



Surgical results and factors affecting outcome in Multi-level cervical myelopathic patients treated with ACDF with standalone PEEK cages

Samy Ibrahim Kamel, Mahmoud Faried Bathalla, Rasha Abdelhamid Zaki, Rabab Yahya Abd Al-Kareem, Mahmoud Kamel Elawady

Lecturers in the Neurosurgical Department, Al-Azhar University, Faculty of Medicine for Girls, Cairo, Egypt

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ABSTRACT

Purpose: To assess long-term outcomes following two or three levels anterior cervical discectomy and fusion (ACDF) with stand-alone polyetheretherketone (PEEK) cages and to determine factors that may affect the surgical outcome. **Methods:** from September 2016 to April 2022, in Alzhraa University hospital an overall 90 subjects of mean age 55.07 ± 7.73 years (40–70) with 2 or 3 levels CSM were prospectively followed after ACDF with standalone PEEK cages. All Patients had been evaluated utilizing the modified Japanese Orthopaedic Association (mJOA) scale and Nurick grade. The study examined the impact of age, length of symptoms, cervical curvature, and the existence or lack of preoperative high signal intensity inside the spinal cord on each participant. Plain radiograph and MRI were obtained for all patients preoperatively and postoperatively. **Results:** During the last follow-up, the clinical outcomes, which encompassed mJOA score, Nurick grading, and Odom's criteria (excellent, good, fair and poor). The mJOA score was 11.33 ± 2.01 points before surgery and 13.07 ± 1.82 points 1 year after surgery ($P=0.002$). The Nurick Grading system score was 2.49 ± 0.97 before surgery and 1.88 ± 0.76 1 year after surgery. There were 15 participants (16.7%) possess excellent results, 64 participants (71.1%) possess good results, 8 participants (8.9%) possess fair results and 3 patients (3.3%) possess poor results. All of the recipients had solid fusion 12 months following surgeries. **Conclusions:** For degenerative cervical disc diseases linked to myelopathy, multilevel ACDF using stand-alone PEEK cages filled with autogenous bone after decompression is a common and very effective surgical option. The most significant prognostic factor was baseline duration and severity of myelopathy of myelopathy followed by age of the patient and associated medical comorbidities.

Keywords: ACDF –Standalone PEEK Cages- Multilevel cervical disc disease -Cervical spondylotic myelopathy.

Introduction

A debilitating condition affecting the cervical spine is called cervical spondylotic myelopathy. This often results from degenerative processes that generate circumferential compression, frequently in a congenitally constricted spinal canal. Exuberant ossification and osteophytes resulting in disc degeneration induce localized chronic compression and repetitive damage to the spinal cord while moving over the afflicted region. Over time, these compressive injuries and alterations result in pathophysiologic alterations similar to acute injuries to the spine and direct modification or damage of neural pathways [1].

However, there may be a decline in cervical myelopathy's natural course. In accordance with Clarke and Robinson, 75% of participants decline gradually, 20% worsen gradually and steadily, and 5% have a sudden onset of symptoms with a steady plateau of dysfunction [2].

Either a direct mechanical impact on the cord or an ischemic impact resulting from compression of the anterior spinal artery might develop myelopathy in response to cord compression. In prospective trials of individuals with CM, surgical therapy has been demonstrated to enhance neurologic status, pain, and functional results. Consequently, unless the patient is reluctant or unable to undergo surgery because of significant medical comorbidities, surgical treatment is the preferred method of therapy for cervical myelopathy [3].

Another crucial component of the operational treatment of CSM is radiographic studies. The typical spinal cord has an antero-posterior dimension of around 8 to 13 mm, and the normal mid-sagittal spinal canal diameter is 17 mm deep. A further 2 to 3 mm of the canal diameter may be occupied by soft tissue structures such as the longitudinal ligament and the ligamentum flavum posterior. Individuals who experience a 13 mm narrowing of the canal are classified as having relative stenosis, whereas those who experience a 10 mm constriction are classified as having absolute stenosis [4].

