Surgery for Cervical Spondylotic Myelopathy: Anterior Versus Posterior Approaches

Waleed F. El-Saadany, Ahmed Yehia, Khaled Abdeen, Mohamed El-Rahmany, Mazen Fakhry
Department of Neurosurgery, Alexandria University

ABSTRACT

Background: Surgical treatment of cervical spondylotic myelopathy (CSM) remains controversial. Several approaches have been advocated to treat cervical spondylotic myelopathy including anterior, posterior and combined approaches. Aim: The aim of this study was to review the clinical and imaging varieties of cervical spondylotic myelopathy and their influence on choosing the appropriate surgical approach. Subjects: Fifty five cases with cervical spondylotic myelopathy operated upon at the neurosurgery department, Alexandria University were reviewed. Methods: The different clinical and imaging features were analyzed, and parameters for choice of surgical approach were addressed. Results: Among all patients with CSM, neck pain was present in 49%, brachialgia in 67%, mild myelopathy in 44% and moderate myelopathy in 56%. Following cervical laminectomy, neck pain improved in 50% and remained stationary in 50%; brachialgia recovered in 33%, improved in 50% and remained stationary in 17%; mild myelopathy showed good outcome in 80% and fair outcome in 20%; whereas moderate myelopathy showed good outcome in 20%, fair outcome in 60% and poor outcome in 20%. Following anterior discectomy with fusion, neck pain recovered in 28.5%, improved in 38% and remained stationary in 28.5%; brachialgia recovered in 58.5%, improved in 31% and remained stationary in 10.5%; mild myelopathy showed excellent outcome in 17%, good outcome in 58% and fair outcome in 25%; whereas moderate myelopathy showed good outcome in 35%, fair outcome in 30% and poor outcome in 35%. Following cervical laminoplasty, neck pain improved in 100%; brachialgia remained stationary in 100%; mild myelopathy showed good outcome in 100%; whereas moderate myelopathy showed fair outcome in 50% and poor outcome in 50%. Conclusion: Early surgical intervention for CSM is associated with higher recovery rate. Selection of surgical approach depends on age, cord morphology, and spine geometry mostly spinal curve and canal diameter. The presence of cervical spine instability necessitates complementation of spine decompression with spine fixation. (Egypt J. Neurol. Psychiat. Neurosurg., 2008, 45(2): 571-586)

INTRODUCTION

Cervical spondylosis is the most common spinal disorder affecting people older than 55 years of age and is characterized by degeneration of the cervical intervertebral discs, with subsequent changes in the bones and soft tissues. Cervical spondylotic myelopathy (CSM) occurs secondary to cervical spondylosis and can produce a variety of clinical signs and symptoms secondary to neural compromise, vascular compromise, and biomechanical involvement of the spinal cord, namely; radiculopathy, myelopathy, and myeloradiculopathy.

Treatment of cervical spondylotic myelopathy remains controversial despite numerous reports of both conservative and surgical management strategies. Although it is generally well accepted that surgical decompression is indicated for patients whose conditions are deteriorating, yet the optimal surgical treatment remains unsettled. Many surgical approaches have been proposed for treatment of patients with CSM, with proponents for either the posterior or the anterior surgical approaches. These approaches included; laminectomy with or without fusion, laminoplasty, ventral discectomy with or without fusion, and median (central) corpectomy with grafting. The presence of multiple surgical approaches to treat CSM raises many questions regarding patients selection criteria and decision-making process.
The aim of this study is to assess the functional outcome of selected anterior and posterior approaches for treatment of patients with CSM, and to identify the different epidemiological, clinical and imaging parameters predictive for good outcome.

PATIENTS AND METHODS

This series included 55 patients operated upon for cervical spondylotic myelopathy between 2003 and 2005 at the department of neurosurgery, Alexandria University.

Clinical Evaluation: All patients underwent a comprehensive clinical evaluation at which time it was ascertained that they had failed to improve following conservative trials with cervical collar, physiotherapy and nonsteroidal antiinflammatory medications, and continued to show progression of symptoms. Presenting clinical manifestations and duration of symptoms were recorded. The severity of myelopathy was assessed using the modified Japanese Orthopedic Association scoring system for cervical myelopathy by Benzel et al.22 "mJOA scale". According to the total points of the mJOA score, patients were divided according to Hirabayashi classification,23 into 3 groups; mild myelopathy with mJOA score (14-18), moderate myelopathy with mJOA score (6-13), and severe myelopathy with mJOA score (0-5). Preoperative assessment of pain was evaluated using the visual analog scale (VAS),24 which measures the intensity of pain by marking a 10 cm line anchored with terms describing the extremes of pain intensity (0 = no pain and 10 = worst pain). According to their pain perception patients were classified into 3 groups; mild pain (1-3), moderate pain (4-7), and severe pain (8-10).

