

Assessment of Anterior Cervical Discectomy

Ali Reza Zali, Afsaneh Zarghi, MD, MPH, PhD, Amir Saied Seddighi, MD, Ahmadreza Rajabi, MD, Reza Khoshnoud Jalili, MD

Functional Neurosurgery Research Center, Shohada Tajrish Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran

ABSTRACT

Purpose: The purpose of this study is to evaluate anterior cervical discectomy.

Methods: This study was conducted on 43 patients underwent surgery through standard Smith-Robison Technique with fusion. Postoperative follow-up period was 24 months. Clinical assessment was done through Odom criteria, Neck disability index and Visual Analog scale (VAS) for neck pain.

Results: According to Odom criteria, patients after surgery had more than 80% acceptable satisfaction. Based on Neck disability index and VAS, patients had significantly improved. Before surgery, none of the participating patients had lack of disability or mild disability. The most common indicator in these patients was severe disability which was observed in 34 cases (79.1%). After surgery, no one had complete disability while mild disability was the most common indicator among 20 patients (46.5%). The successful fusion rate was 95%. The most common symptom was neck pain and sensory disorder was the most prevalent sign. The most common level involved was C5-6. Medium-term of medical treatment was 4.5 months. The main causes of surgery were motor defect and neck pain.

Conclusion: Due to the possibility of complete discectomy and complete removal of compression, anterior surgery approach is preferred over posterior one.

Keywords: Advantage; Cervical discectomy; Anterior approach

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Correspondence to: Ali Reza Zali, MD; Functional Neurosurgery Research Center, Shohada Tajrish Hospital, Tajrish Sq, Tehran, Iran; E-mail: FNRC.AZ@hotmail.com; Tel/Fax: +98(21)22749204

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INTRODUCTION

Generally, surgery is an acceptable method of treatment for degenerative cervical disc diseases associated with neurological signs. In addition, for the time being there is no validated and acceptable method that can analyze results of surgical treatment technique against maintenance treatments¹. Reviewing the radiological results of cervical disc removal in the short term helps to understand the pathology caused by surgery and identify the potential causes of degenerative changes in the neck. Assessment of developing degenerative changes in adjacent segments after the surgery and survey the reasons of patients' referring for treatment of symptoms resulting from these changes was a main point of running the current study.

Surgical treatment is a choice for those patients with no response to medical treatment and for selected patients in which anterior discectomy with fusion is an acceptable treatment. Although the standard treatment of fusion is iliac crest autograft, morbidity recently has attracted surgeons' attention to replace artificial devices instead of disc. One surgical method used for cervical discectomy is Smith-Robinson technique. This ideal technique is associated with problems derived from iliac crest autograft for patients with cervical discectomy. These complications can include pain, infection, hematoma, nerve damage and deformity of iliac crest. Among the side effects of surgery with plate damage to the vein and artery, also spinal cord, trachea, esophagus,

recurrent laryngeal nerve, infection and abscess are seen². The most important point is to determine the pain type; axial neck pain or part of a radicular pain in a limb. The roots of the higher cervical dermatomes such as C3 and C4 are along the shoulder and posterior scapula. Consequently, radicular pain should not be confused with axial neck pain. Patients with neurological disorders experience muscle weakness and sensory loss³⁻⁵. The existence of myelopathy induces severe spinal canal stenosis and direct spinal cord compression in cervical spine⁵. The reason of radiculopathy with motor weakness or sensory loss is one or more nerve root compression which may cause dysfunction in the involved nerves⁶. In case of a severe or unacceptable neurological disorder, emergency surgery is recommended for the pressure relief of the infected nerves^{5,7,8}.

There are two ways to reach the cervical spine; anterior and posterior method. Anterior surgery comprises separation of vital spine structures such as trachea, esophagus and carotid. In this way, cervical spine is easily in sight^{8,9}. The main disadvantage of anterior method is full resolution of the disc and so there is a need for fusion. Nevertheless, fusion is sometimes necessary and useful. Generally, as far as possible, more than three levels of fusion must be avoided. Thus, in multi-level involvement posterior surgery procedure should be done^{10,11}. Since the disc is not visible and it cannot be reached easily, posterior surgery is more restrictive than anterior one^{11,12}. Despite the considerable and chronic axial neck pain, anterior fusion surgery method may be applied by the surgeon¹¹.

