Results of Multilevel Anterior Cervical Discectomy and Cage Assisted Fusion without Plates

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Abstract: Objective: This prospective study was performed to evaluate the safety and efficacy of carbon fibre cages packed with demineralized bone matrix (DBM) mixed with autologous blood and curettage microchip material for treatment of multilevel cervical disc disease and spondylosis without the use of plates, screws or autogenous iliac crest bone graft. **Methods:** Twenty two patients underwent multilevel anterior cervical discectomy and fusion (ACDF). Fifteen patients underwent two level fusion and 7 patients underwent three level fusion; for a total 51 levels. Seventeen patients with cervical radiculopathy and three with radiculomyelopathy. Cervical lordosis and cervical fusion status was assessed on X- ray; and 20 patients also underwent computerized tomography (CT) to assess the results of surgery. **Results:** All the patients were followed clinically and radiologically with a mean of 24 months postoperatively (range 18-26 months). Radiculopathy improved after surgery in all the patients where's myelopathy resolved in three patients. The fusion rate was 96.1% in two level fusion and 93.3% in three level fusion In two patients fusion was incomplete but reoperation was not required at the end of follow up period. No cage migration or cage failure occurred. **Conclusion:** ACDF using carbon fibre cage packed with DBM is a safe and efficient method for treatment of multilevel cervical disc disease and spondylosis. It preserves cervical lordosis and obviates the complications related to iliac crest graft harvest and screw plate fixation.
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1. Introduction

Anterior cervical discectomy and interbody fusion (ACDF) has proven to be a safe and effective procedure for the treatment of degenerative disc disease[1-5]. The anterior approach allows direct visualization of the entire interspace and wide decompression of the anterior aspect of cervical spinal cord and nerve roots and anterior inter body fusion may be performed if required[6]. The success rates decline in multilevel discectomies as the number of level increase[7, 8]. Graft collapse with the use of autogenous bone has been reported in 20-30% of multilevel fusion patients[9-12]. Moreover, even with solid fusion, kyphosis often develops in multilevel discectomies with autogenous iliac crest graft fusion[10-13]. Additionally, morbidity due to bone graft harvest remains high and can compromise the satisfactory clinical result of cervical nerve root and spinal cord decompression.[14-16]

Multilevel cervical discectomy is often combined with plate and screw fixation to maintain the spinal curvature, and increasing the graft fusion rate. However, plates and screws may cause complication such as screw breakage, screw pull out, esophagus perforation and spinal cord or nerve injury.[17-21]

The deficiencies mentioned above have favoured ongoing development of cage technology.[14, 15, 22]

Interbody fusion cages are hollow implant that restore the physiological disc height and lordosis, allowing bone graft growth within and around them, thus stimulating bone fusion. They have been developed to prevent disc space collapse with potential advantage of indirect foraminal decompression by restoration and preservation of intervertebral height and lordosis. In most studies, cages filled with autologous cancellous bone were used. Although this is likely to reduce graft harvesting complications, donor site pain still remain a common problem[23, 24]. The primary complications related to the implantation of fusion cages are subsidence into adjacent vertebral bodies (VBS), cage dislocation, nonunion – related instability and painful pseudoarthrosis[23-25].

The purposes of this study were to evaluate the safety and efficacy of Carbone fiber cages packed with DBM (Crafton) mixed with autologous blood and curettage microchip material; for treatment of cervical degenerative disc disease and their application in multilevel surgery without the addition of an anterior plate system and to determine if it is possible to eliminate donor site complications and to

achieve good outcomes for multilevel discectomy and fusion.

2. Patients and Methods:

In Orthopedic Department, Zagazig University hospital, between February 2006 and September 2010, 22 patients (14 women and 8 men) suffering from degenerative disc disease underwent ACDF using carbon fibre cage packed with DBM (Grafton) mixed with autologous blood and curettage microchip material. Fifteen patients underwent two level fusion and 7 patients underwent three level fusion for a total of 51 levels. No plate instrumentation was used. The mean age was 43 years range (35-60 years). There were seventeen patients with cervical radiculopathy and five patients with radiculomyelopathy. There were 10 patients with kyphotic deformity of the cervical spine. **(Table 1)**

Indication for operation was intractable radiculopathy, and radiculomyelopathy due to nerve root or spinal cord compression and compatible magnetic resonance imaging (MRI) findings. Patients with trauma, infection and neoplasms were excluded. Conforming to international ethical standard, all patients were given detailed information on the operation, the follow-up protocol and radiological investigations and their consent was obtained.

