REVIEW ARTICLE

Functional Outcome of Anterior Cervical Decompression and Fusion in Cervical Compressive Disease

Kawde P[1], Samal N[2], Baheti S[1], Rathi R[3], Kumbhare V[1], Charde P[1], Chandrakar A[4]

1 – Junior Resident, Department of Orthopedics, JNMC, Sawangi, Wardha, M.S., India.
2 - Associate Professor, Department of Orthopedics, JNMC, Sawangi, Wardha, M.S., India.
3 – Assistant Professor, Department of Orthopedics, JNMC, Sawangi, Wardha, M.S., India.
4 – Senior Resident, Department of Orthopedics, JNMC, Sawangi, Wardha, M.S. India

Abstract

Degenerative cervical myelopathy (DCM) is a currently added time period that encompasses degenerative etiologies of cervical myelopathy which includes spondylosis, ossification of the posterior longitudinal ligament, and ossification of the ligamentum flavum. Sufferers with progressive myelopathy are regularly offered surgical remedy to assist stabilize or enhance their neurological signs and characteristic. The list of operations for spinal compressive pathologies encompass laminoplasty and anterior cervical decompression with bone fusion (ASF) depending at the reasons, extension, direction of compression, presence of neck pain, and surgeons' experience. Anterior cervical decompression and fusion is the maximum common procedure due to the fact spondylotic myelopathy is located anteriorly to the spinal cord in maximum cases. In cases of a variable degeneration it's also feasible to combine discectomy and corpectomy inside the same affected person. In the current study, we reviewed various studies in literature on anterior cervical decompression and fusion in cervical compressive myelopathies.

***Keywords**: Cervical decompression, fusion, myelopathy.*

Address for correspondence: Dr. Anurag Chandrakar, Senior Resident, department of Orthopedics, JNMC & AVBRH, Sawangi, Wardha, M.S., India

Introduction

The list of operations for spinal compressive pathologies encompass laminoplasty and anterior cervical decompression with bone fusion (ASF) depending at the reasons, extension, direction of compression, presence of neck pain, and surgeons' experience.[1,2] The effectiveness of the usage of laminoplasty inside the remedy of multi-segment cervical stenosis is properly defined inside the literature.[3,4] In the literature, some suggested less favorable consequences in elderly sufferers with history of preceding trauma and lengthy length of outstanding neurological signs and symptoms.[5,6,7] Other adverse elements diagnosed inside the sufferers covered lower radiological Pavlov ratio (PR), lower twine compression ratio (CCR), and T2 wire signal adjustments in magnetic resonance imaging (MRI).[8]

Degenerative cervical myelopathy (DCM) is a currently added time period that encompasses degenerative etiologies of cervical myelopathy which includes spondylosis, ossification of the posterior longitudinal ligament, and ossification of the ligamentum flavum.[9,10] Sufferers with progressive myelopathy are regularly offered surgical remedy to assist stabilize or enhance their neurological signs and characteristic.[11] The AANS/ CNS recommendations for the management of Cervical Degenerative disorder dedicate four chapters to the surgical management of myelopathy, which includes specific chapters devoted to the surgical strategies of laminectomy,[12] laminoplasty,[13] laminectomy with instrumented fusion,1 and anterior cervical decompression with instrumented fusion. Those reviews suggest a clear need for more comparative studies of each current and novel surgical strategies employed inside the control of patients with DCM.[14] Causes of compressive myelopathy are mentioned in table 1.

Table 1: Causes of compressive myelopathy

Degenerative	
Traumatic	Bone lesion
	Disc herniation
	Epidural hemorrhage
Infectious (abscess)	
Tumors:	
i. Extradural	Benign
	Malignant
ii. Intradural	Intramedullary
	Extramedullary
Vascular	arterio-venous malformations
Syringomyelia	