Imaging Studies: Plain radiographic examination of the cervical spine was done for all patients in the anteroposterior, lateral neutral, hyperflexion, and hyperextension views to assess cervical spine geometry and stability. In all patients the cervical curvature was evaluated according to the method presented by Batzdorf & Batzdorf.25 The presence of normal or abnormal cervical curvature was measured according to the relation of the dorsal aspects of the vertebral bodies C3-C6 to a line drawn from the dorsocaudal aspect of the vertebral body C2 to the dorsocaudal aspect of the vertebral body C7. By definition, a normal cervical lordosis is a configuration of the cervical spine in which no part of the dorsal aspects of the vertebral bodies C3-C6 crosses the C2-C7 line. Conversely, abnormal cervical curvature is a configuration of the cervical spine in which any part of the dorsal aspect of any of the vertebral bodies C3-C7 crosses the C2-C7 line. Accordingly, the cervical spine curvature was described as; lordotic, S-shaped, straight or kyphotic (Fig. 1). Intervertebral discs heights were assessed and described as either preserved or diminished (Fig. 2). The shape of vertebral bodies was inspected and deformation in vertebral body shape was categorized as; anterior lipping, posterior lipping, marginal lipping (both anterior & posterior), and anterior wedging (Fig. 3). Vertebral bone density was evaluated and described as either preserved or diminished. Spinal canal diameter was determined by means of the Pavlov ratio method,26 to detect congenital cervical stenosis. This was obtained by calculating the ratio of the anteroposterior diameter of the spinal canal compared with anteroposterior diameter at the midvertebral body opposite the site of maximum compression as well as at the C3-C7 levels. The canal was considered either; normal or stenotic if more than 3 levels had a ratio less than 0.8. Sagittal alignment in the lateral neutral, hyperflexion and hyperextension views was assessed to determine the presence of spine instability. Sagittal alignment was described as either; preserved or disturbed in both neutral and dynamic positions. Preoperative cervical MR imaging was obtained for all patients for the purpose of diagnosis and to eliminate other causes of myelopathy. In all cases, the number of levels showing compression and the severity of compression as determined by the degree of indentation of the subarachnoid space and neural structures were recorded. Foraminal diameter was evaluated on sagittal MRI views and according to foraminal subarachnoid space visualization was described as either; patent or diminished. Subarachnoid space obliteration was either; retrodiscal, retrovertebral or posterior (Fig. 3). Spinal cord compression was either; anterior, posterior or circumferential (Fig. 4). The size and shape of the cord as well as the presence of any abnormal intrinsic signals were demonstrated. Spinal cord size was either; normal or atrophic (Fig. 5). Spinal cord shape was either; flattened, indented, or hour-glass (Fig. 6). Spinal cord signal was either; absent or present (Fig. 7). Preoperative cervical CT scans were additionally...
obtained in 6 cases where suspicion of ossification of the posterior longitudinal ligament (OPLL) was raised. Preoperative bone densitometry studies were additionally obtained in 15 patients where suspicion of osteoporosis was raised and the surgical decision was to perform anterior discectomy with fusion for more than 2 levels.

**Surgical Approaches:**

**Selection Criteria.** Patients selected for anterior approaches fulfilled any or all of the following criteria; lordotic (normal) cervical curvature, congenital stenosis (Pavlov ratio < 0.8), significant posterior compression, circumferential (symmetrical) compression, elderly with multilevel compression, and diminished bone density. Patients were randomly selected for either posterior laminectomy or posterior laminoplasty. Patients selected for anterior approaches fulfilled any or all of the following criteria; abnormal cervical curvature (lordotic, S-shaped), significant anterior compression, evident instability on dynamic views.

**Cervical Laminctomy.** The patient was placed in a prone position with the table tilted cranially upward at an angle of 30°. A standard midline incision was made to expose the spinous processes from C2-T1 for a typical C3-C7 laminectomy. After the subperiosteal dissection was completed, the interspinous ligaments at C2-C3 and C7-T1 were removed. The Leksell double-action rongeur was used to carefully remove the spinous processes and the laminae overlying the central canal. The lateral extent of the decompression reached to the medial margins of the facet joints and was completed using the Kerrison rongeurs. The decompression was confined to the spinal canal itself without any attempt to breach the facets. No patients underwent durotomy or dentate ligamentectomy. After good hemostasis, a drain was placed and the wound closed in layers.

**Anterior Discectomy with Fusion.** The patient was approached in the supine position and the skin incision was planned according to the levels to be decompressed. For up to 3 levels, a right transverse incision made in the skin crease located appropriate for the level(s) was performed. For more than 3 levels, an oblique incision along the anterior border of the sternocleidomastoid muscle was used. The platysma & superficial cervical fascia were incised and the midline was reached in the plane between the carotid artery laterally and the trachea & esophagus medially. The longus colli muscles were self-retracted laterally and the level(s) to be operated were radiologically verified intraoperatively using the C-arm. The soft disc material was at first incised and removed with pituitary rongeurs, then Caspar intervertebral spreader was placed. The remnants of the disc material in the depth together with the end-plates from the adjacent vertebral bodies were further removed using curets. The osteophytes were visualized and removed with curets, then bilateral anterior foramotomies were done using 1-mm Kerrison rongeur. The posterior longitudinal ligament was preferably opened and excised with a kerrison rongeur to the edges of the area of bone removal. After the decompression was completed, an autologous horse-shoe shaped tricortical bone graft from the iliac crest was used for the interbody fusion. Placement of the bone graft was secured under moderate distraction, then retractors were removed and the wound closed in layers with drain in place.

**Expansive Open-door Cervical Laminooplasty.** The patient was placed in a prone position with the table tilted cranially upward at an angle of 30°. A standard midline incision was made to expose the spinous processes from C2-T1 for a typical C3-C7 laminoplasty. After the subperiosteal dissection was completed, the interspinous ligaments at C2-C3 and C7-T1 were removed. After the C2-C3 and C7-T1 interlaminar spaces were defined, the underlying ligamentum was removed using combined blunt and sharp dissections. A gutter was done on the "open" side at the medial margin of the facet through the cancellous bone, penetrating the inner cortex and opening the canal. A small kerrison rongeur was used to remove the underlying rim of ligamentum flavum. A gutter on the "hinge" side was similarly made except that it did not penetrate through the cancellous bone. Using two angled curettes, the open side was slowly lifted and the spinous processes are pressed towards the hinge side. To maintain this position, sutures were placed through the facet joint capsules, passed through the base of the spinous processes and tied. A drain was left in place and the wound was closed in layers in the standard fashion.
Functional Outcome:
Patients were clinically evaluated regularly every month for 6 months and postoperative functional outcome was documented at last follow-up 6 months after surgery. Postoperative pain assessment was done using the visual analog scale and was verbally classified as recovered, improved, stationary, and worsened. Postoperative assessment of myelopathy was determined using the mJOA score. The recovery rate of myelopathy was calculated according to the proposed formula by Hirabayashi et al. (postoperative score - preoperative score / full score - preoperative score X 100%). Postoperative recovery was estimated according to the aforementioned recovery rate and classified as excellent (75-100%), good (50-74%), fair (25-49%), and poor (0-24%).

