudo meningocele or pneumocephaly [14, 15].

The Ultrasonic bone scalpel (UBS) is novel ultrasonic surgical device that cuts bone, spares soft tissues (e.g., dura, cord, nerve roots, and vessels), and performs accurate, safe, and quick bony excision [16, 17].

Methods

This is retrospective study included 44 patients operated for cervical laminectomy at our institution between January 2016 to February 2020. All patients were operated by single spine surgeon. Indication for laminectomy is multilevel cervical canal stenosis with <13º kyphosis angle, spondylolisthesis <3.5 mm and OPLL is not crossing K-line. On axial view of Computed tomography, spinal cord compression rate (CR) was identified. CR is defined as longest sagittal extension of lesion/sagittal diameter of the spinal canal ×100% [18]. Data retrieved from hospital records and patient's demographic profile, Surgery duration, estimated blood loss and complications like dural tear, neurological deterioration, nerve root injury and kyphotic angle in follow up are recorded. Minimum follow up period was 10 months. Patients had pre- and post-operative assessment with Modified Japanese Orthopedic Association score (JOA), nurick grading and visual analogue score. Recovery rate was calculated as per following equation: Post-operative mJOA score- Preoperative mJOA score / (18-preoperative mJOA score) ×100. Excellent recovery was defined as a Recovery rate is >75%, good as 75% to 50 %, fair as 50% to 25% and poor as <25% [19, 20].

Surgical Technique

After giving general anesthesia, patient was taken in prone position on bolsters with head supported on horseshoe head holder. Head position is made slightly flexed for batter visualization. Standard longitudinal posterior midline incision is made. After dissecting ligamentum nuchae, spinus process are exposed and paraspinal muscles are lifted. Level is confirmed by using C-arm. Interspinous muscles are excised at upper and lower limit of compression. Then bone scalpel is used to make cuts on both lamina at junction of lamina and facet. Both outer and inner cortex of lamina are cut by sweeping motion of scalpel. End point of cut is identified by give-way felling of inner cortex. Tip of scalpel should be kept moving without any undue pressure. In severely stenotic spinal canal, care should be taken while inserting device tip. In these cases, inner cortex should be left intact and that should be made broken by inserting thin osteotome in incomplete trough and doing twisting movement of it. After making complete cut on both side of lamina, lamina and spinus process is removed en block by using nibbler. Adhesions on dura is removed by Penfield retractor. Then hemostasis is achieved by using bipolar cautery and pulsatile movement of cord is observed. Then closure is done into layers and drain is kept.

