



Clinical comparison between simple laminectomy and laminectomy plus posterior instrumentation in surgical treatment of cervical myelopathy

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Abstract

Background Posterior stabilization in patients treated with laminectomy for spondylotic cervical myelopathy is still a debate. Despite both being reported in literature by several authors, some controversies still exist. The aim of this study is to compare clinical and radiological outcomes in patients treated with laminectomy or laminectomy with posterior stabilization.

Material and methods We retrospectively evaluated 42 patients affected by cervical myelopathy (mean age 70.43 ± 5.03 years), 19 treated with laminectomy (group A) and 23 with laminectomy and posterior instrumentation (group B). Neurological status was assessed with Nurick scale, pain with VAS and radiological parameters with C2–C7 SVA, T1 slope and C2–C7 lordosis, clinical function with modified Japanese Orthopaedic Association score (JOA). Also, surgery time and blood loss were recorded. Student's *t* test was used for continuous variables, while Kruskal–Wallis test was used for categorical values.

Results No differences were found in postoperative Nurick scale ($p=0.587$), VAS ($p=0.62$), mJOA ($p=0.197$) and T1 slope ($p=0.559$), while laminectomy with fusion showed better postoperative cervical lordosis ($p=0.007$) and C2–C7 SVA ($p<0.00001$), but higher blood loss ($p<0.00001$) and surgical time ($p<0.00001$). Both groups showed better Nurick scale ($p=0.00017$ for group A and $p=0.00081$ for group B), VAS ($p=0.02$ for group A and $p=0.046$ for group B) and mJOA ($p<0.00001$ for both groups) than preoperative values.

Conclusions Both treatments are a valuable choice, offering some benefits and disadvantages against each other. Each procedure must be carefully evaluated on the basis of patients' general status, preoperative pain, signs of instability and potential benefits from cervical alignment correction.

Keywords Spondylotic cervical myelopathy · Elderly · Laminectomy · Posterior fusion · Lateral mass screw

Introduction

Cervical spondylotic myelopathy (CSM) is the most common cause of spinal cord progressive dysfunction and disability in patients over 50 years old [1, 2]. The worsening of neurological symptoms requires spinal cord decompression. Nowadays, the optimal surgical technique is still controversial. A lot of surgical techniques were proposed by several

authors for the treatment of cervical myelopathy caused by spondylosis or ossification of the posterior longitudinal ligament (OPLL) [3].

The key factors guiding surgical choice were number of stenosis level, length of myelopathy, anatomic levels of myelopathy, sagittal alignment, ankylosing of anterior spinal column, extension of OPLL, dynamic instability and location of compressive structures [4].

Posterior decompression is the most commonly accepted treatment in CSM when three or more segments are involved or in cases with severe stenosis or OPLL. Posterior decompression allows to achieve indirect decompression of the dural sac drifted away from the anterior spurs along the lordotic curvature of cervical spine [5]. From its first description, laminectomy underwent several modifications [6, 7]. Laminoplasty was introduced to avoid complications of laminectomy [8, 9] such as postoperative severe kyphosis

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and instability [10, 11], but some controversies remain [12]. In this retrospective study, we compared two groups of patients who underwent only laminectomy or laminectomy and posterior instrumentation, to evaluate the effectiveness and clinical results of the two techniques to treat CSM.

Patients and methods

Patients with diagnosis of CSM and surgically treated by our institution from 2008 until 2015 were retrospectively reviewed. A total of 98 patients were retrieved with a CSM attributed to spinal cord compression at the level of C3 or below. Inclusion criteria involved clinical and radiographical finding compatible with CSM, age above 60 years and exclusive posterior approach. Exclusion criteria included compression associated with rheumatoid arthritis, central cord syndrome or trauma, patients with underlying neurological disorders (multiple sclerosis, etc.). According to inclusion and exclusion criteria, 42 patients affected by CSM were surgically treated with posterior decompression and were included in the study. Nineteen patients underwent laminectomy alone (group A) (Fig. 1a–c), while other 23 were treated with laminectomy and posterior stabilization with lateral masses screws (group B) (Fig. 2a, b). The choice of posterior instrumentation during laminectomy was based on preoperative alignment or segmental instability to avoid postoperative kyphosis, to gain a significant dorsal compression and the presence of multiple level of myelopathy.