Individuals with mild myelopathy (mJOA score >12) might be given the choice between non-operative therapy and surgical decompression within the first three years of their condition. Surgical decompression ought to be used for the treatment of more severe myelopathy, with advantages continuing for five and fifteen years after surgery [5].

The following procedures were not sufficiently supported by the available data: laminectomy (with or without fusion), anterior corpectomy and fusion, ACDF, and laminoplasty. On the other hand, late kyphotic deformity is more common after laminectomy without fusion [6].

If kyphosis exists, the best way to treat it is likewise via the anterior approach. By eliminating the vertebral bodies that the cord is draped across, anterior decompression may also effectively alleviate neural compression brought on by kyphosis. Furthermore, the anterior decompression-related fusion method preserves the decompressed cord segment by immobilizing it and preventing repeated stenosis at the fused segments. It additionally aids to decrease neck discomfort associated with spondylotic decompression. Anterior surgery for myelopathy has been shown to have excellent neurologic recovery rates [7].

For cervical myelopathy caused by soft-disc herniation or spondylosis restricted to the disc level, anterior cervical discectomy and fusion is recommended. Anterior cervical corpectomy and fusion (ACCF) may be necessary if compression results from multisegment ossification of the posterior longitudinal ligament (OPLL), soft disc/spondylosis that extends considerably beyond the level of the disc, or other retrovertebral disorders [2].

Materials and methods

Design of the work

All participants who undegone ACDF with standalone PEEK cages due to cervical myelopathy from September 2016 to April 2022 were included in our study. Stringent criteria for inclusion have been employed for this investigation. Individuals with medical histories of myelopathic symptoms, whether or not accompanied by radiculopathy (hand clumsiness, gait difficulty, weakness or sphincteric affection), with clinically demonstrable signs (Hoffman, clonus, hyperreflexia, and Lerhmit's) and The MRI results indicated evidence of the compression of the cervical cord at a minimum of two or three levels. The research excluded individuals suffering from peripheral neuropathy, single-level illness, only cervical radiculopathy, and cervical myelopathy caused by infections and other intradural factors.

Methods

An overall 90 participants matched the criteria of inclusion. Two or three levels ACDF with standalone PEEK cages were performed. All patients were operated in Al-Zahraa University Hospital utilising similar and standard operative techniques as described subsequently.

Surgical Techniques

A conventional Smith-Robinson right method has been utilized to uncover the levels where symptoms were present. Following the necessary exposure and localization of the disc, a discectomy was carried out. In addition, a local decompression was achieved by removing the osteophyte and, if needed, the posterior longitudinal ligament. The cartilage endplates were extracted using curettage while ensuring the preservation of the bone endplates. Following decompression, a properly sized cage filled with locally obtained decompression bone from the anterior hypertrophic osteophyte and prospective decompression of the posterior border of the vertebral body has been placed as a stand-alone device [8].

Postoperative Management

A rigid cervical collar is frequently utilized in the postoperative period. Participants are advised to remove the device for eating and washing, typically for around one hour each day. Apart from that, they should wear it continuously for a period of six weeks. Patients are monitored in the hospital overnight to detect any potential obstruction of the airway. Diet and physical exercise are permitted based on individual tolerance. The drain is usually removed on the first day after the surgery, and the patient is released 48 hours after the surgery.

EVALUATION: Clinical Outcomes

The modified Japanese Orthopedic Association (mJOA) scoring system and Nurick grade of disability for cervical spondylosis had been utilised for the assessment of cervical myelopathy prior and following surgeries (**Table 1, 2**). Odom's criteria had been utilised to assess the clinical outcomes.

Table 1: modified Japanese Orthopaedic Association scale (mJOA) [9].