Statistical Analysis:
All data was tabulated to determine the correlation of study parameters. The Statistical Product of Service Solutions (SPSS) for Windows programs was used for statistical analysis. Categoric data was presented by percentage and interval data by their mean and standard deviation. Chi-square ($X^2$) test examined the statistical significance of each categoric variable and Student's $t$ test was used for interval variables. Statistical significance was defined as $P$ value less than 0.05. Excellent and good outcomes were considered satisfactory, whereas fair and poor outcomes were considered unsatisfactory.

RESULTS

Patient Population:
The study group included 33 (60%) males and 22 (40%) females. Among those patients 15 (27%) were younger than 50 years and 40 (73%) were above 50 years of age (range 31-72 years, mean age, 54.5 years). Among 55 patients, 29 patients were operated through anterior cervical discectomies with fusion. Six patients did one level discectomy with fusion, 7 patients had double-level discectomies with fusion, 10 patients had 3-level discectomies with fusion, and 6 patients had 4-level discectomies with fusion. All patients did not apply any instrumentations for fixation. Another 26 patients were operated through posterior approaches, of whom 20 patients did subaxial cervical laminectomy C3-C7, and 6 patients did expansive open-door cervical laminoplasty.

Clinical Data:

Neck pain. Preoperative neck pain was present in 27 (49%) patients. The presence of neck pain related significantly to; the presence of brachialgia ($X^2=26.66$, $P<0.05$), mild myelopathy ($X^2=5.26$, $P<0.05$), abnormal spinal curve ($X^2=16.81$, $P<0.05$), diminished intervertebral disc height ($X^2=13.28$, $P<0.05$), wider spinal canal ($X^2=9.03$, $P<0.05$), diminished foraminal diameter ($X^2=8.03$, $P<0.05$), irregular vertebral body shape ($X^2=21.02$, $P<0.05$), static malalignment ($X^2=13.79$, $P<0.05$), dynamic malalignment ($X^2=55.00$, $P<0.05$), anterior cord compression ($X^2=8.62$, $P<0.05$).

Brachialgia. Preoperative brachialgia was present in 37 (67%) patients, being unilateral in 17 (31%) patients and bilateral in 20 (36%) patients. Among younger age group brachialgia tended to be unilateral whereas among elderly patients brachialgia was either absent or bilateral and the relation was statistically significant ($X^2=10.7$, $P<0.05$). Brachialgia also related significantly to; the presence of motor deficits in the upper limbs ($X^2=10.17$, $P<0.05$), abnormal spinal curve ($X^2=39.85$, $P<0.05$), diminished intervertebral disc height ($X^2=8.90$, $P<0.05$), wider spinal canal ($X^2=8.62$, $P<0.05$), multiple levels involved ($X^2=19.25$, $P<0.05$), irregular vertebral body shape ($X^2=25.46$, $P<0.05$), static malalignment ($X^2=14.72$, $P<0.05$), dynamic malalignment ($X^2=26.66$, $P<0.05$), retrodiscal subarachnoid space obliteration ($X^2=15.95$, $P<0.05$), anterior cord compression ($X^2=28.17$, $P<0.05$).

Myelopathy. According to the mJOA scale 24 (44%) patients had mild myelopathy (14-18) and 31 (56%) patients had moderate myelopathy (6-13), whereas none of our patients suffered of severe myelopathy. Moderate myelopathy related significantly to; male patients ($X^2=5.96$, $P<0.05$), absent neck pain ($X^2=5.26$, $P<0.05$), increased cord signal ($X^2=3.62$, $P<0.05$). Myelopathic manifestations in lower limbs occurred in all 55 (100%) patients who had variable degrees of spastic paraparesis, whereas, myelopathic manifestations in upper limbs were present in only 29 (53%) patients. Myelopathic manifestations in the upper limbs related significantly to; male patients ($X^2=3.94$, $P<0.05$), bilateral brachialgia ($X^2=10.17$, $P<0.05$)
Foraminal diameter. The intervertebral foramina in the affected levels were patent in 29 (53%) patients and diminished in 26 (47%) patients. Diminished foraminal diameter related significantly to; diminished bone density (X²=4.73, P<0.05), irregular vertebral body shape (X²=28.16, P<0.05), dynamic malalignment.

Spine Stability

Static alignment. Vertebral alignment in the neutral position was preserved in 34 (62%) patients and disturbed in 21 (38%) patients. Static malalignment related significantly to; dynamic malalignment (X²=13.79, P<0.05), retrodiscal subarachnoid space obliteration (X²=6.89, P<0.05).

Dynamic alignment. Vertebral alignment in dynamic positions was preserved in 28 (51%) patients and disturbed in 27 (49%) patients. Dynamic malalignment related significantly to; circumferrential cord compression (X²=8.63, P<0.05).

Cord Morphology

Subarachnoid space obliteration. The anterior subarachnoid space was obliterated retrodiscal in 33 (60%) patients and retrovertebral in 18 (33%) patients, whereas the posterior subarachnoid space was obliterated in 4 (7%) patients. Retrodiscal obliteration related significantly to; indented cord shape whereas retrovertebral obliteration correlated with cord flattening (X²=16.29, P<0.05).

Cord compression. The spinal cord was compressed anteriorly in 35 (64%) patients, posteriorly in 4 (7%) patients and circumferentially in 16 (29%) patients.

Cord shape. The cord was flattened in 8 (15%) patients, indented in 35 (63%) patients and hour-glass in 12 (22%) patients. Hour-glass cord shape related significantly to; the presence of increased cord signal (X²=11.44, P<0.05), circumferential cord compression (X²=78.02, P<0.05).

Cord size. The cord size was normal in 51 patients and atrophic in 4 patients.

Cord signal. Cord signal was absent in 31 (56%) patients and present in 24 (44%) patients. Increased cord signal related significantly to; male patients (X²=6.52, P<0.05), motor deficits in the upper limbs (X²=11.94, P<0.05), moderate myelopathy (X²=3.63, P<0.05), indented & hour-glass shaped cord (X²=11.44, P<0.05).

Imaging Data:

Spine Geometry

Spinal curve. The spinal curve was lordotic in 33 (60%) patients, S-shaped in 2 (4%) patients, straight in 4 (7%) patients and kyphotic in 16 (29%) patients. Abnormal spinal curve related significantly to; diminished intervertebral disc height (X²=6.83, P<0.05), static malalignment (X²=7.50, P<0.05), retrodiscal subarachnoid space obliteration (X²=14.25, P<0.05), indented & hour-glass shaped cord (X²=13.47, P<0.05), increased cord signal (X²=11.94, P<0.05).