As measure of instability, we analyze translation on flexion–extension X-rays translation as the linear distance in mm from the posterior–inferior corner of the superior vertebra and the superior–posterior corner of the inferior vertebra [13].

Laminectomy was extended from C3 to C7 in 12 patients, to C6 in 7 patients of group A, to C6 in 5 patients and C7 in 18 patients of group B.

The sample was composed of 24 males and 18 females, with a mean age of 70.43 ± 5.03 years (range 61–79) and suffering from myelopathy for a mean of 3.29 ± 1.07 years (range 2–5). Mean follow-up was 4.86 ± 1.85 years (range 2–8 years). Demographic characteristics and comorbidity are reported in Table 1. Both groups were comparable in terms of age, gender and comorbidities.

Pre- and postoperative neck pain was assessed through VAS scale. All patients had standard X-rays with dynamic tests, MR and CT evaluation. Cervical lordosis between C2–C7 was measured on plain radiography with Cobb angle. C2–C7 sagittal vertical axis (SVA) and T1 slope before treatment and at last follow-up were also recorded as measures of cervical alignment. Radiological measures were calculated using Synapse PACS® (©Fujifilm HOLDING Corporation, Japan).

Clinical evaluation was performed according to modified Japanese Orthopaedic Association Score (mJOA) for cervical myelopathy [14] and Nurick Scale [15]. Nurick scale is a 6 points grading system based on walking difficulty where grade 0 represents the presence of root involvement

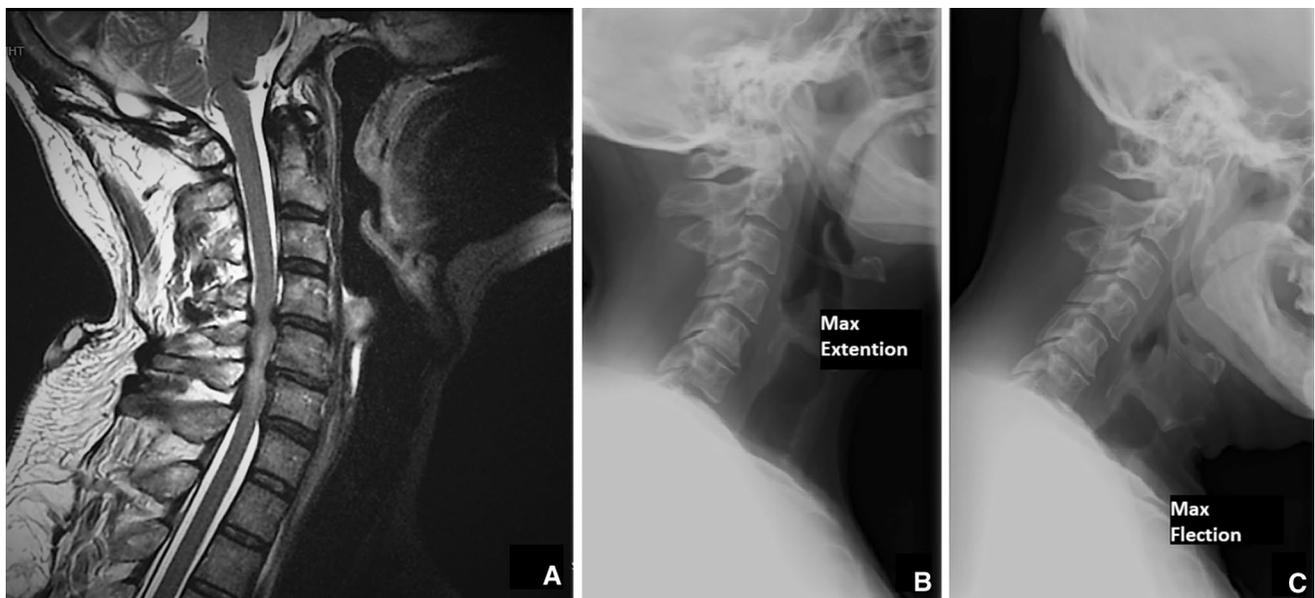
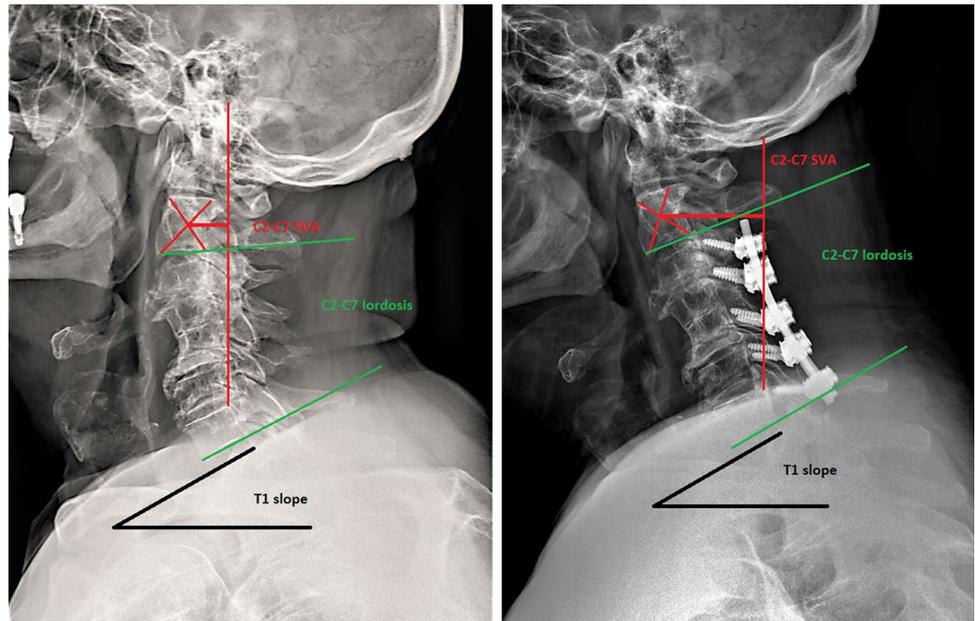