During anterior surgery for the anterior radiculopathy, access through cervical spine is possible^{6,11,12}. By the time the skin and platysma became open, the backbone access is obtained through the distance between the sternocleidomastoids and middle cervical structures (trachea and esophagus). To avoid damage to carotid sheath including internal jugular vein, carotid artery and vagus nerve care should be carried out. The total damaged disc and osteofit are removed and the bone graft is placed in the space where disc was taken. Placing a bone graft restores the disc height, helps to keep the intervertebral foramen size between vertebral and maintains the natural curvature of the neck^{5,12,13}. This graft may be allograft or autograft. For this reason, the surgeon may use an external device (cage). Fusion with autograft alone is still the most common method used in a one-level disease and generally is recommended for most patients⁶. If two or more adjacent levels be involved, to provide the sufficient stability of the structure and to improve the

rate of fusion using the tools is usually recommended. Commonly used tool is a cage with or without anterior plate placement¹⁴.

In cases of posterior longitudinal ligament trapped nerve or destructive spondylitis, treatment involves anterior removal of injured bony structures (such as the osteofit or classified posterior longitudinal ligament) and anterior removal of pressure from the nerve that usually includes a corpectomy; removal of vertebral bodies to remove the nerve pressure¹⁵⁻¹⁷. In corpectomy, discs above and below the damaged surface are completely removed to reach the posterior longitudinal ligament the same as the anterior cervical discectomy with fusion (ACDF) method. Vertebral bodies are also fully removed up to posterior longitudinal ligament. If posterior longitudinal ligament become bony and trapped on the thecal sac, gently could be removed using electric drill, curettes (tools for surgical removal of tissue) and rongeur crimson (tools for surgical removal of bone tissue). Then a cage of fibula autograft or an allograft made up of a bone graft is placed in that segment where no pressure exists. It would also get narrow by the use of plate and screws. The decision to remove the pressure from the nerve through anterior or posterior method is dependent on the number of narrow levels in the cervical spine. Generally, in cases where less than three levels are involved anterior corpectomy and fusion are preferred where three or more levels are involved and lordosis is retained, laminoplasty is the preferred method for posterior removal of pressure^{11,4}. In case of spine kyphosis, an anterior corpectomy following a cervical posterior fusion must be done to maintain the stability of the structure¹¹.

Studies have shown that removal of pressure from the spinal cord is the most effective method for cervical myelopathy treatment with the recovery rate of 85%-99%^{7,18}. In anterior surgical method, cervical vertebrae would be accessible through anterior incision. Anterior longitudinal ligament is cut on the disc place and anterior half of the disc also is removed macroscopically. Lower part of the residual nucleus pulposus and protruding parts of the disc are removed under magnification with a microscope. Osteofit are also removed in this process and graft is taken from axonal anterior iliac. Then the graft is inserted in the place where disc was removed. Six to twelve weeks after the surgery the graft is well welded in the site. Patients wear braces for almost six weeks². This method of surgery can be divided into 3 types of anterior cervical discectomy alone (ACD), ACDF discectomy with intervertebral fusion and instrumentation (ACDFI) and ACDF. Based on previous studies, there is

no significant difference in the clinical results of these surgical types after 2 years follow up of patients^{19,20}. On the other hand, some studies indicate that higher rates of segmental kyphosis are seen in ACD in comparison with ACDF and ACDFI.

Some researchers also refer to lower displacement of graft, graft collapse and higher rates of fusion after ACDFI compared to ACDF. According to some other studies, the complaint rate of ACDFI has been far more than ACDF^{22,22}. There are also some studies which show ACD, ACDF and ACDFI lead to decrease of segmental motion and increase of the stress on discs below and above the fusion site. This in turn leads to degenerative changes at adjacent levels²³.

Furthermore, on the basis of some other studies; ACDF with autograft method include side effects such as prolonged pain syndrome, cutaneous femoral nerve damage, death of grafted bone tissue, secondary infection or fracture, graft protrusion, collapse and disorder in fusion which results in kyphosis and false osteoarthritis²⁴. In addition, using plate and screws can also lead into loss of normal sequence of the cervical spine, dysphasia and damage to the soft tissue.

MATERIALS AND METHODS

We assessed surgical outcomes in patients operated with standard Smith-Robison Technique during 2007 to 2010. Based on sample size formula, pilot study and the probability of loss the sample size was considered. The whole population study was selected through simple random sampling. They were all examined first by neurosurgeon, neurologist and orthopedic specialists. Implementation of the project lasts 2 months. Candidate patients for cervical discectomy were in the age group of 25 to 70 years of both sexes.