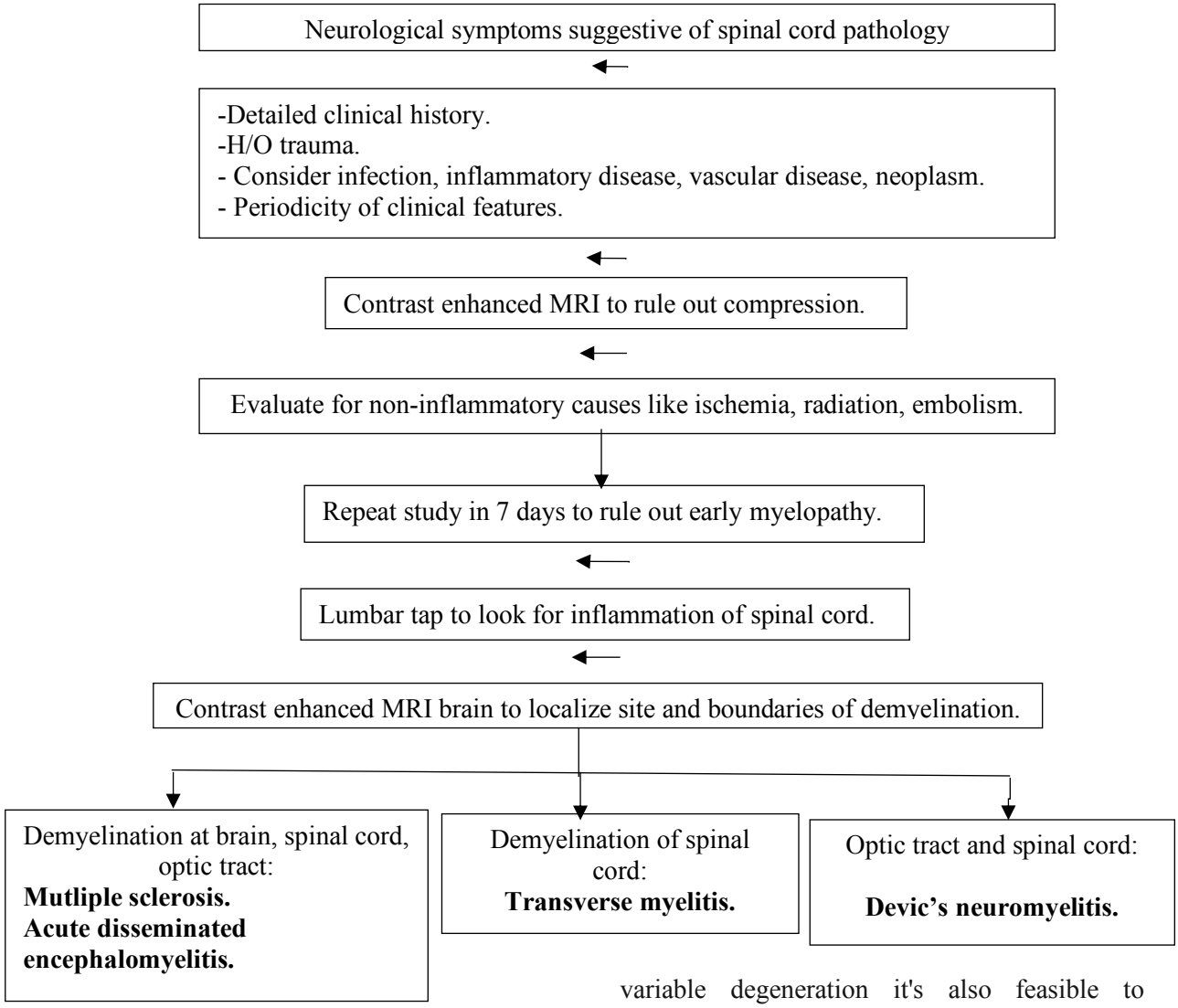
Table 2: Modified Japanese Orthopedic affiliation (mJOA) scale score

Item		Grade
Motor dysfunction score of the upper extremity	Inability to move hands	0
	Inability to eat with spoon but able to move hands	1
	Inability to button shirt but able to eat with spoon	2
	Able to button shirt with great difficulty	3
	Able to button shirt with slight difficulty	4
	No dysfunction	5
Motor function score of the lower extremity	Complete loss of motor and sensory function	0
	Sensory preservation without ability to move legs	1
	Able to move legs but unable to walk	2
	Able to walk on flat floor but with walking aid	3
	Able to walk up and/or down with handrail	4
	Moderate to significant lack of stability but able to walk up and/or downstairs without hand rail	5
	Mild lack of stability but walks with smooth reciprocation unaided	6
	No dysfunction	7
Sensory dysfunction score of the upper extremity	Complete loss of hand sensation	0
	Severe sensory loss of pain	1
	Mild sensory loss	2
	No sensory loss	3
Sphincter dysfunction score	Inability to micturate voluntarily	0
	Marked difficulty in micturition	1
	Mild to moderate difficulty in micturition	2
	Normal micturition	3