Intervertebral discs height. The IVD height was preserved in 30 (55%) patients and diminished in 25 (45%) patients. Diminished IVD height related significantly to; diminished foraminal diameter (X²=30.00, P<0.05), preserved bone density (X²=5.41, P<0.05), irregular vertebral body shape (X²=36.44, P<0.05), static malalignment (X²=9.24, P<0.05), dynamic malalignment (X²=13.28, P<0.05).

Vertebral body shape. Vertebral body showed anterior lipping in 12 (22%) patients, posterior lipping in 12 (22%) patients, marginal lipping in 19 (34%) patients and anterior wedging in 12 (22%) patients. Disturbed vertebral body shape related significantly to; static malalignment (X²=12.61, P<0.05), dynamic malalignment (X²=21.02, P<0.05), circumferrential cord compression (X²=28.40, P<0.05).

Bone density. Bone density was preserved in 43 (78%) patients and diminished in 12 (22%) patients. Diminished bone density related significantly to; vertebral body wedging (X²=19.11, P<0.05), circumferential cord compression (X²=9.22, P<0.05).

Canal diameter. Canal morphology revealed a normal canal in 47 (85.5%) patients and stenotic canal in 8 (14.5%) patients. Stenotic cervical canal related significantly to; multi-level involvement (X²=11.38, P<0.05), preserved static alignment (X²=5.78, P<0.05), preserved dynamic alignment (X²=9.03, P<0.05), retrovertebral subarachnoid space obliteration (X²=7.71, P<0.05), circumferential cord compression (X²=11.56, P<0.05).
Number of levels involved. Among all patients, 10 (18%) patients had single level pathology, 8 (15%) patients had double level, 15 (27%) patients had 3 levels, 18 (33%) patients had 4 levels and 4 (7%) patients had regional pathology involving the whole subaxial cervical spine from C3-C7.

Pathology:
The compressive pathology was discal in 27 (49%) patients, flaval hypertrophy in 4 (7%) patients, combined discoligamental in 10 (18%) patients, vertebral in 2 (4%) patients, discovevertebral in 6 (11%) patients and ossified posterior longitudinal ligament (OPLL) in 6 (11%) patients. Among 2 patients there was an additional syrinx in association with spondylotic pathology (Fig. 8).

Functional Outcome:
1) Overall outcome:
Neck pain. Preoperative neck pain was present in 27 (49%) patients. Postoperatively, neck pain recovered in 6 (22%) patients, improved in 12 (44%) patients, was stationary in 8 (30%) patients and worsened in 1 (4%) patient. Postoperative satisfactory outcome for neck pain occurred in 18 (66%) patients and related significantly to; preoperative kyphotic spinal curve ($X^2=58.64$, $P<0.05$), diminished IVD heights ($X^2=10.11$, $P<0.05$), less number of levels involved ($X^2=3.41$, $P<0.05$), absent wedging of vertebral body ($X^2=37.80$, $P<0.05$), disturbed static alignment ($X^2=19.82$, $P<0.05$), disturbed dynamic alignment ($X^2=55.00$, $P<0.05$), and surgical approach using ADF ($X^2=16.98$, $P<0.05$).

Brachialgia. Preoperative brachialgia was present in 37 (67%) patients. Postoperatively, brachialgia recovered in 19 (51%) patients, improved in 12 (32%) patients and was stationary in 6 (17%) patients. Postoperative satisfactory outcome for brachialgia occurred in 27 (49%) patients and related significantly to younger patients ($X^2=10.83$, $P<0.05$), patent foramina ($X^2=34.67$, $P<0.05$), wide spinal canal ($X^2=8.49$, $P<0.05$), patent foramina ($X^2=10.11$, $P<0.05$), less number of levels involved ($X^2=37.92$, $P<0.05$), preserved IVD heights ($X^2=14.89$, $P<0.05$), preserved static alignment ($X^2=14.89$, $P<0.05$), preserved dynamic alignment ($X^2=32.71$, $P<0.05$), anteriorly indented cord ($X^2=22.71$, $P<0.05$), and surgical approach using ADF ($X^2=36.79$, $P<0.05$).

Myelopathy. Preoperative mild myelopathy was present in 24 (44%) patients and moderate myelopathy was present in 31 (56%) patients. Postoperatively, among patients with mild myelopathy, 2 (8%) patients had excellent outcome, 17 (71%) patients had good outcome and 5 (21%) patients had fair outcome. Among patients with moderate myelopathy, 8 (26%) patients had good outcome, 13 (42%) patients had fair outcome and 10 (32%) patients had poor outcome. Early intervention for myelopathy related significantly to better outcome ($X^2=18.19$, $P<0.05$). Postoperative satisfactory outcome for myelopathy occurred in 27 (49%) patients and related significantly to younger patients ($X^2=10.83$, $P<0.05$).

II) Selective surgical outcome;
Outcome following cervical laminectomy:
Neck pain. Among 20 patients who underwent cervical laminectomy, 4 (20%) patients had preoperative neck pain. Postoperatively, neck pain improved in 2 (50%) patients and remained stationary in the other 2 (50%) patients. Thus, satisfactory outcome for neck pain following cervical laminectomy occurred in 50% of patients.

Brachialgia. Among 20 patients who underwent cervical laminectomy, 6 (30%) patients had preoperative brachialgia. Postoperatively, brachialgia recovered in 2 (33%) patients, improved in 3 (50%) patients and remained stationary in 1 (17%) patient. Thus, satisfactory outcome for brachialgia following cervical laminectomy occurred in 83% of patients.

Myelopathy. Among 20 patients who underwent posterior cervical laminectomy, 10 (50%) patients had preoperative mild myelopathy and 10 (50%) patients had preoperative moderate myelopathy. Postoperatively, among patients with mild myelopathy, 8 (80%) patients had good outcome and 2 (20%) patients had fair outcome. Among patients with moderate myelopathy, 2 (20%) patients had good outcome, 6 (60%) patients had fair outcome and 2 (20%) patients had poor outcome. Thus, satisfactory outcome for myelopathy following cervical laminectomy occurred in 50% of patients.