The study protocol was approved by ethical committee of the university and filling the written informed consent was necessary. After initial imaging was done and maintenance therapies almost led to failure, patients were introduced to have surgery. They were classified on the basis of Odom criteria for assessing the results. Patients were under study for 1, 3, 6, 12, 18, 24 months clinically and radiologically. Research tests involving Visual Analog scale (VAS) of neck pain and neck disability index (NDI) questionnaires were completed by patients after surgery. All patients underwent cervical spine x-ray and magnetic resonance imaging (MRI) before and after surgery. Clinical and radiological criteria in accordance with these two questionnaires were controlled. To prevent fatigue effects on study results, questionnaires

and computerized tests had to be conducted in 2 hours.

For data analysis, passion distribution model was used to determine the distribution of qualitative data and t-test to compare the mean between two groups of qualitative data.

RESULTS

The study population included 61 patients out of which 18 cases (29.5%) were excluded from the study due to lack of standard or inclusion criteria. 43 patients (70.4%) remained in the study, 25 (58.1%) of them were male. The mean age of participants was 49.74 years with standard deviation of 10.96. The youngest participant was 24 and the oldest one was 77 years old. Before surgery,

Table 1. Frequency of pain type and sensory disorder in patients before surgery

Symptom	Frequency	%	
Pain type of patients before surgery	Neck pain	33	76.6
	Right unilateral radicular pain	14	32.6
	Left unilateral radicular pain	19	44.2
	Bilateral radicular pain	5	11.6
	Back head pain	4	9.3
	Pain between the shoulders	2	4.7
Type of pain spreading	Above the shoulder (C5)	6	18
	Thumb and forefinger (C6)	1	2.3
	Behind the arm and middle finger (C7)	2	4.7
	Forearm and little finger (C8)	0	0
	Combination of the above patterns	30	75
Existence of sensory disorder	37	86	
Type of sensory disorder	Patchy	11	29.7
	Dermatomal with C6	2	4.7
	Dermatomal with C5 and C6	11	29.7
	Dermatomal with C6 and C7	5	11.6
	Dermatomal with C7 and C8	2	4.7
	Other types of sensory disorder	6	16.3
Having paresthesia	36	83.7	
Paresthesia span	C5	5	13.9
	C5 and C6	16	44.4
	C7	5	13.9
	C6 and C7	16	44.4
	C7 and C8	3	8.3
	C5, C6 and C7	5	13.9
	C6, C7 and C8	2	5.6

the mean duration of disease symptom onset was 14.6 months with standard deviation of 23.5 while the mean duration of disease symptom exacerbation was 3 months with standard deviation of 4.43.

As table 1 show, the most common type of pain among participating patients was neck pain which was reported in 33 cases (7.7%). Besides, the most common spread type of radicular pain was radicular pain with mix spread which was observed among 30 patients (75%). Considering the type of sensory disorder before surgery, the most common type of sensory loss was dermatomal involvement with simultaneous involvement of C5 and C6 and patchy involvement which were both seen in 11 patients (29.7%). Paresthesia also was observed in 36 (83.7%) participants. The most common reported paresthesia was simultaneous involvement of C5 and C6 which was found in 16 cases (44.4%).

According to table 2, Gait abnormalities were seen in 13 patients (2.3%). Thirty-three patients (76.7%) showed motor symptoms while simultaneous involvement of C6 and C7 was observed among 4 patients (10.8%). Seven (16.3%) patients had lower extremity weakness out of which 4 had right lower extremity weakness with proximal and distal involvement and 3 had left lower extremity

weakness with proximal and distal involvement. Seven patients (16.3%) also experienced atrophy.

Among patients with atrophy, 5 (11.6%) had unilateral atrophy and 2 (4.7%) had bilateral atrophy.

The most common symptoms of myelopathy in this study were the concurrency of babinski reflex, hyperreflexia and hoffman sign in 5 patients (11.6%). Respectively, 41 patients (95.3%) and 43 (100%) had no sphincter and sexual disorders. Among 2 patients with sphincter disorder, 1 had urinary incontinence and the another had urinary and fecal incontinence simultaneously. The number of patients who had 1 involved level was 35 (81.4%). Those who had 2 involved levels were 8 in number (18.6%). Extrusion of disc was mostly seen in C5 and C6 levels in 15 patients (34.9%).