At the same time as inside the beyond the documentation of stepped forward scientific results the usage of patient-stated outcome has proved hard,[15] extra latest research have stated enhancements after spine surgical operation with patient-stated outcome measures.[11,16,17,18,19,20] Some may also argue that medical final results following surgical treatment for DCM is excellent assessed by means of a disorder-specific measure of neurological incapacity which includes the modified Japanese Orthopaedic affiliation (mJOA) scale score [table 2]. A capability situation of the use of the computers as a primary outcome measure is that it represents a measure of general health as opposed to a disease-specific degree.[21] Notwithstanding this problem, affected person-said well-known

fitness outcome measures were utilized in clinical studies addressing spinal surgical treatment results.[16,18,19,22,23,24] The surgical aim is to decompress, stabilize and to repair the alignment of spine. LaRocca was one of the first to recommended early spinal cord decompression with or without stabilization to halt the progression of the sickness for sufferers providing with mild practical incapacity.[25] The control of cervical spondylotic myelopathy remains shrouded in controversy. Commonplace surgical method includes discectomy without fusion or discectomy with fusion (ACDF)[26,27,28,29] and corpectomy with fusion (ACCF).[30,31,32] Fusion technique consists of use of bone graft or cage and addition of plate.[30,32] ACDF has been showed to be beneficial in treatment of cervical myelopathy in both long and brief-time period observe up.[33,34,35] Further, it is able to be divided into anterior or posterior tactics in phrases of technique to the cervical spine.[36] Diagnostic flowchart of myelopathies is depicted in figure 1.

Figure 1: Diagnostic flowchart for myelopathy



Anterior Approach

Indications

Anterior decompression and fusion is the maximum common procedure due to the fact spondylotic myelopathy is located anteriorly to the spinal cord in maximum cases. In cases of a variable degeneration it's also feasible to combine discectomy and corpectomy inside the same affected person.[37,38] The very best fusion charge is accomplished through the use of an iliac crest bone graft.[39] Although, this technique bears the danger of donor web site morbidity. Opportunity implants for vertebral

body substitute are (distractable) titanium cages or phenyletheretherketone (PEEK) cages. In two studies, the PEEK cages showed an especially excessive charge of subsidence (25%) 1 year after surgery.[37,40]

Anterior Cervical Interbody Fusion

The maximum frequently mentioned approach for anterior discectomy and fusion is the one described by way of Emery et al.[41] The populace of the anterior technique for discectomy and fusion has improved because this approach avoids exposure of the spinal canal and outcomes in less gentle tissue harm.[42]

The commonplace surgical method to deal with cervical spondylotic myelopathy is removal of the broken disc(s) and/or osteophyte with bone transplantation. The fusion fee for unmarried-level fusions ranged from 89 to 99% [43,44] and for dual-level fusions ranged from 70-90%.[45]

For the multilevel fusions, the fusion rate became decreased as compared with the single- or dual stage fusions.[46] The achievement fee for the multilevel fusions ranged from 60 to 88%.[47] Maximum regularly mentioned issues encompass postoperative ache, wound hematoma, infection, pelvic fracture, nerve palsy, and continual donor web page ache with the prevalence of a mean of 2.4%.[48] In a study that specially looked at donor website ache, no much less than 90% of patients complained of donor web site ache.[49,50]

Adjoining disc degeneration after anterior cervical interbody fusion is also a relatively commonplace problem. The occurrence of adjacent disc degeneration after cervical anterior cervical interbody fusion has been reported as 11–33%.[51,52] Patient-triggered symptomatic adjacent disc degeneration occasionally requires additional surgical operation at the cervical spine. In long-time period observe-up studies, the price of revision surgical treatment has been said to be 6.3–16.9%.[51,53]

There are decompressive surgical processes for cervical myelopathy because of OPLL: PDS and advertisements. Each has advantages as well as risks.[54,55,56,57] We choose laminoplasty for cervical OPLL, due to the fact this process is simple to perform, mainly for multilevel disease. Although several postoperative complications,[13] consisting of C5 palsy,[58,59] axial signs,[60,61] and reduced cervical variety of movement, have been said after cervical laminoplasty, the lengthy-time period surgical final results can be predicted to be first-class.[62,63,64,65]

A file of a scientific overview said that cervical laminoplasty is suggested for the remedy of cervical spondylotic myelopathy or OPLL (magnificence III).[13,66,67,68,69] Such deterioration may additionally require in addition anterior decompression.

According to some authors, those causes of such deterioration are age older than 60 years, decreased sagittal diameter of the spinal canal, development of ossification of the posterior longitudinal ligament, and minor trauma.[62,70,71,72] It's far well known that development of kyphosis every so often takes place after cervical laminoplasty.[62,72,73,74] However, there are numerous disadvantages to the anterior method and it is able to be technically disturbing.[54] Commercials calls for corpectomy and the elimination or floating of OPLL in some cases with excessive OPLL. In 1 study, 4 sufferers had CSF leakage after surgery.[74,75,76,77] Bone grafting affords another series of ability issues.[57,75,78,79]

Anterior approach

Anterior interbody strut grafting of three or more stages is associated with an increased failure fee.[80] In these cases, the authors usually carry out an additional posterior fusion. Moreover, a demonstration for circumferential instrumentation is given in instances of bad bone quality due to metabolic problems.[37,81]

Ways to avoid complications?