Outcome following anterior discectomy with fusion:
Neck pain. Among 29 patients who underwent anterior discectomy with fusion, 21 (72.5%) had preoperative neck pain. Postoperatively, neck pain recovered in 6 (28.5%) patients, improved in 8 (38%) patients.
patients, remained stationary in 6 (28.5%) patients, and worsened in 1 (5%) patient. Thus, satisfactory outcome for neck pain following anterior discectomy with fusion occurred in 66.5% of patients.

**Brachialgia.** All 29 (100%) patients who underwent anterior discectomy with fusion had preoperative brachialgia. Postoperatively, brachialgia recovered in 17 (58.5%) patients, improved in 9 (31%) patients, and remained stationary in 3 (10.5%) patients. Thus, satisfactory outcome for brachialgia following anterior discectomy with fusion occurred in 89.5% of patients.

**Myelopathy.** Among 29 patients who underwent anterior discectomy with fusion, 12 (41%) patients had preoperative mild myelopathy and 17 (59%) patients had preoperative moderate myelopathy. Postoperatively, among patients with mild myelopathy, 2 (17%) patients had excellent outcome, 7 (58%) patients had good outcome and 3 (25%) patients had fair outcome. Among patients with moderate myelopathy, 6 (35%) patients had good outcome, 5 (30%) patients had fair outcome and 6 (35%) patients had poor outcome. Thus, satisfactory outcome for myelopathy following anterior discectomy with fusion occurred in 51.5% of patients.

**Outcome following expansive open-door cervical laminoplasty:**

**Neck pain.** Among 6 patients who underwent expansive laminoplasty, 2 patients had preoperative neck pain. Postoperatively, neck pain improved in these 2 patients.

**Brachialgia.** Among 6 patients who underwent expansive laminoplasty, 2 patients had preoperative brachialgia. Postoperatively, brachialgia remained stationary in these 2 patients.

**Myelopathy.** Among 6 patients who underwent expansive laminoplasty, 2 (33%) patients had preoperative mild myelopathy and 4 (67%) patients had preoperative moderate myelopathy. Postoperatively, among patients with mild myelopathy, 2 (100%) patients had good outcome. Among patients with moderate myelopathy, 2 (50%) patients had fair outcome and 2 (50%) patients had poor outcome.

![Fig. (1): Plain radiographs of the cervical spine -lateral view- showing different curves of the spine. From left to right: lordotic, S-shaped, straight, & kyphotic](image1)

![Fig. (2): Plain radiographs of the cervical spine -lateral view- showing intervertebral discs height. From left to right: preserved & diminished](image2)
Fig. (3): Plain radiographs of the cervical spine -lateral view- showing different vertebral body shapes. From left to right: anterior lipping, posterior lipping, marginal lipping & anterior wedging.

Fig. (4): Non contrast-enhanced T2-weighted MR images of the cervical spine showing variants of subarachnoid obliteration. From left to right: retrodiscal, retrovertebral & posterior

Fig. (5): Non contrast-enhanced T2-weighted MR images of the cervical spine showing variants of cord compression. From left to right: anterior, posterior & circumferential

Fig. (6): Non contrast-enhanced T1-weighted MR image of the cervical spine showing cord atrophy.
Fig. (7): Non contrast-enhanced T2-weighted MR images of the cervical spine showing different shapes of the cervical cord. From left to right: flattened, indented & hour-glass.

Fig. (8): Non contrast-enhanced T2-weighted MR images of the cervical spine showing increased cord signal opposite C3-C4 compression.

Fig. (9): Non contrast-enhanced T2-weighted MR images of the cervical spine showing cervical spondylosis with associated syringomyelia.
DISCUSSION

Cervical spondylotic myelopathy (CSM) is one of the most common spinal disorders that occurs secondary to cervical spondylosis. Although it often has a progressive pattern, yet its natural history, pathophysiology and optimal treatment remains controversial. Conservative treatment was reported to result in a 64% nonimprovement rate, with 26% of those patients displaying neurological deterioration.\(^\text{27}\) Surgical decompression is indicated for patients whose conditions are deteriorating,\(^\text{5,6,17}\) however, the optimal approach after initial diagnosis remains unclear. Selection strategy is critical for the surgical management of CSM. First, it involves the selection of surgical candidate. Second, it involves the selection of the most appropriate operation. Selecting a good surgical candidate is relatively straightforward, whereas selecting the type of operation to be performed is much more complicated, and as such, is very controversial. Surgical failures may occur secondary to either.\(^\text{27,30,31}\)

In this study we investigated a selected population of 55 patients who presented with myelopathic manifestations associated with cervical spondylosis. Among this group 60% were males and 40% were females. A higher male to female distribution agrees with previous reports. Naderi, et al.\(^\text{4}\) investigated 27 patients operated through a posterior approach, had 20 (74%) males and 7 (26%) females. Fessler, et al.\(^\text{15}\) reported a series of 93 patients operated through an anterior approach, of whom 68 (73%) were males and 25 (27%) were females. Ebersold, et al.\(^\text{5}\) studied 84 patients operated through either anterior or posterior approaches, that included 67 (80%) men and 17 (20%) women.

In our study, the age pattern included 73% above 50 years and 27% below 50 years. In their series Naderi, et al.\(^\text{4}\) had 55.6 % older than 50 years and 44.4% of their patients below 50 years. Among their population, there was no statistically significant difference in their mean preoperative JOA scores. The age of the patient at the time of presentation affects cervical spinal cord compression and decision-making process because of: the effect of age on the spine, its ligaments, and on intrinsic spinal stability; the effect of age on the spinal cord and its vasculature; and the effect of age on bone density. Older patients usually have greater intrinsic spinal stability, which they acquired through the aging/spondylotic process. The aged spine is characterized by a decreased range of motion in which relative immobility, rather than hypermobility is present,\(^\text{1}\) however, in some cases, dynamic spinal stenosis (retrospontylolisthesis of the vertebral body following neck extension) occurs. Vascular changes associated with spondylosis may be more severe in the older patient group and may result in ischemia of the nerve roots or spinal cord. This phenomenon can affect the tolerance of the spinal cord to compression. On the other hand, the spinal cord may be atrophic in older patients,\(^\text{1,3}\) thus minimizing the compressive effect of spinal stenosis.