Score	Description	
Upper Extremity (UE) Motor Dysfunction		
0		unable to feed self
1		unable to use knife & fork; can eat with spoon
2		can use knife & fork with much difficulty
3		can use knife & fork with slight difficulty
4		none (normal)
Lower Extremity (LE) Motor Dysfunction		
0		unable to walk
1		can walk on flat surface with walking aid
2		can walk up and/or down stairs with handrail
3		lack of smooth and stable gait
4		none (normal)
Sensory Deficit		
0		severe sensory loss or pain
1	UE	mild sensory loss
2		none (normal)
0		severe sensory loss or pain
1	LE	mild sensory loss
2		none (normal)
0		severe sensory loss or pain
1	Trunk	mild sensory loss

2	none (normal)
Sphincter Dysfunction	
0	unable to void
1	marked voiding difficulty (retention)
2	some voiding difficulty (urgency or hesitation)
3	none (normal)
Total score ranges from 0 to 17 (normal)	

The findings were categorized as 'excellent' (no complaints regarding the cervical lesion and a smooth returning of daily work and activities), 'good' (occasional complaints relating to the cervical lesion but no significant difficulties in performing daily activities and work), 'fair' (the individual satisfied with the postoperative enhancement of subjective symptoms but experiencing difficulties in conducting daily work and activities), or 'poor' (worsening or no enhancement of symptoms following surgeries). [10, 11].

Table 6: Nurick grade of disability from cervical spondylosis [12].

Grade	Description
0	Signs or symptoms of root involvement without myelopathy
1	Myelopathy, but no difficulty in walking
2	Slight difficulty in walking, able to work
3	Difficulty in walking but not needing assistance, unable to work full-time
4	Able to walk only with assistance or walker
5	Chairbound or bedridden

RESULTS

The participants age ranged between **40 to 70** years with a mean age of **55.07** years. There were **53** males (57.5%), and **37** females (**41.1%**), Males to females' ratio were **1.4:1** (**Table 3**). Clumsy hand had been the main symptoms. Other symptoms include abnormal gait, upper extremities sensory symptoms, neck pain and radiculopathy (**Fig. 1**). The mean length of symptoms prior to operation was 13 months, with a range of 2 to 24 months.

Table 3: Demographic data of the participants with cervical myelopathy:

History		No. = 40
Age	Mean $\pm$ SD	55.07 $\pm$ 7.73
	Range	40 – 70
Sex	Female	37 (41.1%)
	Male	53 (58.9%)
Duration of myelopathy (months)	Mean $\pm$ SD	8.47 $\pm$ 4.22
	Range	2 – 24
Clumsy Hands	Negative	7 (7.8%)
	Positive	83 (92.2%)
Preoperative JOA score	Mean $\pm$ SD	11.33 $\pm$ 2.01

Complications

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A concise overview of difficulties may be found in **(Table 4)**. No participants presented with infections, and there were no cases of vascular, tracheal, or esophageal damage associated with the surgery. The symptom of dysphagia was temporary and vanished after a period of 2 months. CSF leaking occurred following a dural rip throughout the procedure as a result of constrictive adhesions. Nevertheless, the tear was of a minor size and a drainage tube was inserted and kept in place for 24 hours before being taken out.. One patient died due to hepatic failure two weeks post op.