Whilst choosing iliac crest bone graft as vertebral frame replacement complications end result from donor website morbidity: haematoma, infection, fracture, nerve damage. Those headaches may be averted by way of selecting (distractable) titanium cages or PEEK cages for the substitute. In instances of corpectomies of three or more stages and/or metabolic problems a further posterior fusion avoids failure of the instrumentation.[37]

Specific perioperative considerations

In instances of bone harvesting from the iliac crest the patient has to be knowledgeable approximately donor site morbidity. Fehling et al. analyzed the cases of 302 patients who underwent both an anterior-best, posterior-best or blended anterior-posterior methods for the

treatment of spondylotic myelopathy and figured out a usual perioperative problem rate of 15.6 %.[82] The most common complications had been cardiopulmonary events (3.0 %), dysphagia (3.0 %), and superficial wound infection (2%). Perioperative worsening of myelopathy became pronounced in 1.3%. After a comply with-up of two years there has been a delayed difficulty price of 4.4 %. Zhu et al. figured out a extensively higher reoperation fee for anterior surgical procedure (9 %) as compared to posterior surgical procedure (0.3 %) in a meta-analysis that included eight studies.[83]

Hirai et al suggested that residual anterior compression of the spinal cord after posterior laminoplasty was the cause of the lower recovery rate in the posterior group.[84] While the examine via Shibuya et al demonstrating a lower healing price within the anterior organization compared with the posterior organization (41%±26.6% vs 50.9%±25.9%, respectively; P>.05) become excluded, there has been no huge difference in healing fee between the two groups (P>.05; weighted suggest difference=10.19 [range, -0.45 to 20.83]; heterogeneity: P=.24; I2=29%).[85] Further, Wada et al,[86] Iwasaki et al,[87] and Shibuya et al [85] stated the medical consequences with lengthy-term follow-up extra than 10 years. Although the warning signs for reoperation among research have been no longer steady, ADF for the treatment of multilevel cervical compressive myelopathy regarded to have a higher danger of reoperation.[88]

Wada et al stated a vast correlation among pseudoarthrosis and number of fused segments, demonstrating that the incidence of pseudoarthrosis turned into augmented with the expanded variety of fused segments.[86] Fraser and Hartl said that the anticipant fusion price in a single section with anterior decompression and fusion was 97.1%; it changed into 95% in 2 segments and 83% in three segments.[89] Corpectomy has emerged as an exquisite surgical modality CSM. In one study, the Nurick's rating improved from 3.8 to 1.67. In a have a look at via Chagas et al., the mean Nurick score improved from 2.97 to 2.1 after corpectomy.[90] In a examine by Rajashekar and Kumar, the suggest Nurick rating improved from 4.24 to 2.47 after corpectomy.[91] In a similar take a look at via Chibbaro et al., development of mJOA score become visible from 12.2 to 15.[92] Different surgical modalities of treatment of CSM are cervical laminectomy, laminoplasty, and discectomy. In a metaanalysis by way of Ratliff and Cooper, the suggest restoration fee after cervical laminectomy and laminoplasty changed into stated to be 55% (20-80%).[93] Chiba et al. despite the fact that stated excellent recovery rates after laminoplasty segmental motor paralysis, kyphosis, mounted earlier than and after surgical operation, and past due deterioration because of age-associated degeneration remained difficult troubles.[94] Moreover, techniques in modern use for expansive laminoplasty operations at the cervical backbone damage the extensor mechanisms, resulting in limit of neck movement, lack of lordosis, and persistent axial pains.[95]

Conclusion

To date, several studies were conducted to find which procedure is superior to the others for the treatment of cervical myelopathy. Nowadays, each surgeon tends to choose each method by evaluating patients' clinical conditions.

Conflict of Interest: *None declared*
Source of Support: *Nil*

References

1. Sakaura H, Hosono N, Mukai Y, et al. Long-term outcome of laminoplasty for cervical myelopathy due to disc herniation: a comparative study of laminoplasty and anterior spinal fusion. Spine 2005; 30:756e9.
2. Rao RD, Gourab K, David KS. Operative treatment of cervical spondylotic myelopathy. J Bone Joint Surg Am 2006; 88:1619e40.
3. Kawakami M, Tamaki T, Iwasaki H, et al. A comparative study of surgical approaches for cervical compressive myelopathy. Clin Orthop Relat Res. 2000; 381:129e36.
4. Chiba K, Toyama Y, Watanabe M, et al. Impact of longitudinal distance of the cervical spine on the results of expansive open-door laminoplasty. Spine 2000; 25:2893e8.
5. Fujiwara K, Yonenobu K, Ebara S, et al. The prognosis of surgery for cervical compression myelopathy. J Bone Joint Surg Br 1989; 71B:393e8.
6. Epstein JA, Janin Y, Carras R, et al. A comparative study of the treatment of cervical spondylotic myeloradiculopathy. Experience with 50 cases treated by means of extensive laminectomy, foraminotomy, and excision of osteophytes during the past 10 years. Acta Neurochir (Wien) 1982; 61:81e104.
7. Tanaka J, Seki N, Tokimura F, et al. Operative results of canal-expansive laminoplasty for cervical spondylotic myelopathy in elderly patients. Spine 1999; 24:2308e12.
8. Matsuda Y, Miyazaki K, Tada K, et al. Increased MR signal intensity due to cervical myelopathy. Analysis of 29 surgical cases. J Neurosurg 1991; 74:887e92.
9. Nouri A, Tetreault L, Singh A et al. Degenerative cervical myelopathy. Spine (Phila Pa). 2015;40:E675–E693.