Fig. 1 Preoperative MRI of a 68-year-old male patient with spondylotic cervical myelopathy at C4–C5 and C5–C6 level (a). Postoperative functional X-ray of cervical spine after posterior decompression

without stabilization at 12 months of follow-up in maximal extension (b) and flexion (c)

Fig. 2 Pre- (a) and postoperative (b) (3 months) X-ray assessment of cervical spine in a 73-year-old female patient with spondylosis myelopathy. In red the evaluation of C2–C7 SVA; in green the evaluation of C2–C7 lordosis and in black the evaluation of T1 slope before and after decompression surgery and posterior stabilization (colour figure online)



but without evidence of spinal cord disease and grade 5 the condition of chairbound or bedridden.

Each clinical and radiological control was performed at 1, 3, 6, 12, 24 months after surgery and then approximately every 2 years.

Mean intraoperative blood loss and operation time along with complications were recorded. After surgery, all patients wore a rigid cervical collar for approximately 40 days for both groups.

The research has been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Statistical analysis

Data were reported as mean \pm standard deviation and range. Student's *t* test was used to assess statistical difference between continuous variables, while Kruskal–Wallis test was used for assessment of rank-ordering data of categorical values. SPSS software version 19.0 was used (SPSS, Chicago, IL), and a *p* value < 0.05 was considered statistically significant.

Results

Before treatment, patients were graded as Nurick grade 4 in 2 patients, grade 3 in 33 patients, grade 2 in 7 patients. Thirteen patients (30%) complained a preoperative major axial neck pain (with VAS ranging from 5 to 9). Global mean VAS score was 4.19 ± 1.87 (4.42 ± 1.74 in group A and 4 ± 2.02 in group B). Cervical lordosis C2–C7

was $16.79^\circ \pm 9.91^\circ$ Cobb for group A and $17.04^\circ \pm 9.14^\circ$ Cobb for group B (range 2° – 38°) with segmental instability (angular or anterior-posterior displacement) at one or two levels in 7 cases (17%) and focal segmental kyphosis of 4° in 3 (1%) patients. Preoperative C2–C7 SVA was $22.95 \text{ mm} \pm 9.57 \text{ mm}$ (range 7–43) and $23.43 \text{ mm} \pm 9.98 \text{ mm}$ (range 7–41), respectively, for group A and B. Preoperative T1 slope was $28.95^\circ \pm 8.67^\circ$ (range 14° – 44°) for group A and $28.65^\circ \pm 9.81^\circ$ (range 10–45) for group B.