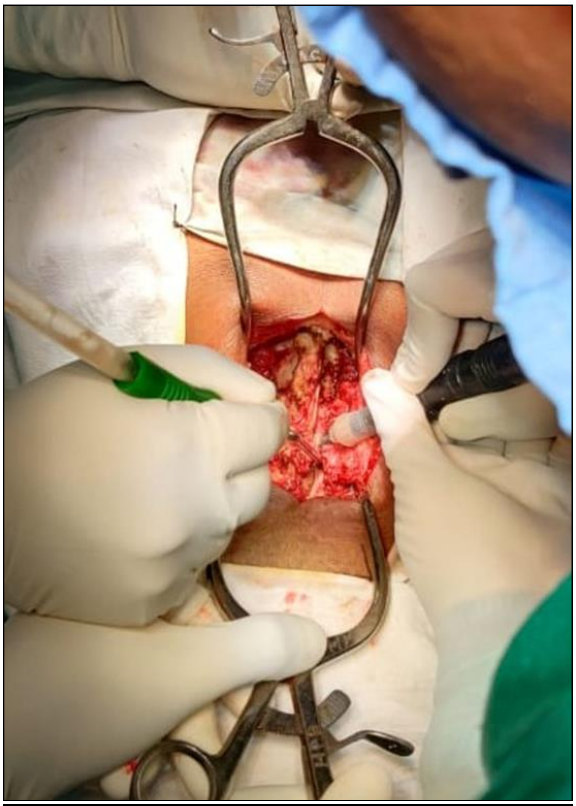

Fig 1: Cutting of lamina by using UBS

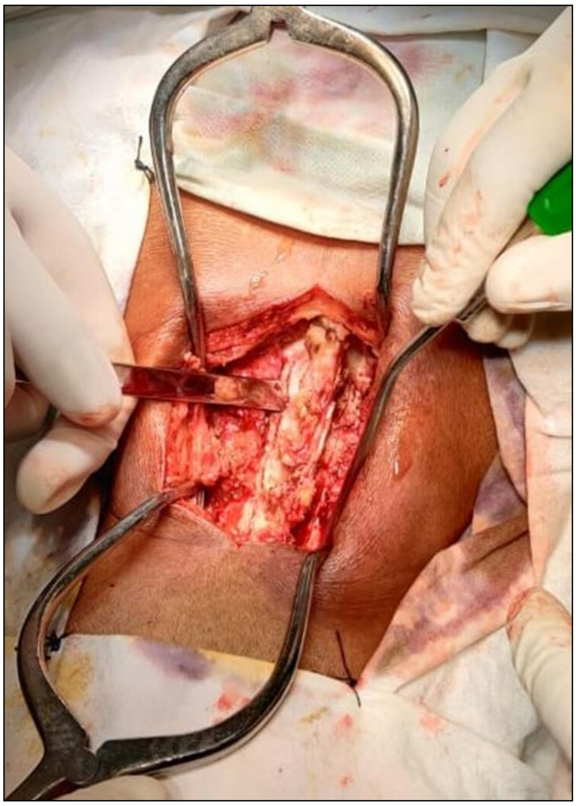

Fig 2: Outer cortex should be cut by using UBS and thin inner cortex is broken by twisting osteotome to prevent inadvertent dural injury

Fig 3: Complete removal of lamina after putting bilateral cut by UBS then pulling of spinous process by using bone nibbler.

Fig 4: Complete enblock removal of lamina and spinus process.

Results

Total 52 cases of cervical laminectomy are operated in our institute between January 2016 to February 2020. Out of which 2 patients were died due to conditions unrelated to surgery (n=2) and 6 patients were lost in follow ups (n=6). After excluding these patients this study includes 44 patients with minimum 10 month follow ups. Table 1 includes demographics variables.

Table 1: Demographic variables of patient included in our study

Parameter	Values
Total no. of patients	44
Age (SD) in years	56.27(8.82)
Male /Female	39/5
Expected Blood loss in ml (SD)	131.34(23.96)
Surgery durations in minutes (SD)	67.5(7.5)
Time per level in min (SD)	3.7(0.6)
Length of hospital stay in days (SD)	6.5(0.87)
Canal Compression Rate (%) (SD)	42.6% (8.9)

Mean follow up duration was 17 months (range 10-50 months). Laminectomy made at total 163 levels. Average time taken for removal of single lamina was 3.7±0.6 min. Expected blood loss occur during surgery was 131.3±23.9 ml and average length of hospital stays was 6.5±0.87 days. No patients required blood transfusion during surgery.

Mean canal compression rate was 42.6±8.9%. Canal compression was due to OPLL in 33 pateints (75%) and OLF in 4 pateints (9.1%).

Outcome was measured by using modified Japanese association score (mJOA). Mean pre-op mJOA score is 9.2±2.82 and average post-op mJOA score is 14±3.81. Recovery rate in our study is 59.7±29.2%.

Table 2 showing post-operative complications in our study. There is one case of dural tear and deep infection, 2 cases of C5 nerve palsy, 3 cases of delayed wound healing. Dural tear was repaired by using proline 5-0 suture, watertight closure and drain was kept for 48 hours. Same patient had increase in spasticity post operation which was normalize after 3 months. Deep infection leads to delayed wound healing in one case which was treated by debridement surgery. Two patients had superficial infection which leads to wound dehiscence. They required frequents dressings and antibiotics for a month. No major neurological deterioration was found post operatively. Two patient develops C5 nerve palsy after surgery. Both recovered within 7-8 month.

Table 2: showing post-operative complications

Dural Tears	1
C5 nerve Palsy	2
Delayed wound healing	3
Deep infection	1

Discussions

Cervical myelopathy occurred due to chronic compression of cervical spinal cord due to degenerative spondylosis, spondylolisthesis, OLF or combinations of any of these. Decompression of spinal canal needs to be done for relieve symptoms. Decompression is achieved by either anterior or posterior or combined approach. Various methods are described for achieving decompressions like ACDF, laminectomy with or without fusion, laminoplasty. Selection of approach and procedure is determined by number of levels involved, location of pathology, kyphotic angle, bone quality, desired to retained neck motion and neck pain [21]. Posterior approach is feasible when there is multilevel pathology, local kyphosis <13º, maintained cervical lordosis. Cervical laminectomy alone is established treatment of cervical myelopathy. It has high incidence of post laminectomy kyphosis [22]. According to some authors post laminectomy kyphosis is not related to worsening of symptoms or neurology [23, 24]. Posterior instrumented fusion is added when there is instability or loss of cervical lordosis. When there is any additional nerve root compression, foraminotomy should be added.