Three patients (7%) had cervical spinal stenosis, 2 (4.7%) had lumbar spinal canal stenosis with cervical spinal stenosis and 1 (2.3%) had just lumbar spinal canal stenosis. Extrusion was the most common amount of pressure on the disc that was seen in 32 patients (74.4%) and paracentral was the most common type of pressure on the disc observed in 34 patients (79.1%). Imaging findings obtained from MRI can be seen in table 3. The

Table 2. Types of motor symptoms in patients before surgery

Types of motor symptoms	Frequency	%
Gait disorder	13	30.2
Types of motor symptoms		
C5	1	2.7
C6	1	2.7
C7	1	2.7
C8	3	8.1
C6 & C7	4	10.8
Left clumsiness	4	10.8
Right clumsiness	1	2.7
Left clumsiness Right clumsiness	2	5.4
C6 & C5 & Left clumsiness	3	8.1
C6 & C5 & Right clumsiness	2	5.4
Others	11	29.7
Right lower extremity weakness	4	9.3
Left lower extremity weakness	3	7
Myelopathy		
babinski	2	4.7
hoffman sign	2	4.7
babinski reflex, hyperreflexia and hoffman sign	5	11.6
hyperreflexia	4	9.3
Spasticity, babinski reflex, hyperreflexia and hoffman sign	4	9.3
hyperreflexia and hoffman sign	3	7
babinski reflex and hoffman sign	2	4.7
Others	5	11.6

Table 3. Imaging findings of patients

Imaging findings	Frequency MRI	%
Extrusion of disk		
C3-C4	9	9.3
C4-C5	8	18.6
C5-C6	15	34.9
C6-C7	8	18.6
C3-C4 & C6-C7	1	2.3
C6-C7 & C5-C6	3	7
C5-C6 & C4-C5	4	9.3
Amount of pressure on the disc		
Bulging	0	0
Protrusion	11	23.8
Extrusion	32	76.2
Type of pressure on the disc		
Central	4	9.3
Para-central	34	79.1
Foraminal	2	4.7
Broad based	3	7
X-ray		
Reduction of vertebral disc height	17	39.5
Reduction of vertebral disc height with loss of lordosis	9	20.9
Reduction of vertebral disc height with loss of lordosis and existence of osteofit in lesion level	9	20.9
Reduction of vertebral disc height and existence of osteofit in lesion level	6	14
Others	2	4.7

most common finding includes reduction of vertebral disc height which was indicated in 17 patients (39.5%).

Indications for surgery are given in table 4. The most common Indication for surgery was refractory pain which was seen in 19 patients (45.2%). Type of surgery in all patients was anterior cervical discectomy with cage which its performance was dependent to the number of involved levels. In 35 cases of patients (81.4%), 1 level was involved and in 8 cases (18.6%) 2 levels were involved.

According to table 5, pain recovery in 39 patients (90.7%), resolution of sensory disorders in 35 patients (81.4%) and recovery of motor status were diagnosed in 31 cases (72.1%). Table 6 show surgical outcomes in patients with Odom criteria. On the examination of

Table 4. Causes of surgery on patients participated in this study

Causes of surgery on patients	Frequency	%
Resistant pain	19	45.2
The incidence of sensory neurological defects	3	7
The incidence of motor neurological defects	1	2.3
Myelopathy symptoms	1	2.3
Resistant pain with myelopathy symptoms	7	16.3
Resistant pain along with the incidence of sensory neurological defects	3	7
Resistant pain along with the incidence of motor neurological defects	2	4.8
Other causes	7	16.3

Table 5. Clinical improvement after surgery

Clinical recovery after surgery	Frequency	%
Neck pain	5	11.6
Neck pain with radicular pain	34	79.1
Resolution of sensory disorders	35	81.4
Recovery of UMN symptoms		
Recovery of hyperreflexia symptoms	2	4.7
Recovery of Spasticity, babinski reflex, and hyperreflexia symptoms	5	11.6
Recovery of Spasticity, myelopathy and hyperreflexia symptoms	2	4.7
Recovery of babinski reflex, and hyperreflexia symptoms	1	2.3
Recovery of Spasticity, myelopathy, hyperreflexi and hoffman sign symptoms	3	7
Other states of UMN symptoms resolution	6	13.8
Recovery of motor status	31	72.1

Table 6. Surgical outcomes in patients with Odom criteria.