In 37 cases (92%), there was a neurological improvement (15 patients Nurick grade 0, 13 patients grade 1, 7 patients grade 2 and 2 patients grade 3) following surgery, while 5 patients remained stable (4 Nurick grade 2 and 1 grade 3). A significant difference was found between before and after treatment values in group A ($p = 0.00017$) and group B ($p = 0.00081$), while no difference was found between postoperative scores ($p = 0.587$).

VAS changed from 4.42 ± 1.74 and 4 ± 2.02 to 2.42 ± 1.95 and 2.74 ± 2.14 of groups A and B, respectively. The best results were achieved in patients with short-time symptoms. Three patients (8%) treated with laminectomy, 1 with a long-time preoperative severe neurological deficit and 2 with comorbidities (severe chronic kidney disease at final stage renal failure in hemodialysis), worsened after the initial neurological recovery (finally grade 2 in 2, grade 3 in 1) associated with a severe neck pain in the 2 hemodialytic patients (VAS 8)(5%). In 5 cases (12%), 3 from group B, complained transient or occasional mild pain at cervicothoracic junction for 6 months (VAS 3), treated and resolved with physical and medical therapy. A significant difference was found between pre- and postoperative scores in group A

Table 1 Main demographic characteristics of patients included in the study

Patients	Gender	Age	Times of symptoms (years)	Comorbidity
1	M	73	2	CKD, HY
2	M	63	2	HY, DM, COPD
3	F	68	4	CKD, DM
4	F	75	4	HY
5	F	79	3	HY
6	M	78	5	CKD, DM, COPD
7	F	64	2	HY, COPD, CD
8	M	71	3	HY, CD
9	F	69	4	DM, CD, HY
10	M	70	3	CKD, HY
11	F	75	3	COPD
12	M	72	5	CKD
13	M	71	2	HY, DM
14	M	65	2	None
15	F	68	2	CD, HY, DM
16	M	77	4	HY, COPD
17	M	61	4	None
18	F	62	3	None
19	M	66	5	HY, COPD
20	M	76	2	CKD, HY
21	F	71	3	COPD
22	M	73	4	HY, CD
23	M	63	3	None
24	M	74	3	HY, CD, COPD, DM
25	M	77	5	CKD, DM
26	F	66	2	HY, DM
27	F	65	2	DM
28	M	72	2	CKD, COPD, HY, CD
29	F	75	4	HY
30	M	74	4	COPD, CKD, DM
31	F	61	3	None
32	M	63	5	HY
33	F	72	2	DM, CDK
34	F	73	3	HY, COPD, DM
35	M	71	4	CKD, HY
36	M	69	3	HY, CD, DM
37	F	78	3	CDK, DM, COPD
38	F	72	5	HY, COPD, CD
39	M	74	2	HY, CD
40	M	68	5	DM, CD, HY
41	M	69	3	HY, DM, COPD, CKD, CD
42	F	75	4	CD, HY

Age, gender, times of symptoms and principal comorbidity are reported

HY hypertension, CKD chronic kidney disease, DM diabetes, COPD chronic obstructive pulmonary disease, CD coronary disease

($p=0.02$) and group B ($p=0.046$), while no difference was retrieved between postoperative score of 2 groups ($p=0.62$).

Preoperative cervical lordosis was $16.93^\circ \pm 9.38^\circ$ ($16.79^\circ \pm 9.91^\circ$ in group A and $17.04^\circ \pm 9.14^\circ$ in group B). In group A, cervical lordosis decreased to $11.89^\circ \pm 6.35^\circ$ but without any changes in clinical and radiological excursion of the cervical spine. In group B, lordosis was preserved ($18.26^\circ \pm 7.86^\circ$) with an average increase of 4° from preoperative value in 7 patients with no junctional instability or hardware mobilization. No differences were found between pre- and postoperative values in group A ($p=0.078$) and group B ($p=0.63$), while a significant difference was found between postoperative values of both groups ($p=0.007$).