10. Tetreault L, Goldstein CL, Arnold P et al. Degenerative cervical myelopathy: a spectrum of related disorders affecting the aging spine. Neurosurgery. 2015; 77(4):S51–S67.
11. Fehlings MG, Ibrahim A, Tetreault L et al. A global perspective on the outcomes of surgical decompression in patients with cervical spondylotic myelopathy: results from the prospective multicenter AOSpine international study on 479 patients. Spine (Phila Pa). 2015; 40:1322–1328.
12. Ryken T, Heary R, Matz P, et al. Cervical laminectomy for the treatment of cervical degenerative myelopathy. J Neurosurg Spine. 2009; 11:142–149.
13. Matz P, Anderson P, Groff M et al. Cervical laminoplasty for the treatment of cervical degenerative myelopathy. J Neurosurg Spine. 2009; 11:157–169.
14. Matz P, Holly L, Mummaneni P et al. Anterior cervical surgery for the treatment of cervical degenerative myelopathy. J Neurosurg Spine. 2009; 11:170–173.
15. King J, Moossy J, Tsevat J et al. Multimodal assessment after surgery for cervical spondylotic myelopathy. J Neurosurg Spine. 2005; 2:526–534.
16. Auffinger B, Lam S, Shen J et al. Usefulness of minimum clinically important difference for assessing patients with subaxial degenerative cervical spine disease: statistical versus substantial clinical benefit. Acta Neurochir (Wien). 2013; 155:2345–2355.
17. Auffinger B, Lall R, Dahdaleh N et al. Measuring surgical outcomes in cervical spondylotic myelopathy patients undergoing anterior cervical discectomy and fusion: assessment of minimum clinically important difference. PLoS One. 2013; 8:e67408.
18. Carreon L, Glassman S, Campbell M et al. Neck Disability Index, Short Form-36 physical component summary, and pain scales for neck and arm pain: the minimum clinically important difference and substantial clinical benefit after cervical spine fusion. Spine J. 2010; 10:469–474.
19. Whitmore R, Ghogawala Z, Petrov D et al. Functional outcome instruments used for cervical spondylotic myelopathy: interscale correlation and prediction of preference-based quality of life. Spine J. 2013; 13:902–907.
20. Lubelski D, Alvin M, Nesterenko S et al. Correlation of quality of life and functional outcome measures for cervical spondylotic myelopathy. J Neurosurg Spine. 2016; 24:483–489.
21. Holly L, Matz P, Anderson P et al. Clinical prognostic indicators of surgical outcome in cervical spondylotic myelopathy. J Neurosurg Spine. 2009; 11:112–118.
22. Birkmeyer N, Weinstein J, Tosteson A et al. Design of the Spine Patient Outcomes Research Trial (SPORT). Spine (Phila Pa) 2009; 27:1361–1372.
23. Zhou F, Zhang Y, Sun Y et al. Assessment of the minimum clinically important difference in neurological function and quality of life after surgery in cervical spondylotic myelopathy patients: a prospective cohort study. Eur Spine J. 2005; 24:2918–2923.
24. Ghogawala Z, Benzel E, Heary R et al. Cervical spondylotic myelopathy surgical trial: randomized, controlled trial design and rationale. Neurosurgery. 2014; 75:334–346.
25. LaRocca H. Cervical spondylotic myelopathy: natural history. Spine (Phila Pa). 1988; 13: 854-855.
26. Ding C, Hong Y, Liu H et al. Comparison of cervical disc arthroplasty with anterior cervical discectomy and fusion for the treatment of cervical spondylotic myelopathy. Acta Orthop Belg. 2013; 79: 338-346.
27. Li J, Zheng Q, Guo X, et al. Anterior surgical options for the treatment of cervical spondylotic myelopathy in a long-term follow-up study. Arch Orthop Trauma Surg. 2013; 133: 745-751.
28. Basu S, Sreeramalingam R. Adjacent level spondylodiscitis after anterior cervical decompression and fusion. Indian J Orthop. 2012; 46:360-363.
29. Lin Q, Zhou X, Wang X et al. A comparison of anterior cervical discectomy and corpectomy in patients with multilevel cervical spondylotic myelopathy. Eur Spine J. 2012; 21: 474-481.
30. Burkhardt J, Mannion A, Marbacher S et al. A comparative effectiveness study of patient-rated and radiographic outcome after 2 types of decompression with fusion for spondylotic myelopathy: anterior cervical discectomy versus corpectomy. Neurosurg Focus. 2013; 35: E4.
31. Liu Y, Hou Y, Yang L et al. Comparison of 3 reconstructive techniques in the surgical management of multilevel cervical spondylotic myelopathy. Spine (Phila Pa). 2012; 37: E1450-1458.