Odom criteria	Frequency	%
All preoperative symptoms and abnormal findings are improved	16	37.2
Minimum remained preoperative symptoms	19	44.2
Major improvement of preoperative symptoms	8	18.6
Unchanged or worsened symptoms	0	0

NDI before surgery as can be seen in table 7, none of the participating patients had lack of disability or mild disability. The most common indicator in these patients was severe disability which was observed in 34 cases (79.1%). After surgery, no one had complete disability while mild disability was the most common indicator among 20 patients (46.5%).

In table 8, results of the NDI reveal that preoperative pain severity average score of the patients was 2.93 with

Table 7. Neck disability index (NDI) in patients before and after surgery.

The severity of NDI	Preoperative frequency	%	Postoperative frequency	%
Without disabilities	0	0	6	14
Mild disability	0	0	20	46.5
Moderate disability	4	9.3	16	37.2
Severe disability	34	79.1	1	2.3
Complete disability	5	11.6	0	0

Table 9. Reviewing Visual Analog Scale (VAS) variables and comparing their difference before and after surgery.

VAS variable	Time	Mean	SD	P value
Neck pain	Before	7.26	1.8	P<0.001
	After	1.27	0.9	
Night pain	Before	8.02	1.7	P<0.001
	After	1.33	1.03	
Pain in the activity	Before	6.92	2	P<0.001
	After	2.44	1.87	
Palliative consumption	Before	3.64	1.83	P<0.001
	After	0.6	0.8	
Shoulder and right arm pain	Before	3.82	3.82	P<0.001
	After	0.69	0.92	
Shoulder and left arm pain	Before	4.3	3.56	P<0.001
	After	0.69	1.12	
Pain caused immobility of right arm or hand	Before	4.12	3.84	P<0.001
	After	0.61	0.93	
Pain caused immobility of left arm or hand	Before	4.4	3.6	P<0.001
	After	0.7	1.02	
Anesthesia or paresthesia in the right hand	Before	4.28	3.67	P<0.001
	After	0.47	0.8	
Anesthesia or paresthesia in the left hand	Before	4.53	3.62	P<0.001
	After	0.42	0.81	
Headache	Before	0.74	1.8	P=0.067
	After	0.64	1.1	
Headache frequency	Before	0.66	1.5	P=0.072
	After	0.54	1.2	
Pain during driving	Before	4.3	3.9	P<0.001
	After	0.7	1.1	
Pain at rest	Before	4	2.5	P<0.001
	After	0.66	1	
Disruption at work	Before	7.94	1.5	P<0.001
	After	1.73	1.5	
The need for job reform	Before	8.7	1.4	P<0.001
	After	2.1	1.67	

Table 8. Neck disability index (NDI) results.

NDI	Assessment	Mean	SD	P value
Pain severity	Before	2.93	0.59	P<0.001
	After	0.65	0.61	
Personal care	Before	2.35	0.61	P<0.001
	After	0.72	0.66	
Lifting the objects	Before	3.2	0.77	P<0.001
	After	1.5	0.88	
Reading	Before	3.98	0.63	P<0.001
	After	1.67	1.47	
Headache	Before	0.2	0.88	P=0.05
	After	0.103	0.3	
Concentration	Before	3.25	0.81	P<0.001
	After	1.04	0.68	
Job	Before	3.32	0.74	P<0.001
	After	1.04	0.81	
Driving	Before	4.11	0.87	P<0.001
	After	2.65	1.9	
Sleeping	Before	2.72	0.95	P<0.001
	After	0.6	0.87	

standard deviation of 0.59. This average score became 0.65 with standard deviation of 0.61 after surgery. Statistically, this difference was significant with P-value of less than 0.001.

VAS was reviewed before and after surgery based on table 9. Patients' pain was reduced in all variables which have been questioned. These changes were statistically significant.

DISCUSSION

Determining the type of pain before surgery is important. The reason of radiculopathy with motor weakness or sensory loss is one or more nerve root compression which may cause dysfunction in the involved nerves. This has been approved in previous studies^{6,11}. An important step for making decisions about diagnosis and referral for treatment is to identify the patients' complaints of axial neck pain or radicular symptoms. In most cases, neurological examination is normal and the patient's chief complaint is pain. Cervical spondylosis is a common and chronic lesion of cervical spine. In case of myelopathy or radiculopathy, surgery may be required. Laminectomy is one of the first methods of cervical spine surgery. Then, anterior discectomy which is now very common entered the field of surgery. Pain, myelopathy and radiculopathy are the main lesions of cervical spondylosis and the aim of treatment is to relieve these symptoms. Non-surgical treatments are largely effective. Palliatives, physiotherapy and modification of life style are effective strategies to improve the symptoms of spondylosis. The most common symptom of cervical

spondylosis is pain while myelopathy and radiculopathy are less common. Myelopathy and radiculopathy respond better to surgical methods than neck pain. Neck pain alone is considered a rare indication of surgery.