Among our selected group of patients with cervical spondylotic myelopathy, neck pain was present in 49%, brachialgia was present in 67% mild myelopathy in 44% and moderate myelopathy in 56%. There was significant relation between the presence of neck pain, brachialgia and mild myelopathy. This relation probably implies that the severity of pain with failure of conservative measures, prompted the patient for surgical intervention before worsening of myelopathic manifestations. The overall postoperative outcome showed that neck pain recovered in 22%, improved in 44%, was stationary in 30% and worsened in 4%. Postoperative brachialgia recovered in 51%, improved in 32% and was stationary in 17%. Among patients with mild myelopathy, the postoperative outcome was excellent in 8%, good in 71% and fair in 21%. Among patients with moderate myelopathy the postoperative outcome was good in 26%, fair in 42% and poor in 32%. In Kumar, et al.\(^\text{8}\) series, the presenting symptoms and signs were neck pain (76%), brachialgia (60%), lower limbs myelopathy 100%, upper limbs myelopathy 96%. Naderi, et al.\(^\text{7}\) had 6 (22%) patients with mild myelopathy and 21 (78%) patients with moderate myelopathy. The final neurological examinations revealed improvement in the JOA scores of 23 (85%) and deterioration of 2 (7.5%) patients whereas 2 (7.5%) patients remained stationary. The difference between the preoperative and postoperative JOA scores for all patients was statistically significant. Ebersold, et al.\(^\text{3}\) had 53 (63%) patients with mild myelopathy and 31 (37%) patients with moderate myelopathy. The overall late outcome showed 44% improvement, 26% unchanged and 30% deteriorated. Among patients who underwent anterior approach the late outcome was 54.5% improvement, 27% unchanged, and 18.5% deteriorated, whereas among patients who underwent posterior approach the late
outcome was 37% improvement, 26% unchanged, and 37% deteriorated.

Spine geometry is predominantly affected by the degenerative process. Normally the intervertebral disc height is predominantly thicker in the ventral aspect than the dorsal aspect which contributes to the "natural" cervical lordosis. Degeneration of the intervertebral discs results in loss of the ventral aspect of the disc height and the lordotic posture of the cervical spine is diminished and eventually lost.28,31 A "straightening" of the spine increases the forces placed on the ventral aspect of the vertebral bodies, which begin to lose more height ventrally with development of forward bending of the dural sac and spinal cord. Eventually, cervical kyphosis occurs and compresses both the neural structures and the ventral spinal cord blood vessels. Thus, in cervical spondylosis the spine's curvature can be described to be either an "effective lordosis," "effective kyphosis," or a borderline form termed "straightened spine".32 Decisions about the type of surgery to be performed may be made, in part, on the basis of cervical curvature. In patients with an effective kyphosis, there is a high probability of failure associated with a dorsal approach.9 These cases perhaps should be treated via a ventral approach. The most important hazard of laminectomy in cases with an effective kyphosis is the risk of the "sagittal bowing" of the spinal cord, in which the spinal cord can be tethered over ventral osteophytes in the sagittal plane. Effective lordosis is often associated with dorsal compression of the cervical spinal cord; a dorsal approach may be appropriate in this situation. Surgical decision making, however, may be more complex in cases with a straightened spine who may be managed via ventral or dorsal surgery depending on the surgeon's bias. Among 27 patients with CSM, Naderi, et al.9 found that 19 (70.4%) patients had normal cervical lordosis, whereas 8 (29.6%) patients had abnormal cervical curve. There was no statistically significant difference in the mean preoperative JOA scores of both groups. Postoperatively, despite the improvement in the mean JOA score for both groups, yet only the improvement among patients with normal cervical lordosis was statistically significant.

Bone density is another variable that can affect surgical strategies. A 50% decrease in the mass of osseous tissue results in a reduction of strength to 25% of the original strength.28 Age-related osteoporosis (Type 2 osteoporosis) can complicate a patient's postoperative course. In cases of corpectomy and grafting, an aggressive bracing management strategy may be necessary.

Spinal canal size in the sagittal and coronal planes can affect both neurological and biomechanical aspects of CSM. Normal and pathological sagittal spinal canal diameters have been defined and documented,35,36 to determine to what extent congenital stenosis is involved. Edwards and LaRocca,37 reported that a narrow spinal canal is a significant mechanical factor of CSM. They reported that a 10-mm or less segmental sagittal diameter of the spinal canal associated with cervical spondylosis is likely to be associated with myelopathy (10-13 mm may be considered as a premylelopathy group, a 13-17 mm diameter exhibiting a tendency for symptomatic spondylosis, and a spinal canal diameter > 17 mm less prone to develop CSM). On the other hand, acquired stenosis may occur due to several structures that compromise the spinal canal. These include dorsal osteophytes, multiple herniated intervertebral discs, degenerated hypertrophic facets and uncovertebral joints, as well as hypertrophic or calcified ligamentum flavum or posterior longitudinal ligaments that may invaginate the spinal canal.35,36 Normally, the disc and the ligamentum flavum in the human spine are at approximately the same vertical coordinate level, thus if both are protruding into the spinal canal at the same level, as with extension of the neck, there is a likelihood of significant spinal cord compression. In this situation, there is a dynamic compression, known as the pincer phenomenon, in which there is a guillotine effect on the spinal cord. Because congenital cervical stenosis is not usually associated with dorsally directed ventrally located osteophytes, a laminectomy is most often expected to offer symptomatic relief and is, therefore, the operation of choice in most cases.33,34 Naderi, et al.3 had 14 (51.9%) patients with stenotic canals and 13 (48.1%) patients with non-stenotic canals. Among this population, there was no statistically significant difference in their mean preoperative JOA scores. Postoperatively, both groups showed a statistically significant improvement in their mean JOA scores, yet with no statistically significant difference between recovery rates of both groups.