The operative procedure was performed as described by Robinson and Smith[26]. The disc, posterior longitudinal ligament, and osteophytes, including the posterior part of the uncinate process were removed endplate cartilage was also removed with a high speed drill and curette. Curettage microchip material was conserved. Cages were inserted into the disc space after packing with DBM mixed with autologous blood and curettage microchip material.

The wound was closed with re-approximation of anatomic planes over a suction drainage system. All patients wore a Philadelphia collar for 6 weeks after surgery and 14 patients received physiotherapy after removal of the collar.

Clinical and radiological follow-up was performed at the 3rd, 6th, 12th and 24thmonths postoperatively. In addition to standard neurosurgical examination, we evaluated spinal curves, mobility and fusion status with X-ray was evaluated. Four views of X- ray were used, including anterior posterior, neutral and flexion and extension lateral views (Fig.s 1, 2).

Criteria of Evaluation:

At the end of follow up 24 months range (18-26 months), the following criteria were used to judge the success of surgery: recovery of neurological function, absence/presence and intensity of neck pain, extent of fusion on cervical X-ray films, degree of spinal curvature on X- ray films, position of the cage, and return to work.

The operation segment was deemed to be fused if there was no change in position of levels on dynamic views (flexion and extension).

Fusion was considered complete if the endplates had disappeared into both adjacent VBs and if the two VBs formed a block with no radiolucency demonstrated except by the cage itself.

Lateral X-ray films were performed to evaluate the spinal curve pre and postoperatively. The Ishihara curvature index (ICI) was used for this evaluation[27]. A straight line was drawn from the posterior border of the dens to the posterior border of the C7. Another line was drawn from the posterior border of C4 perpendicular to the first line, in which the intersected length was measured in millimeters as the degree of spinal curvature. A positive intersected length indicates the degree of lordosis. If the intersected length is negative it indicates kyphosis. When the intersected length is zero, the spinal curve is referred to as straight.

3. Results:

None of the patients suffered neurological deterioration, and there were no major complications during immediate post-operative period; postoperative X-ray confirmed appropriate positioning of the vertebral cages**.**

Recovery of neurological function:

All patients suffering from radiculopathy improve gradually after surgery; except one patient was still complaining of mild sensory loss at 1 year follow up. Of the five patients with radiculomyelopathy the radicular dysfunctions resolved in all five where's myelopathic dysfunctions resolved in three patients only.

Fusion rate:

At final follow up, 14 (93.3%) of the 15 patients surgically treated with two levels fusion, and 29 (96.6%) of 30 levels showed complete radiological fusion i.e. one patient with one incomplete fusion level.

Also 6 (85.7%) of 7 patients surgically treated for three level fusion and 20 (95.2%) of 21 levels, showed complete radiological fusion i.e one incomplete fusion level in one patient with three level fusion). Totally: 49/51 levels (96%) showed complete fusion **(Table 2)**.

In those two patients where the fusion was incomplete; this was confirmed on follow up C.T. studies. Those two patients complained of mild neck pain but exhibited no symptoms of pseudoarthrosis. Imaging showed no cage failure or dislodgement. Reoperation for non-fusion was not necessary in

addition, no mobility was seen on dynamic x- ray films at any operated segments.

Neck pain:

Post operatively. The mean visual analog pain score was (VAS) 3.2 (range 1-6) compared with a preoperative score of 8.2 (range 7-10), the difference was statically significant ($P < 0.01$)

Spinal curvature:

The kyphotic deformity was corrected in nine of ten patients. No case of iatrogenic cervical deformity was observed postoperatively.

Cage positioning:

No patient with cage extrusion was observed. In three levels, cage settling inside the disc end plate were observed with no evidence of symptoms recurrence or iatrogenic kyphosis in any of these patients.

Return to work:

All patients who suffered preoperatively from radiculopathy improved after surgery and returned to their preoperative jobs, except for one patient with moderate radiculopathy who had obliged to change to occupations requiring milder activity. In one patient in whom myelopathic dysfunction did not improve after surgery had not returned to work at 24 months follow up **(Table 3)**.

Complication:

None of the patients suffered major complications or neurological deterioration. There were two cases of dysphagia however this resolved in two weeks there was. One patient with transient vocal cord dysfunction and there one patient with superficial wound infection treated successfully with antibiotics **(Table 4)**.