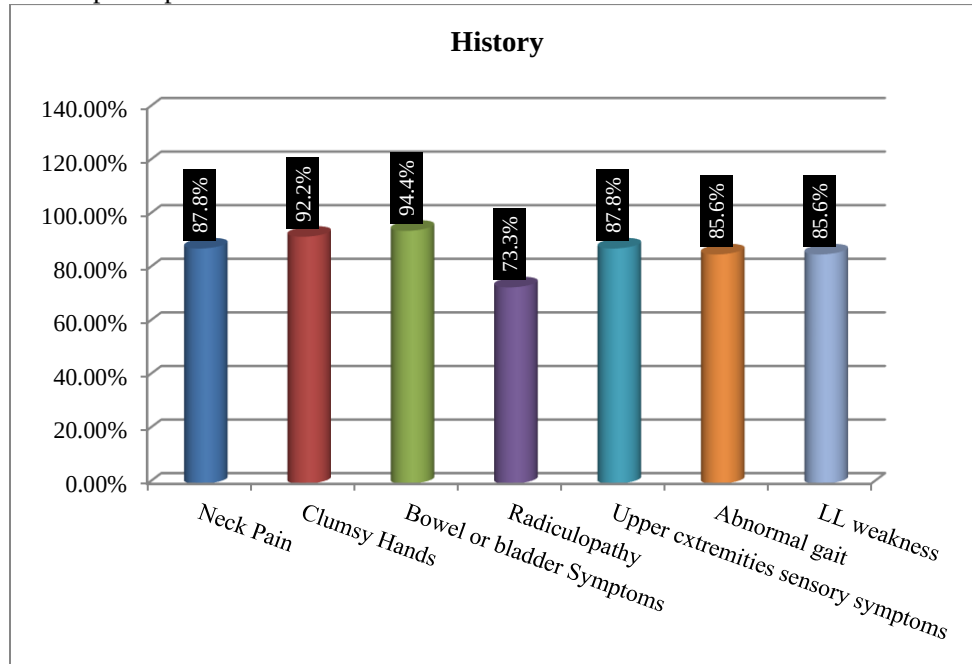


Figure 1: Main symptoms

Table 4: Summary of Complications

Complication	Total (n=90)	
	No.	%
Intraoperative		
Dural Tear	2	2.2%
No	88	97.8%
Immediate Postoperative		
DVT,Temporary Dysphagia	1	1.1%
Temporary dysphagia	75	83.3%
Temporary dysphagia and hoarseness	2	2.2%
Temporary dysphagia and temporary CSF Leakage	1	1.1%
Temporary dysphagia, temporary CSF Leakage	1	1.1%
Temporary dysphagia,ICU Admission due to cardiac arrhythmia	1	1.1%
Temporary dysphagia,lt UL pain in C 8 Dermatome	1	1.1%
Temporary dysphagia,Mild sensory affection of the lt hand	1	1.1%
Temporary dysphagia,Temporary CSF leakage	1	1.1%
Temporary dysphagia,Temporary Weakness of hand grip	2	2.2%
Temporary dysphagia,weakness Grade 2 LL and UL	1	1.1%

Temporary dysphagia,Weakness of the Lt side Grade 2	1	1.1%
No	2	2.2%
Late postoperative		
Displacement of the Cage	1	1.1%
Hepatic Failure Died	1	1.1%
No	88	97.8%

Clinical and radiologic outcomes

As regard mJOA scores and Nurick Grading system: The mJOA score was 11.33 ± 2.01 points before surgery and 13.07 ± 1.82 points 1 year following surgeries. The Nurick Grading score was 2.49 ± 0.97 before surgery and 1.88 ± 0.76 1 year after surgery. Satisfaction participants with the surgeries had been assessed utilising Odom's criteria. There were 15 participants (16.7%) possess an excellent outcome, 64 participants (71.1%) possess good results, 8 participants (8.9%) possess fair results and 3 participants (3.3%) possess poor results (**Fig. 2**). Postoperative radiographs revealed that 95% fusion was successfully attained within 6 months (**Fig. 3**), and complete fusion was seen in all of the recipients within 12 months following the operation.