Spine stability plays a role in surgical decision making.28 Nolan and Sherk,29 reported that the dorsal ligamentous complex acts as a static stabilizer of the cervical spine, whereas the extensor musculature (that is, the erector spinae muscle) acts as a dynamic
stabilizer, particularly of the lower cervical spine. Age-related ligamentous insufficiency should prompt consideration of surgical fusion. In cases with paraspinal ligamentous and musculature weakness, the likelihood of postoperative kyphosis is greater. Therefore, a ventral approach may be more appropriate. Alternatively, a dorsal approach for decompression (laminectomy) and stabilization (lateral mass fusion) may be appropriate in selected cases. The latter alternative may be an appropriate choice in situations in which significant kyphosis is not present, and simultaneously, in which progressive deformity such as kyphosis is likely; for example, in a straightened spine with moderately advanced degenerative changes. Postoperative instability is rare in series in which laminectomy is limited only to the lateral-most aspect of the dural sac. Although dorsal decompressive operations alone diminish intrinsic spinal stability, yet the extent of their effect on stability is often exaggerated. Wide laminectomies that extend beyond the medial one-quarter to one-third aspect of the facet and foraminotomies that disrupt facet integrity should be avoided or be accompanied by a stabilization and fusion procedure, if appropriate. The presence of an intrinsically unstable spine often dictates a ventral approach for both decompression and fusion or a dorsal approach for decompression combined with dorsal fusion.

Cord morphology secondary to CSM signifies the effects of spinal cord compression which is the main cause of neurological deficit. Fundamentally, three mechanisms of spinal cord distortion play a role in the CSM process: 1) direct spinal cord compression, 2) tethering of the spinal cord over extrinsic masses in the sagittal plane (sagittal bowstring effect) and 3) tethering of the spinal cord over extrinsic masses in the coronal plane (coronal bowstring effect). Spinal cord compression results from annular constriction of the spinal cord secondary to ventral osteophyte, dorsolateral facet, and dorsal hypertrophied ligamentum flavum compression. Tethering of the spinal cord over extrinsic structures is an underestimated cause of neurological dysfunction in CSM, which can be related to either ventral or dorsal structures in sagittal plane; however, extrinsic masses located ventral to the spinal cord are most commonly implicated. The neurological deficit in a patient with an effective kyphosis is, in part, related to tethering in the sagittal plane (sagittal bowstring effect). This explains the likelihood of neurological worsening in some cases following dorsal decompression procedures. The neurological dysfunction in these cases may be related, in part, to vascular compromise of the spinal cord. It has been suggested that the spinal cord can also be tethered in the coronal plane. This coronal plane tethering (coronal bowstring effect) is secondary to the ventral tethering of the spinal cord by the nerve roots or dentate ligaments. A laminectomy is often ineffective in relieving spinal cord distortion when this occurs. A central decompressive procedure or a laminectomy plus dentate ligament section (DLS) may alternatively relieve the spinal cord distortion in this type of situation.

High signal intensity was present in 47.6% patients who did preoperative cervical MRI in the series of Naderi, et al. whereas 52.4% did no show signal change in their MRI study. Among those with preoperative high signal intensity, 1 (10%) disappeared, 4 (40%) decreased, and 5 (50%) remained unchanged. There was no statistically significant difference in the mean preoperative JOA scores of patients with and without high MRI signal intensity. Comparing the two groups postoperatively, their was no statistically significant difference in the improvement of their mean postoperative JOA scores. In kumar, et al. series, hyperintense signal was noted in 10 (40%) of the patients. Postoperatively, 7 (70%) had good outcome and 3 (30%) had poor outcome.

Both ventral and dorsal surgical approaches play a role in the management of CSM. Choosing an appropriate surgical approach necessitates a thorough neurologic and functional assessment of the patient, determination of the predominant cause of neural compression i.e. spinal canal compromise, and determination of the spinal canal geometry in both the coronal and sagittal planes. The advantages and disadvantages of each must be considered in nearly all cases. It is imperative that one determines which patients are most likely to benefit from any given surgical approach while minimizing the risk/benefit ratio. The variety of ventral approaches to cervical decompression include discectomy (single & multiple levels) combined with osteophysectomy and corpectomy. The use of single-level ventral decompression in the treatment of CSM is widespread. The ventral approach, combined with grafting (with or without instrumentation) provides: 1) decompression of the spinal cord, nerve roots, and vessels ventral to the spinal cord, and 2) the ability to limit or reduce the kyphosis. A patient with an
effective kyphosis of the cervical spine usually requires a ventral surgical approach, provided surgery is indicated. The ventral approach is indicated in some cases of ventral plus dorsal compressive degenerative processes of the cervical spine, with an effective lordosis or straightened spine. In these cases, a dorsal surgical approach may be considered as a second stage. However, as the length of decompression and fusion increases, the incidence of both early and late postoperative complications increases. Regardless of the decompression procedure used, grafting is necessary. The use of grafting introduces the risks of graft-related problems, such as donor-site morbidity, graft migration (intrusion or extrusion), nonunion, or delayed union. The use of instrumentation following corpectomy in the degenerated cervical spine continues to be controversial. Most studies demonstrate a decreased rate of union and an increased rate of graft-related complications following multiple-level corpectomies without instrumentation. Furthermore, in cases with long decompression and fusion, the use of external splinting is necessary.