Table (1): Patients demographic data.

	N = 18	
Age (years)		
$\bar{x}$ ± SD	43 ± 6.7	
Range	35-60	
Gender		
Men	8	36.6%
Women	14	634%
Operative data		
Patient with radiculopathy	17	77.3%
Patient with radiculomyelopathy	5	22.7%
Patients with pre-operative kyphosis	10	45.4%
Patients with two level fusion	15	68.2%
Patients with three level fusion	7	31.8%
Follow up period (months)	24 ± 4.4 Range (18-26)	

Table (2): Post-operative fusion rate.

Fusion rate	Patient N	Fused level (N)
Two level fusion	15	30
Solid fusion	14 (93.3%)	29 (96.6%)
Three level fusion	7	21
Solid fusion	6 (85.7%)	20 (95.2%)
Total fusion rate	18/20 (90%)	49/51 (96%)

Table (3): Post-operative results

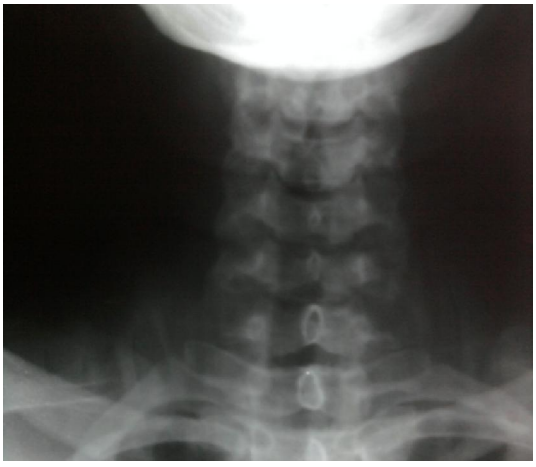
	(X ± SD)	(Range)
Neck pain (VAS)		
Pre – operative	8.2 ± 0.5	(7-10)
Post- operative	3.2 ± 1.4	(1-6)
Kyphosis		
Pre- operative	10/22	(45.4%)
Post- operative	1/22	(4.5%)
Recovery of neurological function		
Radiculopathy improvement	16/17	94.1%
Mild sensory loss	1/17	5.8%
Complication		
Dysphagia	2	9%
Vocal cord dysfunction	1	4.5%
Superficial wound infection	1	4.5%

$P < 0.001$ when compare with pre-operative

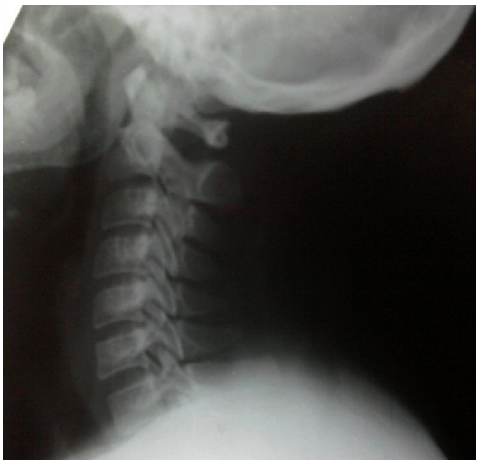
Table (4): Results at final follow up.