32. Gao R, Yang L, Chen H et al. Long term results of anterior corpectomy and fusion for cervical spondylotic myelopathy. PLoS One. 2012; 7: e34811.
33. Liu X, Min S, Zhang H et al. Anterior corpectomy versus posterior laminoplasty for multilevel cervical myelopathy: a systematic review and meta-analysis. Eur Spine J. 2014; 23: 362-372.
34. Yan D, Wang Z, Deng S et al. Anterior corpectomy and reconstruction with titanium mesh cage and dynamic cervical plate for cervical spondylotic myelopathy in elderly osteoporosis patients. Arch Orthop Trauma Surg. 2011; 131: 1369-1374.
35. Wen Z, Du J, Ling Z et al. Anterior cervical discectomy and fusion versus anterior cervical corpectomy and fusion in the treatment of multilevel cervical spondylotic myelopathy: systematic review and a metaanalysis. Ther Clin Risk Manag. 2015; 11: 161-170.
36. Nishizawa K, Mori K, Saruhashi Y, et al. Operative outcomes for cervical degenerative disease: A review of the literature. International Scholarly Research Network Orthopedics. 2012:1-6.
37. König S, Ranguis S, Spetzger U.Management of complex cervical instability. J Neurol Surg A Cent Eur Neurosurg. 2013; 13(1): 21-9.
38. Medow J, Trost G, Sandin J. Surgical management of cervical myelopathy: indications and techniques for surgical corpectomy. Spine J. 2006; 6(6):233S–241S.
39. Epstein N. Iliac crest autograft versus alternative constructs for anterior cervical spine surgery: Pros, cons, and costs. Surg Neurol Int. 2012; 3(3):S143–S156.
40. Hussain M, Nassr A, Natarajan R et al. Biomechanics of adjacent segments after a multilevel cervical corpectomy using anterior, posterior, and combined anterior-posterior instrumentation techniques: a finite element model study. Spine J. 2013; 13(6): 689–696.
41. Emery S, Bolesta M, Banks M et al. Robinson anterior cervical fusion: comparison of the standard and modified techniques. Spine. 1994; 19(6):660– 663.
42. Fraser R. Interbody, posterior, and combined lumbar fusions. Spine. 1995;20(24):167–177.
43. Wright I, Eisenstein S. Anterior cervical discectomy and fusion without instrumentation. Spine. 2007; 32(7):772–774.
44. Epstein N. Anterior cervical diskectomy and fusion without plate instrumentation in 178 patients. Journal of Spinal Disorders. 2000;13(1): 1–8.
45. Bolesta M, Rechtine G, Chrin A. One- and two level anterior cervical discectomy and fusion: the effect of plate fixation. Spine Journal. 2002; 2(3):197–203.
46. Wang J, McDonough P, Endow K et al. Increased fusion rates with cervical plating for two-level anterior cervical pas and fusion. Spine. 2000; 25(1):41–45.
47. H. Koller, A. Hempfing, L. Ferraris, O. Maier, W. Hitzl, and P. Metz-Stavenhagen, "4- And 5-level anterior fusions of the cervical spine: review of literature and clinical results," European Spine Journal. 2007;16(12): 2055–2071.
48. McConnell J, Freeman B, Debnath U et al. A prospective randomized comparison of coralline hydroxyapatite with autograft in cervical interbody fusion. Spine. 2003; 28(4): 317-323.
49. Heneghan H, McCabe J. Use of autologous bone graft in anterior cervical decompression: morbidity and quality of life analysis. BMC Musculoskeletal Disorders. 2009;10(1):158-65.
50. Jacobs W, Anderson P, Limbeek J et al. Single or double-level anterior interbody fusion techniques for cervical degenerative disc disease. Cochrane Database of Systematic Reviews, no. 4, 2004 Article ID CD004958.
51. Komura S, Miyamoto K, Hosoe H et al. Lower Incidence of adjacent segment degeneration after anterior cervical fusion found with those fusing C5-6 and C6-7 than those leaving C5- 6 or C6-7 as an adjacent level. Journal of Spinal Disorders & Techniques. In press.
52. Katsuura A, Hukuda S, Saruhashi Y et al. Kyphotic malalignment after anterior cervical fusion is one of the factors promoting the degenerative process in adjacent intervertebral levels. European Spine Journal. 2001; 10(4): 320–324.
53. Hilibrand A, Carlson G, Palumbo M et al. Radiculopathy and myelopathy at segments adjacent to the site of a previous anterior cervical arthrodesis. Journal of Bone and Joint Surgery. 1999; 81(4):519–528.