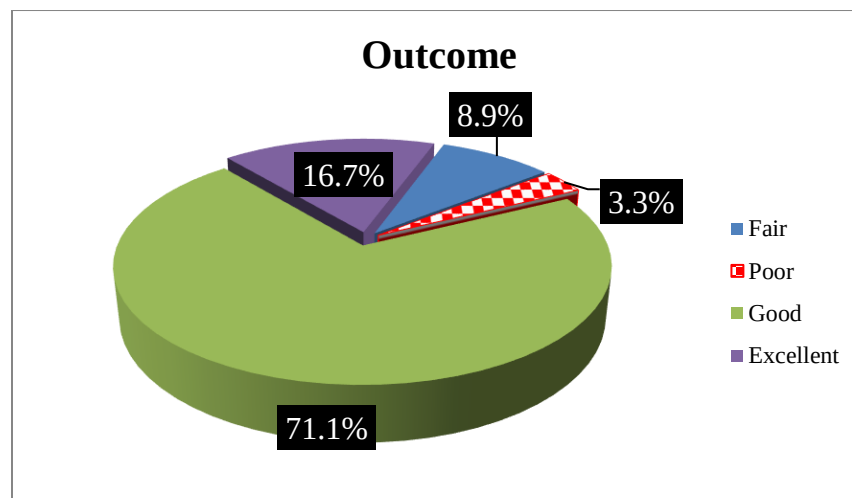


Figure 2: Outcome

DISCUSSION

CSM is a prevalent degenerative condition affecting the spinal cord that frequently receives treatment by spine surgeons. In recent years, there has been a significant rise in the number of spinal fusion surgeries done to treat CSM [13]. Surgical decompression has the ability to modify the progression of CSM and may impact the outlook for patients with CSM. Therefore, surgery is recommended for managing this condition [14, 15]. The objective of surgery is to alleviate pressure on the spinal cord and nerve roots, regain the original height, restore the natural curvature of the spine, and stabilize the spinal column to avoid further deterioration at the afflicted level [16].

While there is ongoing debate over the best surgical strategy for multilevel CSM, each method has its own distinct benefits and drawbacks. However, if there is anterior compression and kyphosis, it is necessary to use an anterior surgical technique. The anterior technique not only enables immediate decompression, but it additionally facilitates the restoration of interbody space height and the reconstruction of cervical lordosis by meticulous intraoperative distraction. If the anterior compression is caused by either a disc or osteophytes, a direct decompression of the neural components may be achieved using an anterior approach using either multilayer discectomy or corpectomy. Nevertheless, there is ongoing debate about the

advantages and disadvantages of cervical fusion following multilevel discectomy or corpectomy in cases with multilevel CSM [17].

Oh et al. [18] examined a group of 31 individuals who had 2-level CSM without OPLL and received anterior surgical therapy. The study revealed that ACDF surpassed ACCF in terms of surgical duration, amount of blood loss, and radiological outcomes. **Hwang et al. [19]** found that multilevel discectomy and cage fusion with plate fixation is superior to corpectomy and structural graft fusion with plate fixation in treating multilevel cervical degenerative disc disease. This is because it has fewer complications at the donor site, fewer construct failures, and results in a shorter hospital stay.

Out of a group of 90 individuals diagnosed with 2 or 3 levels of CSM, the duration of myelopathy varied from 2 months to two years. The average length was 8 months. In a study of 39 recipients, the average length of time they had symptoms before surgery was shorter than a year, with a mean duration of 11.8 months [20]. The range of symptom duration varied from 1.5 months to 10 years, with a mean of 11.7 months. The majority of the participants sought medical attention 6 to 12 months (54, 37%) following the beginning of symptoms, followed by a period of no more than six months and 13 to 24 months (32, 21.9% each) [21].



Figure 3: A 54-year-old woman had a gradual deterioration of sensation in both hands and weakness in all four limbs over a period of 5 months, with a more rapid decline occurring in the last month. The preoperative MRI examinations revealed compression of the spinal cord at the C5-6 and C6-7 levels. The patient had a 2-level ACDF procedure using standalone PEEK cages. The operation was successful without any problems. Following the surgical procedure, her mJOA ratings increased from 9 before the surgery to 14 following the surgery. Postoperative flexion and extension cervical radiographs demonstrated the graft got bony fusion (C-D). In E, F, G, H another patient with myelopathic symptoms with compression at C5-6, C6-7 submitted to ACDF with standalone cages and her dynamic x-ray cervical spine at 6 weeks (E,F) and 12 weeks (G,H) showed good decompression and fusion of the graft.