	Age	Sex	Complain	Level	Kyphosis Pre. op.	Lordosis post. op.	Fusion	Complications
1	48	♂	Radiculopathy	C3-4, C4-5	–	+ ve	+ve	
2	50	♀	Radiculopathy	C3-4, C 4-5	+	+ ve	+ ve	
3	35	♀	Radiculopathy	C4-5, C5-6	–	+ ve	+ ve	
4	54	♂	Radiculopathy	C4-5, C5-6	+	+ ve	+ ve	Mild sensory loss
5	37	♂	Radiculopathy	C4-5, C5-6	–	+ ve	+ ve	Vocal cord dysfunction
6	40	♂	Radiculopathy	C4-5, C5-6	+	+ ve	+ ve	
7	50	♀	Radiculopathy	C4-5, C5-6	–	+ ve	+ ve	
8	54	♀	Radiculopathy	C5-6, C6-7	–	+ ve	+ ve	Superficial wound infection
9	60	♂	Radiculopathy	C5-6, C6-7	_	+ ve	+ ve	
10	60	♂	Radiculopathy	C5-6, C6-7	–	+ ve	+ ve	
11	56	♀	Radiculopathy	C5-6, C6-7	–	+ ve	+ ve	
12	54	♀	Radiculomyelopathy	C5-6, C6-7	–	+ ve	One level fusion only	
13	60	♀	Radiculopathy	C5-6, C6-7	–	+ ve	+ ve	Dysphagia
14	58	♀	Radiculopathy	C5-6, C6-7	+	+ ve	+ ve	
15	57	♀	Radiculopathy	C5-6, C6-7	+	+ ve	+ ve	
16	52	♂	Radiculomyelopathy	C 3,4, C4,5 C5,6	–	+ve	Two level fusion only	Myelopathy
17	40	♀	Radiculomyelopathy	C 3,4, C4,5 C5,6	–	+ve	Two level fusion only	Myelopathy
18	48	♀	Radiculomyelopathy	C4,5 C5,6, C 6,7	+	– ve	+ve	Myelopathy
19	58	♀	Radiculomyelopathy	C4,5 C5,6, C 6,7	+	– ve	+ve	Myelopathy
20	52	♂	Radiculopathy	C4,5 C5,6, C 6,7	+	+ ve	+ ve	Dysphagia
21	50	♀	Radiculopathy	C4,5 C5,6, C 6,7	+	+ ve	+ ve	
22	60	♀	Radiculopathy	C4,5 C5,6, C 6,7	+	+ ve	+ ve	