In group A, postoperative C2–C7 SVA increased to $31.32 \text{ mm} \pm 8.55 \text{ mm}$ ($p=0.007$) from preoperative values, while it decreased in a not significant manner in group B to $18.87 \text{ mm} \pm 7.09 \text{ mm}$ ($p=0.081$). A significant difference in postoperative score was found between groups ($p<0.00001$). T1 slope trended to remain stable over time for group A with a mean postoperative value of $28.05^\circ \pm 6.95^\circ$ ($p=0.728$); in group B, mean postoperative score was $26.78^\circ \pm 6.95^\circ$ ($p=0.46$). No significant differences were also found between postoperative value of groups A and B ($p=0.559$).

Cervical movement limitation was observed in sagittal plane, while rotation was preserved leading to compensation movement of the trunk and the limbs in the oldest 5 patients. Arthrodesis was not evaluable through X-ray in 15 patients, while it was documented in 5 cases.

Functional preoperative mJOA was 10.21 ± 1.69 and 10.26 ± 1.60 , while at follow-up it reached 14.79 ± 1.62 and 15.43 ± 1.56 for groups A and B, respectively. Global preoperative and at follow-up mJOA score was 10.24 ± 1.62 and 15.14 ± 1.60 . A significant difference between pre- and postoperative values was retrieved in group A ($p=0.00001$) and group B ($p=0.00001$), while no difference was found between postoperative values of both groups ($p=0.197$).

Blood loss was of $200 \text{ cc} \pm 32.15 \text{ cc}$ and $350 \text{ cc} \pm 86.08 \text{ cc}$, respectively, ($p=0.00001$), and operation time was $139.21 \text{ min} \pm 25.35 \text{ min}$ for group A and $220.22 \pm 20.81 \text{ min}$ for group B ($p=0.00001$). Injury of the dural sac and articular screw violation were in two cases without neurological consequences. Wound healing delay was observed in the case of dural leak and in one instrumented patient but without infection.

Main findings and statistical analysis are reported in Table 2.

Discussion

The optimal posterior surgical technique for CSM is still debated. Laminectomy, initially limited to 2 or 3 levels with articular disruption, was the first technique

Table 2 Main outcomes and statistical analysis of the study

			<i>p</i>
Nurick scale	Preoperative Nurick scale (A)	Postoperative Nurick scale (A)	
	17 Nurick 2, 1 Nurick 3, 1 Nurick 4	1 Nurick 3, 4 Nurick 2, 7 Nurick 1, 7 Nurick 0	0.00017
	Preoperative Nurick scale (B)	Postoperative Nurick scale (B)	
	20 Nurick 2, 2 Nurick 3, 1 Nurick 4	8 Nurick 0, 6 Nurick 1, 7 Nurick 2, 2 Nurick 3	0.00081
VAS	Postoperative Nurick scale (A)	Postoperative Nurick scale (B)	
	1 Nurick 3, 4 Nurick 2, 7 Nurick 1, 7 Nurick 0	8 Nurick 0, 6 Nurick 1, 7 Nurick 2, 2 Nurick 3	0.587
	Preoperative VAS (A)	Postoperative VAS (A)	
	4.42 ± 1.74	2.42 ± 1.95	0.02
CL	Preoperative VAS (B)	Postoperative VAS (B)	
	4 ± 2.02	2.74 ± 2.14	0.046
	Postoperative VAS (A)	Postoperative VAS (B)	
	2.42 ± 1.95	2.74 ± 2.14	0.62
mJOA	Preoperative cervical lordosis (A)	Postoperative cervical lordosis (A)	
	16.79° ± 9.91°	11.89° ± 6.35°	0.078
	Preoperative cervical lordosis (B)	Postoperative cervical lordosis (B)	
	17.04° ± 9.14°	18.26° ± 7.86°	0.63
Blood loss	Postoperative cervical lordosis (A)	postoperative cervical lordosis (B)	
	11.89° ± 6.35°	18.26° ± 7.86°	0.007
	Preoperative mJOA (A)	Postoperative mJOA (A)	
	10.21 ± 1.69	14.79 ± 1.62	0.00001
Time	Preoperative mJOA (B)	Postoperative mJOA (B)	
	10.26 ± 1.60	15.43 ± 1.56	0.00001
	Postoperative mJOA (A)	Postoperative mJOA (B)	
	14.79 ± 1.62	15.43 ± 1.56	0.197
C2–C7 SVA	Group A blood loss	Group B blood loss	
	200 ± 32.15 cc	350 ± 86.08 cc	0.00001
T1 slope	Group A operation time	Group B operation time	
	139.21 ± 25.35 min	220.22 ± 20.81 min	0.00001
T1 slope	Preoperative C2–C7 SVA (A)	Postoperative C2–C7 SVA (A)	
	22.95 ± 9.57	31.32 ± 8.55	0.007
	Preoperative C2–C7 SVA (B)	Postoperative C2–C7 SVA (B)	
	23.43 ± 9.98	18.87 ± 7.09	0.081
T1 slope	Postoperative C2–C7 SVA (A)	Postoperative C2–C7 SVA (B)	
	31.32 ± 8.55	18.87 ± 7.09	0.00001
	Preoperative T1 slope (A)	Postoperative T1 slope (A)	
	28.95° ± 8.67°	28.05° ± 6.95°	0.728
T1 slope	Preoperative T1 slope (B)	Postoperative T1 slope (B)	
	28.65° ± 9.81°	26.78° ± 6.95°	0.46
	Postoperative T1 slope (A)	Postoperative T1 slope (B)	
	28.05° ± 6.95°	26.78° ± 6.95°	0.559