In this study the results were as follow: There were 15 patients with excellent outcome ranged from 2-10 months, there were 64 patients with good outcome ranged from 2-18 months, there were 8 patients with fair outcome ranged from 4-18 months and there were 3 patients with poor outcome ranged from 12-24 months. The disparities between length groups and result exhibit a high level of statistical significance (test value =11.62, P= 0.001). **Accordingly duration of myelopathy has strong correlation to surgical outcome.**

• **Other studies:** Regarding the duration of symptoms, several prior research have shown that individuals who have symptoms for longer than a year are more inclined to have a negative result compared to those with a shorter period [22]. No significant differences were seen in duration of symptom [20]. no substantial variation was existed in duration of symptom [23].

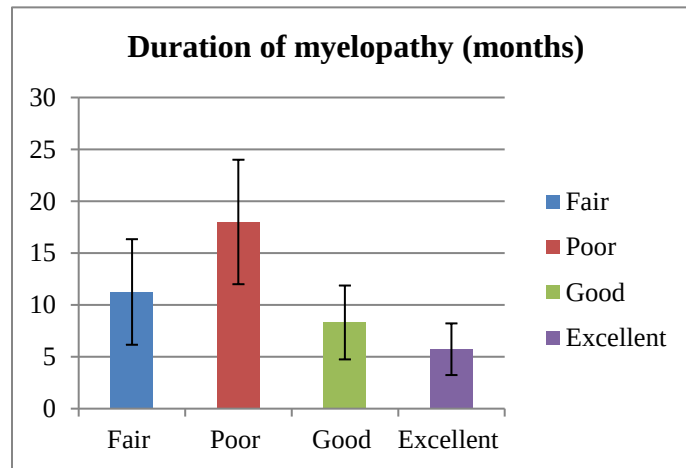


Figure 4: Duration of Myelopathy and Outcome

As regard to the severity of myelopathy: The mean preoperative mJOA is 11.33 ± 2.01 . The mean postoperative mJOA is 13.07 ± 1.82 . **In the series of Yamazaki et al, (2003) [24],** the mean preoperative JOA score had been (13.3 ± 2.9) and postoperative JOA score had been (15.2 ± 2.5). **In this study** the results were as follow: there were 15 patients with excellent outcome, their mJOA was 8:15. There were 64 patients with good outcome, their mJOA was 7:15. There were 8 patients with fair outcome, their mJOA was 6-12. There were 3 patients with poor outcome, their mJOA was 8-11 (test value =6.880, P= 0.001), **Accordingly preoperative mJOA is strongly correlated to surgical outcome (Table 5).**

Table (5): Association between Outcome and Grade of Myelopathy.

Grade of Myelopathy	Outcome				Test value	P-value	Sig.
	Fair (n=8)	Poor (n=3)	Good (n=64)	Excellent (n=15)			
Nurick (grade)							
Grade I	0(0.0%)	0(0.0%)	5(7.8%)	7(46.7%)	55.582	0.001	HS
Grade II	1(12.5%)	0(0.0%)	34(53.1%)	5(33.3%)			
Grade III	4(50.0%)	1(33.3%)	14(21.9%)	2(13.3%)			
Grade IV	3(37.5%)	1(33.3%)	11(17.2%)	1(6.7%)			
Grade V	0(0.0%)	1(33.3%)	0(0.0%)	0(0.0%)			
Modified JOA	B	B	B	A			
Mean $\pm$ SD	10.00 $\pm$ 2.07	9.67 $\pm$ 1.53	11.17 $\pm$ 1.78	13.07 $\pm$ 1.98	6.880	0.001	HS