54. Tani T, Ushida T, Ishida K, et al. Relative safety of anterior microsurgical decompression versus laminoplasty for cervical myelopathy with a massive ossified posterior longitudinal ligament. Spine 2002; 27: 2491–8.
55. Sugrue P, McClendon J, Halpin R, et al. Surgical management of cervical ossification of the posterior longitudinal ligament: natural history and the role of surgical decompression and stabilization. Neurosurg Focus 2011; 30:E1.
56. Smith Z, Buchanan C, Raphael D, et al. Ossification of the posterior longitudinal ligament: pathogenesis, management, and current surgical approaches. A review. Neurosurg Focus 2011; 30:E10.
57. Iwasaki M, Yonenobu K. Choice of surgical procedure. In: Yonenobu K, Nakamura K, Toyama, eds. Ossification of the posterior longitudinal ligament. 2nd edn. Tokyo: Springer, 2006:181–5.
58. Kaneyama S, Sumi M, Kanatani T, et al. Prospective study and multivariate analysis of the incidence of C5 palsy after cervical laminoplasty. Spine 2010; 35:E1553–8.
59. Imagama S, Mastuyaa Y, Yukawa Y, et al. C5 palsy after cervical laminoplasty. A multicentre study. J Bone Joint Surg Br. 2010; 92: 393–400.
60. Hosono N, Yonenobu K, Ono K. Neck and shoulder pain after laminoplasty. A noticeable complication. Spine 1996; 21:1969–73.
61. Kawaguchi Y, Matsui H, Ishihara H, et al. Axial symptoms following en bloc cervical laminoplasty. J Spinal Disord 1999; 12:392–5.
62. Kawaguchi Y, Kanamori M, Ishihara H, et al. Minimum 10-year follow up after en bloc cervical laminoplasty. Clin Orthop Relat Res 2003; 411:129–39.
63. Maeda T, Arizono T, Saito T, et al. Cervical alignment, range of motion, and instability after cervical laminoplasty. Clin Orthop Relat Res. 2002; 401:132–8.
64. Hyun S, Rhim S, Roh S et al. The time course of range of motion loss after cervical laminoplasty. A prospective study with minimum two-year follow-up. Spine 2009; 34:1134–9.
65. Fujiyoshi T, Yamazaki M, Kawabe J, et al. A new concept for making decisions regarding the surgical approach for cervical ossification of the posterior longitudinal ligament. Spine 2008; 33:E990–3.
66. Kawaguchi Y, Kanamori M, Ishihara H, et al. Progression of ossification of the posterior longitudinal ligament following cervical laminoplasty. J Bone Joint Surg Am 2001; 83:1798–802.
67. Hori T, Kawaguchi Y, Kimura T. How does the ossification area of the posterior longitudinal ligament progress after cervical laminoplasty? Spine 2006; 31:2807–12.
68. Hori T, Kawaguchi Y, Kimura T. How does the ossification area of the posterior longitudinal ligament thicken following cervical laminoplasty? Spine 2007; 32:E551–6.
69. TokuhashiY, AjiroY, Umezawa N. A patient with two re-surgeries for delayed myelopathy due to progression of ossification of the posterior longitudinal ligaments after cervical laminoplasty. Spine 2009; 34:E101–5.
70. Ebersold M, Pare M, Quast L. Surgical treatment for cervical spondylitic myelopathy. J Neurosurg 1995; 82:745–51.
71. Satomi K, Nishu Y, Kohno T, et al. Long-term follow-up studies of open-door expansive laminoplasty for cervical stenotic myelopathy. Spine 1994; 19:507–10.
72. Iwasaki M, Kawaguchi Y, Kimura T, et al. Long-term results of expansive laminoplasty for ossification of the posterior longitudinal ligament of the cervical spine. More than 10 years follow up. J Neurosurg 2002; 96:180–9.
73. Saruhashi Y, Hukuda S, Katsuura A, et al. A long-term follow-up study of cervical spondylotic myelopathy treated by ‘‘French window’’ laminoplasty. J Spinal Disord. 1999;12:99–101.
74. Suda K, Abumi K, Ito M, et al. Local kyphosis reduces surgical outcomes of expansive open-door laminoplasty for cervical spondylotic myelopathy. Spine 2003; 28:1258–62.
75. Iwasaki M, Okuda S, Miyauchi A, et al. Surgical strategy for cervical myelopathy due to ossification of the posterior longitudinal ligament. Part 1: advantages of anterior decompression and fusion over laminoplasty. Spine 2007; 32:647–53.