Data are reported before and after surgery for each group. A comparison between postoperative outcomes of both groups was also performed through Student's *t* test for continuous variable and Kruskal–Wallis test for rank-ordering data of categorical values. *p* was considered statistically significant if minor than 0.05

introduced for CSM. Iatrogenic instability and spondylolisthesis in aggressive facetectomy, postoperative progressive kyphosis or swan neck deformity, attributed to loss of the musculoskeletal tension band are some of the complications of this pathology. Moreover, tissue scar

could constrict the dural sac and lead to cervical pain and spinal cord compression with neurological deterioration. These complications are more likely to occur in patients with straight and hypermobile cervical spine and treated with laminectomy [16, 17].

It must be noted that post-laminectomy kyphosis is one of the most significant complications. Kyphotic changes after multiple levels of laminectomy can be connected with several factors. The disruption of anatomical stabilizations acts as the major risk factor. Extension of capsule resection of more than 50% and facetectomy caused significant kyphosis and cervical instability. Under physiological loading, facet joints were responsible for anterior shear, extension, lateral bending and torsion. Therefore, facet resection was found to weaken torsional and extensive stress resistance which could result in instability and kyphotic angular deformity [17–19].

A recent analysis on cervical spine deformity surgery developed a predictive model to describe risk factors for complications. C2–C7 SVA, mJOA score and male gender were considered as major risk factors for complications, since 64.2% of patients undergoing cervical deformity surgery sustained any complication. Despite the fact that several factors could be involved in occurrence of complications, C2–C7 SVA remains the strongest isolated risk factor for cervical surgery complications [20].

Cervical alignment parameters undergo age-based changes. In our series, some parameters differ from those described by Iorio et al. Preoperative C2–C7 SVA was lower in our study, while T1 slope had only little differences. The differences in C2–C7 SVA may be related to the specific pathology of cervical spine of our group and also to a different ethnicity of examined population. However, after surgical treatment patients treated with posterior instrumentation reached comparable age-related values, due to restoration of cervical lordosis. On the other side, T1 slope values are comparable with our population and it did not change after surgical procedure. T1 slope is an indicator parameter of spine alignment. Hyperkyphotic deformity of thoracic spine and spinopelvic imbalance could reflect on cervicothoracic junction. The stability of T1 slope values before and after procedures and between groups suggested no major global spine sagittal alterations [21, 22].

In order to avoid neurological complications, laminectomy was replaced by laminoplasty, where lamina is preserved to maintain stability.

A possible alternative is laminectomy with fusion, where stabilization is meant to improve neck pain, post-laminectomy kyphosis and limiting repetitive microtrauma on spinal cord. Currently, there is no evidence that one procedure is clearly preferred compared with the other [23–26]. In this retrospective study, we compared laminectomy with laminectomy and fusion on a limited number of patients. Laminectomy was performed in cases with rigid cervical spine and in debilitated patients preserving articular processes and sparing the muscle insertions at the extremities on the spinal processes. Since the majority of stenosis was located at C4–C6 level, decompression was limited to C3 to C7 or C6 level, with good clinical results over time in most patients.