Range	6-12	8-11	7-15	8-15			
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The mean Nurick Grading score was 2.49 ± 0.97 before surgery and 1.88 ± 0.76 1 year after surgery. **In this study** the results were as follow: In preoperative Nurick'gait disability grade I, there had been 12 participants. 7 participants have excellent results and 5 participants have good results. In preoperative Nurick'gait disability grade III, there had been 21 participants. 3 participants enhanced to grade I, 15 participants enhanced to grade II, and 3 participants remain stationary. In preoperative Nurick'gait disability grade IV, there had been 16 participants. 10 participants recovered to grade II, 1 participant deteriorated to grade V, 1 participant improved to grade I and grade III and 1 participant remained stationary. In preoperative Nurick'gait disability grade V, there had been 1 participant not improved. The mean Nurick's grade enhanced from 2.49 preoperatively to 1.88 at the last follow-up, with average 0.61 improvement. These variations had been highly statistically significant (P value: <0.001). **In the series of Tani et al, 2000 [25]**, the mean Nurick grade enhanced from 3.5 prior surgery to 2.2 at the last follow-up. **In the series of Macdonald et al, 1997 [26]**, The average preoperative Nurick grade was 3.1 ± 1.4 , and this showed a considerable improvement to 2.4 ± 1.6 after an average follow-up period of 31 ± 20 months. The researchers found that the patient's preoperative grade was a significantly reliable indicator of their postoperative Nurick grade.

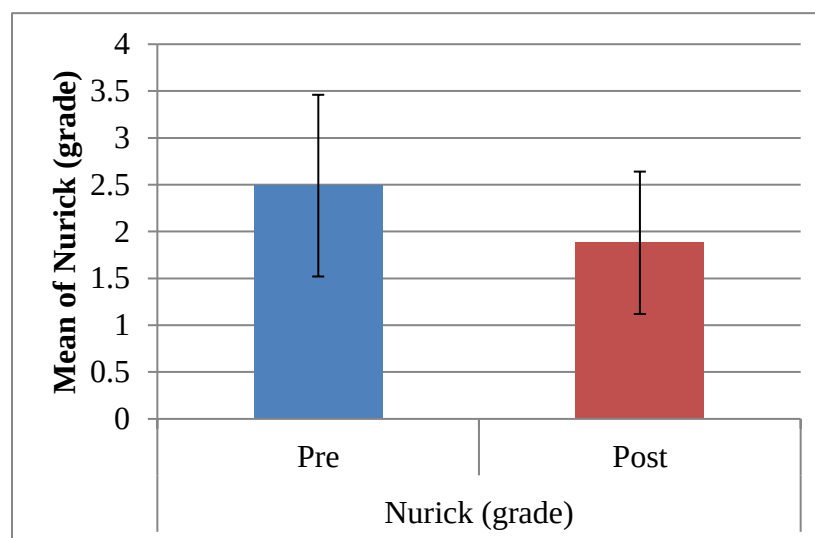


Figure (5): Comparison between pre and post regarding Nuric among study group.

RADIOLOGICAL FINIDINGS

In this study, A total of 60 patients exhibited positive high signal intensity on the sagittal view of T2 weighted MRI. Out of the total number of participants, 6 individuals (10%) had an exceptional result, 47 individuals (78.3%) possessed a good result, 6 individuals (10%) possessed a fair result, and 1 individual (1.6%) possessed a poor result. Out of the thirty participants who had negative high signal intensity on T2 weighted MRI sagittal view, 9 individuals (30%) possessed an exceptional result, 17 individuals (56%) possessed good results, 2 individuals (6.6%) possessed a fair result, and 2 individuals (6.6%) possessed a poor result. These differences were statistically not significant (Chi-Square test value: 26.137, P value: 0.668). **Accordingly high signal intensity on T 2 weighted MRI sagittal view has no relation with outcome in CSM.**

In the series of **Chung et al (2002) [27]**: Typically, there are noticeable variations in signal strength at the point where the spinal cord narrows. Numerous studies have investigated the importance of a region in the cord with a high signal intensity. Nakamura, Fujimura, and Kohno et al. have shown that a high signal intensity is indicative with a negative prognosis. Nevertheless, Morio et al. and Yone et al. argued that the existence or lack of a high-intensity region didn't demonstrate any connection with the outcomes of the surgery. In our research, participants in the fair group had a higher frequency of signal alterations in the spinal cord compared to those in the good group. However, it is important to note that the distinction wasn't reach statistically significant.