As shown in table 2, motor disorder was observed in most patients. The most common symptom of myelopathy in this study was the concurrency of babinski reflex, hyperreflexia and hoffman sign. In previous studies, to determine the need for surgery neurological disorders had been examined. Generally, presence or absence of neurological disorders is a determinant factor in this regard. Changes in bowel and bladder may be a primary manifestation of neurological disorders^{25,26}. This is inconsistent with findings of current study which shows that 95.3% and 100% of patients had no sphincter and sexual disorders, respectively. However, some studies have also confirmed that not all patients have neurological disorders, but typically they complain of pain. This pain can be influenced by activity and is referred to as mechanical pain⁶.

Non-surgical methods in the treatment of radiculopathy include rest, medicines, medical necklace, physiotherapy, patients' training about the correct style of living and injection of topical medications. If symptoms in patients with myelopathy do not get improved or 6 to 8 weeks after treatment they become worsen surgical removal of pressure from the nerve would be recommended. Based on the results of many surgical studies, in such cases the pain is not resolved without surgery despite the maintenance treatment methods. Therefore, surgical intervention is a good choice especially because the results are desirably predictable^{5,6}. Surgical indications consist of progressive neurological deterioration despite the supportive therapies and continuation or regression of pain for more than 6 weeks with positive imaging findings. As it seems myelopathy is a progressive process and surgical procedure gets more necessity. Due to the possibility of complete discectomy and complete removal of compression, anterior surgery approach is preferred over posterior one. Only when more than 3 levels are involved in the neck posterior approach is preferred.

The most common cause of the need for surgery in patients was resistant pain. The only surgical treatment for axial neck pain caused by destructive disc disease is fusion^{27,28}. Fusion of the vertebral components eliminates the motion between adjacent segments and therefore reduces the pain caused by damaged surface²⁹. On the other hand, fusion is a permanent procedure with its own possible problems in short or long term period. Thus, fusion is only considered when the symptoms are

chronic and non-reducible and all of the non-surgical treatment options have failed³⁰. Generally, the more involved levels in axial neck pain are fused the results tend to get worsen^{28,31}. Hence, multi-level fusion is rarely underscored^{11,26}. In such cases, patients should be advised that the results are not reliable and their expectations will not be substantial.

Complications of surgery are divided into two categories of early and late complications. Early complication which are seen in about 20% of patients include dysphasia, hematoma, nerve palsy, recurrent laryngeal, dura rupture, esophagus rupture, nerve damage (increase of Horner syndrome myelopathy), displacement of installed devices and wound infection. Late complications consist of adjacent segment lesion, pseudoarthrosis and indentation of the installed device in the trunk. It appears that incidence of adjacent segment lesion is about 2.9% per year that only half of the cases will need surgery intervention. In the present study which was conducted on operated patients (60% male and 40% female) in Shohada Hospital, the most common symptoms was neck pain which was observed in more than 75% of the whole patients. Neurological symptoms were found in more than 70% of the patients and the most common involved level was C5 and C6. Myelopathy symptoms were seen in 60% of cases. In about 20% of patients more than one level was involved. The most common type of cervical disc extrusion was paracentral.

Patients were under medical treatment for an average term of 4.5 months. Indications of surgery were pain with no response to treatment, motor and neck pain defect. Early complications of surgery were seen in 3 patients; 1 experienced recurrent laryngeal nerve damage, 1 had esophagus rupture and 1 hematoma. Based on Odom criteria, more than 30% had great improvement and 40% had considerable improvement. No patient complained about worsening of symptoms. According to NDI, almost 70% of patients had considerably improved in mentioned cases of the questionnaire. Only headache was not improved through surgery. Patients' pain had also significant improvement on the basis of VAS. In a 2 year follow-up, adjacent segment disease was observed in 4 patients (10%); 2 of them (5%) underwent second surgery. Fusion was successful in 95% of cases which is in line with figures mentioned in the papers.

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