76. Joseph V, Kumar SS, Rajshekhar V. Cerebrospinal fluid leak during cervical corpectomy for ossified posterior longitudinal ligament. Incidence, management, and outcome. Spine 2009; 34:491–4.
77. Chen Y, Guo Y, Lu X, et al. Surgical strategy for multilevel severe ossification of posterior longitudinal ligament in the cervical spine. J Spinal Disord Tech 2011; 24:24–30.
78. Nancy N. Reoperation rates for acute graft extrusion and pseudoarthrosis after one-level anterior corpectomy and fusion with and without plate instrumentation: etiology and corrective management. Surg Neurol 2003;56:73–8.
79. Geisler F, Caspar W, Pitzen T, et al. Reoperation in patients after anterior cervical plate stabilization in degenerative disease. Spine 1998; 23:911–20.
80. Komotar R, Mocco J, Kaiser M. Surgical management of cervicalmyelopathy: indications and techniques for laminectomy and fusion. Spine J. 2006; 6(6):252S–267S.
81. Kim P, Alexander J. Indications for circumferential surgery for cervical spondylotic myelopathy. Spine. 2006; 6(6): 299S–307S.
82. Fehlings M, Smith J, Kopjar B et al. Perioperative and delayed complications associated with the surgical treatment of cervical spondylotic myelopathy based on 302 patients from the AOSpine North America Cervical Spondylotic Myelopathy Study. J Neurosurg Spine. 2012; 16(5): 425–432
83. Zhu B, Xu Y, Liu X et al. Anterior approach versus posterior approach for the treatment of multilevel cervical spondylotic myelopathy: a systemic review and meta-analysis. Eur Spine J. 2013; 22(7):1583–1593
84. Hirai T, Okawa A, Arai Y, et al. Middle-term results of a prospective comparative study of anterior decompression with fusion and posterior decompression with laminoplasty for the treatment of cervical spondylotic myelopathy. Spine (Phila Pa). 2011; 36:1940-1947.
85. Shibuya S, Komatsubara S, Oka S, et al. Differences between subtotal corpectomy and laminoplasty for cervical spondylotic myelopathy. Spinal Cord. 2010; 48:214- 220.
86. Wada E, Suzuki S, Kanazawa A, et al. Subtotal corpectomy versus laminoplasty for multilevel cervical spondylotic myelopathy: a long-term follow-up study over 10 years. Spine (Phila Pa). 2001; 26:1443-1448.
87. Iwasaki M, Okuda S, Miyauchi A, et al. Surgical strategy for cervical myelopathy due to ossification of the posterior longitudinal ligament: Part 2. Advantages of anterior decompression and fusion over laminoplasty. Spine (Phila Pa). 2007; 32:654-660.
88. Liu X, Wang H, Zhou Z et al. Anterior decompression and fusion versus posterior laminoplasty for multi-level myelopathy. Orthopedics. 2014; 37(2): e117-e122.
89. Fraser JF, Hartl R. Anterior approaches to fusion of the cervical spine: a meta-analysis of fusion rates. J Neurosurg Spine. 2007; 6:298-303.
90. Chagas H, Domingues F, Aversa A, Vidal Fonseca AL, de Souza JM. Cervical spondylotic myelopathy: 10 years of prospective outcome analysis of anterior decompression and fusion. Surg Neurol 2005; 64:S130-5.
91. Rajshekhar V, Kumar GS. Functional outcome after central corpectomy in poor-grade patients with cervical spondylotic myelopathy or ossified posterior longitudinal ligament.Neurosurgery 2005; 56:1279-84.
92. Chibbaro S, Benvenuti L, Carnesecchi S et al. Anterior cervical corpectomy for cervical spondylotic myelopathy: Experience and surgical results in a series of 70 consecutive patients. J Clin Neurosci 2006; 13: 233-8.
93. Ratliff J, Cooper P. Cervical laminoplasty: A critical review. J Neurosurg 2003; 98:230-8.
94. Chiba K, Ogawa Y, Ishii K et al. Long-term results of expansive open-door laminoplasty for cervical myelopathy--average 14-year follow-up study. Spine 2006; 31:2998-3005.
95. Shiraishi T. Skip laminectomy: A new treatment for cervical spondylotic myelopathy, preserving bilateral muscular attachments to the spinous processes: A preliminary report. Spine J 2002; 2:108-15.