Number of Levels of Compression and Outcome

In this work, there were 69 patients (76.7%) with 2 levels of compression, and 21 patients (23.3%) with 3 levels of compression. **In this series**, C5-6 was the commonest cervical level affected (86.6%). C4-5 was the second cervical level affected (75.5%). C6-7 was third cervical level affected (32.2%). C3-4 was the fourth cervical level affected (28.8%). **According to Sampath et al (2000) [28]**, the C5/6 level is involved most frequently (76%), followed by C 4-5 (48%) and then C 6-7 (45%).

Graft Material and Fusion Rate:

In this study we insert PEEK cages filled with autogenous bone from decompression to all patients without plates and the fusion rate was 100%.

- **Other series:** In the series of **Demircan et al (2007) [29]**, they concluded that Utilizing PEEK cages filled with DBM, autologous blood, and microchips of curettage material for interbody fusion is a secure and efficient operation. It may serve as a viable option to the posterior method for treating multilevel cervical disc condition. It maintains the natural curvature of the spine and eliminates the problems associated with taking bone grafts and using screws and plates for stabilization.

In the series of **Chen et al (2013) [8]**, The adjacent bone that had undergone decompression has been obtained and inserted into the PEEK cages. The final follow-up verified a 100% fusion rate in every participant, indicating that it is a successful alternative material for bone fusion without any problems from the donor site. Furthermore, it was seen that stand-alone PEEK cages effectively maintained intervertebral height and cervical lordosis and resulted in superior long-term clinical results in contrast to titanium cages, particularly when anterior cervical plate augmentation was not used. These benefits were included into the management of multilevel CSM.

PROGNOSTIC FACTORS FOR CSM

- Several variables, including the patient's age at the time of the surgery, the length of time the symptoms have been present, the presence of signal alterations on the MRI scan, and the size of the compressed region of the spinal cord, have been shown to impact the results of the surgical procedure [24]. **Our statistical analysis** demonstrated that the most substantial prognostic factor was baseline severity of myelopathy, duration of myelopathy followed by age of the patient and associated medical comorbidities.

• **Other series:** Age was recently identified as a significant predictive factor in predicting the prognosis following surgeries in CSM [30]. **Holly et al (2009) [31]:** has demonstrated that individuals with a reduced Nurick's grade have a more favorable result.

OUTCOME

In this thesis, the overall outcomes were 15 participants (16.7%) possessed excellent results, 64 participants (71.1%) possessed good outcome, 8 participants (8.9%) possessed fair outcome and 3 participants (3.3%) possessed poor outcome. Other series are show in **(Table: 6)**

Table 6: Outcome in other series

Authors (s)	Year	No. of cases	Outcome
Mastronardi et al [32]	2005	36	Excellent (80.5%)
Lin et al [17]	2012	57	Excellent/good/fair/bad : 16/29/9/3
Guyen et al [33]	2016	35	Excellent/good/fair/poor : 12/22/1/0
Chiles et al [9]	1999	76	Excellent and Good (79.7%)
Topuz et al [34]	2009	79	Excellent and Good (87.3%).
Yu et al [35]	2014		Excellent/good/fair/bad
		106	14/39/42/11 (2 level group)
		98	18/36/39/5 (3 levels group)

Conclusion

According to the findings of this work, surgical managements of 2 or 3 levels CSM by ACDF with standalone PEEK cages showed better results in comparison with other approaches. Furthermore, ACDF surpasses ACCF with regard to of reduced blood loss, enhanced improvements in lordotic curvature, and lower rates of complications associated to instrumentation and grafting. The only exception to this superiority is the duration of the operation.

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