Preservation of muscular attachment, limited use of external orthoses and quick recovery of cervical mobility in a fixed spine reduce the postoperative neck pain. To maintain stable results, scar tissue surrounding the dural sac has to show wide peridural space. In our experience, recurrence of neurological damage was observed in three cases. In the first one, a severe preoperative impairment was related to the long-time waiting for surgery and worsened after initial slight recovery despite wide decompression in MRI as it would be the natural evolution of the myelopathy [27, 28]. The other two patients undergoing hemodialysis worsened after surgery with intractable neck pain and subsequent sign of instability. As widely reported in the literature, patients undergoing hemodialysis are more inclined to develop spine modifications [29–33]. These modifications are related to β_2 microglobulin amyloids deposited into intervertebral disks, which could progressively lead to destructive spondyloytic arthropathy (DSA) [34]. Patients of our series started hemodialysis few months ago (1 and 4 months) and did not show any sign of instability at dynamic X-ray or macroscopic amyloid deposition at MRI. Moreover, chronic renal failure causes an alteration of normal bone tropism with a bad bone quality with possible implant mobilization and an increasing need of revision surgery [35]. Moreover, it must be considered that DSA progression and severity are directly proportional to the spent time in hemodialysis [29, 36]. According to these factors, we opted for sole laminectomy; however, both patients developed a post-surgical instability with worsening of neck pain. The poor clinical outcomes of both patients support the previous results described in the literature that posterior stabilization is almost mandatory, since instability will rapidly worsen after laminectomy as for the natural course of DSA in these patients [37, 38].

Laminectomy with fusion with articular screws fixation was performed with good clinical results in case of preoperative instability, reduced lordosis, mild focal flexible kyphosis, higher degenerative neck pain and in combination with foraminotomy and poor neck muscular tone. Osteoporosis, previous deformity and poor quality of arthrodesis preparation were not absolute contraindications, but they could increase the risk of reoperation [39–42]. Laminectomy and fusion had a significant longer operative time and more operative blood loss. During the procedure, the surgeon needed to pay attention to avoid cervical misalignment and limited final range of motion. Posterior arthrodesis reduced neck pain from facets arthropathy, preserved stability and alignment of cervical spine in order to facilitate neurological recovery, especially in those cases with spine at risk of neurological impairment progression [43].

According to our results, there was not a prevalence of one of the two groups in terms of better clinical score, while both of them revealed better clinical outcome than preoperative assessment. We believe that both options had

their own distinct set of advantages because both groups demonstrated significant improved Nurick's grades. Posterior instrumentation provided a better sagittal alignment of cervical spine, while it offers longer operative time and greater blood loss [44].

Even if laminectomy without fusion is rarely performed, nowadays we believe that this is still a valid, easier and faster surgical approach. The spinal degenerative changes in older patients may ensure spine stability. Instrumented laminectomy is essential to preserve lordosis and stability and is a valid alternative in cases where simple laminectomy is contraindicated. Still questionable is the indication to instrumentation in younger patients with narrow congenital channel in lordosis against the possibility of a junctional late instability. In our series, patients treated with or without fusion showed similar clinical and neurological results. Choice therefore has to be made in each individual patient considering the benefits and consequences of the both treatments [45].

Some limitation of this study must be acknowledged; some are intrinsic to the study design, such as the lack of a randomization and the retrospective design. The decision of performing decompression alone or decompression plus stabilization has been entrusted to surgeon's own experience and could be non-reproducible criteria. Despite the fact that several preoperative radiological exams could guide surgeon choice, some borderline cases remain. Moreover, a not homogeneous follow-up time must be noted (range 2–8 years). Giving that, we have no available data on recurrence rate since it was not investigated. Also, the low number of patients and the lack of a priori sample size calculation could be source of potential bias. No systematic investigation of global spine alignment was performed. This could be considered a source of bias since misalignment of thoracic spine and alterations of spinopelvic parameters could influence also cervical alignment as reported by some authors [46, 47].

Conclusions

Both treatments revealed to be a valuable choice of treatment, offering similar clinical results. Both offer some benefits and disadvantages against each other. The choice of one or the other must be carefully evaluated on the basis of patients' comorbidities and general status, preoperative neck pain, signs of instability and the need to correct or preserve cervical lordosis.

Compliance with ethical standards

Conflict of interest All authors declare they have no conflict of interest.

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