Dorsal surgical approaches to spinal canal decompression appear to be safe and effective. Laminectomy, and to a certain extent laminoplasty, are relatively simple operations. The complications associated with dorsal approaches are predictable and preventable. A dorsal approach may be selected in cases of an effective lordosis. Laminectomy for the treatment of CSM has been accepted as a standard procedure for years. It is most commonly indicated in patients who have a compressive myelopathy with an associated effective cervical lordosis. In kumar, et al. series, the postoperative myelopathy scores improved for 19 (76%) patients and remained stationary for 6 (24%) patients. Cases with a straightened spine may be treated by either a ventral or dorsal decompressive operation. A dorsal decompression may be combined with a dorsal fusion in such cases. In rare cases, a DLS may be added to a laminectomy procedure. The addition of DLS to laminectomy is considered safe, although its efficacy has been reported to be questionable. Laminctomy plus DLS is most clearly indicated in those patients who are adversely effected by the coronal bowstring effect and in whom an effective kyphosis does not exist. Laminctomy plus DLS provides similar neurological outcomes to ventral decompressive operations, particularly in patients with more severe myelopathies. On the other hand, laminectomy plus DLS has no significant acute risks for ventral bone graft and upper airway complications. Furthermore, long-term risks of accelerated degenerative changes above and below the fusion are not encountered. The similarity of neurological results (compared with ventral decompressive operations) may be related to the effective ventral decompression associated with DLS (that is, relief of the coronal bowstring effect). Thus, in selected patients with a patent cerebrospinal fluid space dorsal to the spinal cord and no cerebrospinal fluid space ventral to the spinal cord, DLS appears to provide additional ventral spinal cord decompression over that attained with cervical laminectomy alone. Yet, these cases are rarely encountered. In selected cases, laminectomy may be combined with a dorsal fusion. A dorsal fusion should be performed: 1) to prevent kyphosis; 2) to obtain a wide laminectomy; 3) in the presence of a straightened spine; and 4) to prevent progression of the degenerative process (which is motion dependent). Fusing the spondylotic spine does not significantly effect movement and range of motion in most cases, because normal movement is already substantially reduced via the spondylotic process. Cervical laminoplasty has become the choice of treatment for CSM in many countries. This procedure has been recommended for CSM and ossification of the posterior longitudinal ligament (OPLL). The main goal of laminoplasty is to enlarge the spinal canal with prevention of kyphosis, instability, postlaminectomy membrane formation, arachnoiditis, and restenosis. Three fundamental laminoplasty procedures are commonly used: Z-plasty; hemilateral open door laminoplasty; and bilateral open door laminoplasty (middorsal laminoplasty or French door laminoplasty). In the presence of an effective lordosis, cervical laminoplasty may be indicated in multiple level OPLL, congenital spinal canal stenosis, multilevel cervical stenosis, dorsal ligamentous hypertrophy, and as part of a staged ventral-dorsal spinal canal expansion procedure. Most of the studies on CSM and OPLL have reported postoperative enlargement of the spinal canal and an improved neurological outcome. Laminoplasty was found to provide increased stability, with less translation, tilting, and range of motion compared with laminectomy. However, several recent studies suggest that there may be no significant postoperative difference between laminectomy and laminoplasty regarding...
decompression, neurological recovery, kyphosis, and instability. Comparing the results of 28 cases, (10 laminectomy and 18 laminoplasty with 5-year follow up), Hukuda, et al. did not find superiority of laminoplasty over laminectomy in CSM for functional recovery and enlargement of the epidural space. There was no difference in the occurrence of kyphosis or instability. They reported a reduction in neck extension in those patients who underwent laminoplasty. Yoshida, et al. reported 50% limitation in flexion and extension of the neck following laminoplasty. On the other hand, Tsuzuki, et al. reported radiculopathies following laminoplasty procedures. They hypothesized that this was caused by an extradural nerve root tethering. Although all laminoplasty techniques have been used for the prevention of kyphosis and instability, several authors reported a rate of kyphosis development of up to 28%. 

Conclusion
Failure of surgical treatment is defined as the inability to reverse a neurological deficit or arrest a progressive myelopathy. Recurrence of myelopathy after an initially successful surgery may also occur. Causes of surgical failure and/or recurrence include; inaccurate diagnosis, delayed surgery after the spinal cord has sustained irreversible damage as well as an inappropriately chosen procedure or technically inadequate operation. Among surgical candidates early intervention for CSM is mandatory for better results. Selection of the surgical approach relates to static and dynamic factors that reduce the volume of the spinal canal either anatomically or mechanically or as a combination of both. Accurate identification of the neural compression process as well as proper assessment of the cervical spine geometry are the most important factors for surgical decision making.

REEFERENCES


الملخص العربي

جراحة الاعتلال النخاعي الفقاري العنقى: مقارنة المداخل الجراحية الأمامية والخلفية

الخلفية: يظل العلاج الجراحي للاعتلال النخاعي الفقاري العنقى موضوع اختلاف. لقد تم اعتماد العديد من المداخل الجراحية لعلاج الاعتلال النخاعي الفقاري العنقى، وتشمل المداخل الجراحية الأمامية والخلفية وكلاً منهما المشتركة.

الهدف: تهدف الدراسة إلى مراجعة الأنماط الأكاديمية والتصويرية المختلفة للاعتلال النخاعي الفقاري العنقى وتأثيرها على اختيار المدخل الجراحي المناسب.

الأشخاص: تم إجراء مراجعات خمسة حالات وقد بلغت نسبة الإجابة لمراجعات الاعتلال النخاعي الفقاري العنقى بقيم جراحة الاعصاب، كلية الطب، جامعة الإسكندرية.

الطريقة: تم تحليل المعالم الأكاديمية والتصويرية المختلفة، واندفاع المعايير الدالة على اختيار المدخل الجراحي.

النتائج: في مجموعة المرضى الكلية كان آل الرقية 49%، الآل العضدي 67%، الاعتلال النخاعي السبيط 44% واإلعتلال النخاعي السبيط المتوسط 56%. وقد أوضحت الدراسة حدوث تحسن في آل الرقية، الآل العضدي، الاعتلال النخاعي السبيط والمتوسط بعد الجراحة ولكن ليس في نسبة مساوية في المدخل الجراحي المستخدم.

الخلاصه: المداخل الجراحية المبكرة للاعتلال النخاعي الفقاري العنقى يمكن مصححها بمعالجات أعلى للتعافي. إن اختبار المدخل الجراحي يعد بمثابة الفيبر، وتشمل المعايير النخاعية والرنيني، والتعافي النخاعي السبيط والمتوسط، وتأثيره على الانتقادات النخاعية في حالة وجود اختلالات قبلي قبلي بضخ الدم الفقاري بالفجار.