Conventional classic laminectomy performed by Kerrison and Leksell rongeur. By the time it was replaced by high-speed drill (HSD). HSD also have a potential for dural injury by direct or indirect means like thermal injury, vibrations, drill slippage or uncontrolled motion of drill.[11] Due to potential complications of Conventional and HSD laminectomy, ultrasonic device came into use.

The use of ultrasonic device first came into use in 1947 in dental surgery [25] then it was used in neurosurgery [26]. Since last some years its use came into spine surgeries. The Bone Scalpel assembly consists of an ultrasonic generator/irrigation console that connects to a handpiece bearing a disposable cutting tip. The cutting tip oscillates back and forth a very small distance at rate of 22,500 times per second (a frequency in low ultrasonic range). Cutting tip behaves like a blade (ultrasonic osteotome for removal of bone) and shaver blade (non-rotating burr selectivity for bone). Self-Irrigation system provides lubrication and reduces thermal energy. Large amount of energy is transferred to a small amount of bone at point of single contact which leads to destruction of bone. When it comes to contact with soft tissue structures like ligamentum flavum, posterior longitudinal ligament, dura mater; it can band, deforms, or vibrate upon contact with blade, thus dampening energy transfer and protecting the tissue from destruction. Due to elastic properties of soft tissue structures, they can withstand exposure to ultrasonic energy without any adverse effects.

Complications associated with posterior cervical laminectomy is dura tear, neurological deterioration, infections, C5 nerve root palsy, hematoma collection etc. Dural tear is not completely avoidable with use of ultrasonic device. Various authors reported (0.9-6.5%) dural injuries with the use of ultrasonic device [27, 28, 29, 30, 31, 32]. In current study, dural tear occurred in one case (2.27%). Risk of dural tear was due to mechanical compressions at single point but not due to direct effect of vibrations. Possible reasons for dural tears include: (1) When blade of ultrasonic device is placed at single point for long time which leads to thermal damage (2) Calcified dura is also risk factor for dural tears. Every case should be evaluated preoperatively for dural calcification in Ct-scan (3) Blade of device oscillates longitudinally along its axis so when blades put perpendicular to dura, theoretically there is more chances of dural injury. So, blade of ultrasonic device should be placed more horizontally to dura.

Post-operative neurological deterioration was dreaded complication in cervical laminectomy procedure. It may be due to acute cord dilatation occurred after decompression[30] [33] or cord injury during laminectomy procedure. Deterioration due to acute cord dilatation was inevitable and unpredictable complication but cord injury can be preventable by using UBS. It is necessary to evaluate lateral part of canal in axial section of CT scan to identify narrow canal due to OLF or OPLL which is likely to be injured and cause nerve root injuries while using UBS. So, it is advisable to cut only outer cortex of lamina by using UBS and cut remaining thin inner cortex by twisting action of osteotomy or nibbler. Observed rate of neurological deterioration was 1.8 to 10% in different studies [34, 35, 36, 37]. We observed one case (2.27%) of post-operative deterioration in our series. The patient having dural tear was deteriorated after surgery. Intra operative dural tear was repaired and he gained his preoperative neurology within 3 months.

Other advantages of ultrasonic device over high-speed drill are using cotton patties without fear of grabbing in drills. Accidental slippage is possible with high-speed drills but it is not occurred in ultrasonic device due to its blade type morphology and its longitudinal oscillation. In our study, expected blood loss is 131.34±23.96 ml and average duration for surgery was 67.5±7.5 min. Compared with HSD, USB is less time consuming and having less blood loss during surgery [26, 29 38]. There are less complications which reduces hospital admission days. So, it is advisable to use ultrasonic device because of secondary gains like low complications rates, improved outcome, reduces hospital cost and healthcare burden over hospitals.

Conclusion

Cervical laminectomy is frequently used approach for cervical spondylotic myelopathy. Laminectomy done by using ultrasonic bone scalpel which is safe, rapid and having less complications like dural injury, thermal injury, neurological deterioration, blood loss and also decreases hospital admission days. To prevent dural injury, put ultrasonic blade as horizontal to dura, don't put blade at single point for long time and constant irrigation help to prevent thermal injury. Pre-operative identification of calcified dura and leaving thin inner cortex which is subsequently break by twisting of osteotome may help to reduce dural injury.

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