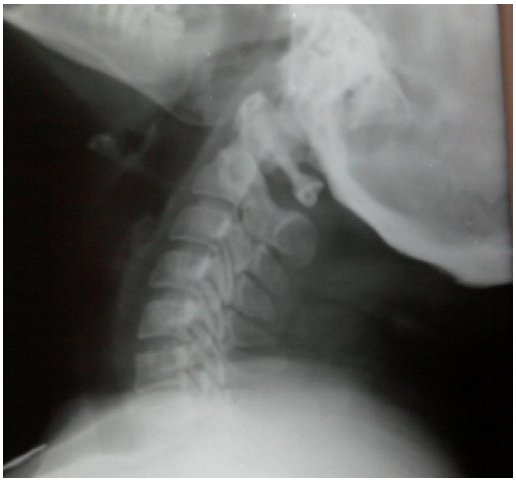
Case I



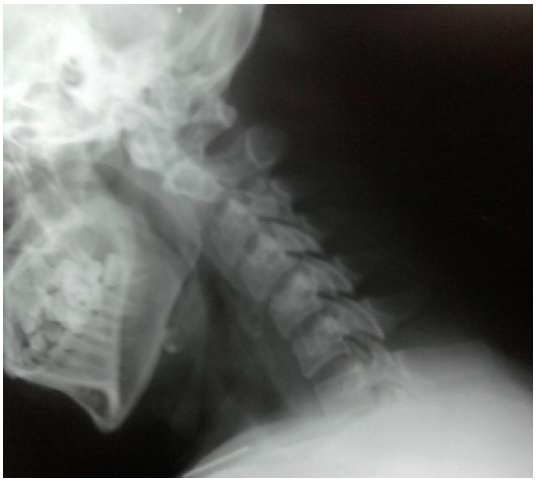
Pre- operative A.P x- ray



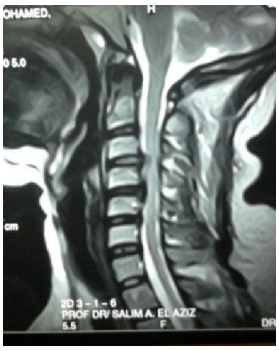
Pre- operative lateral view x- ray



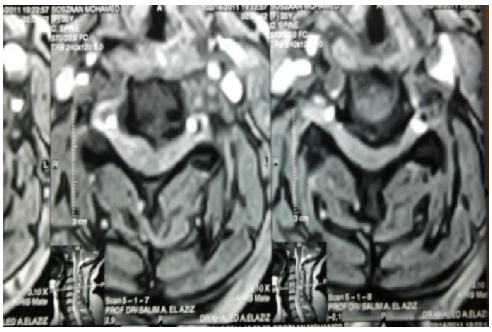
Pre-operative lateral extension x-ray



Pre- operative lateral flexion x- ray



Pre- operative M.R.I



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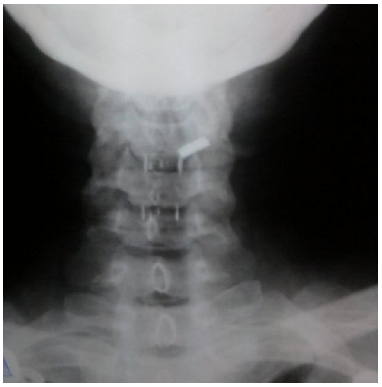
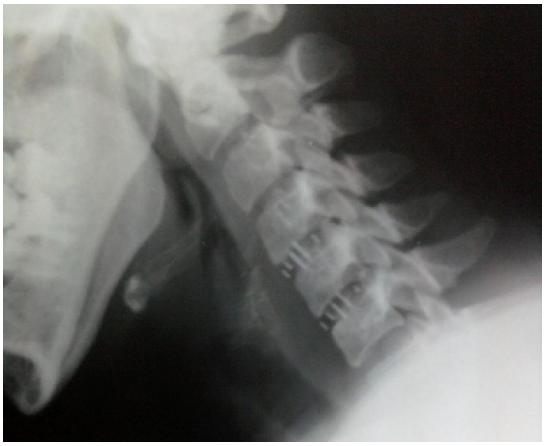
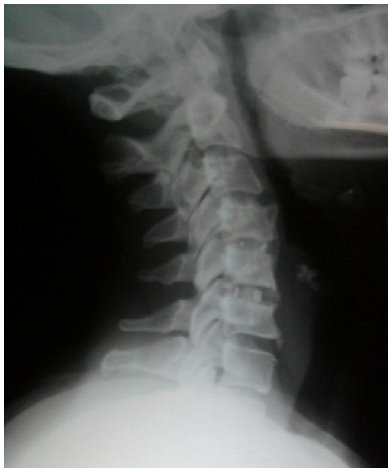


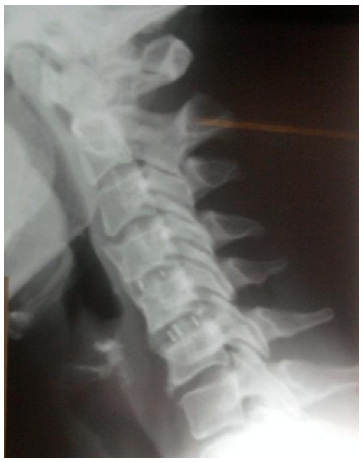
6 months post – operative



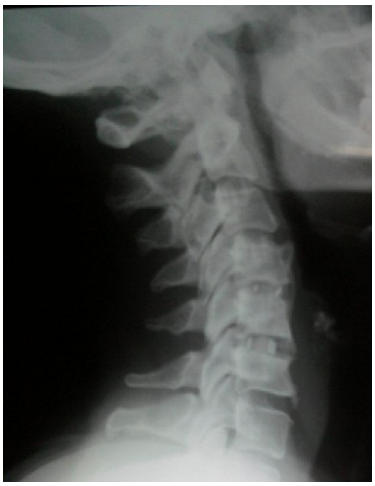
6 months post – operative



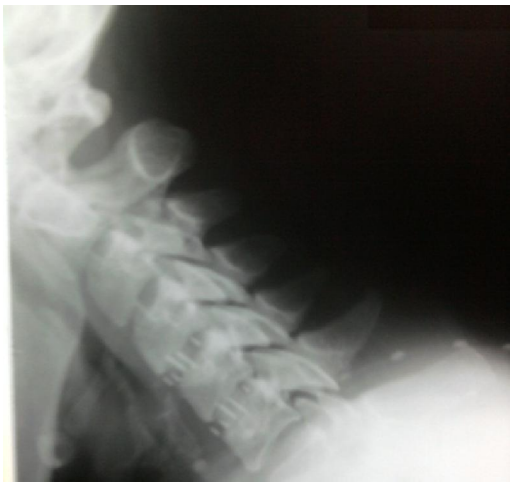
1 year post – operative



1 year post- operative



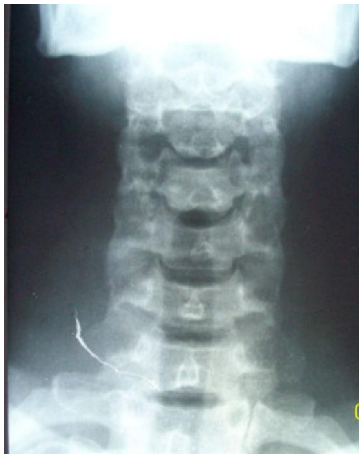
18 months post-operative extension



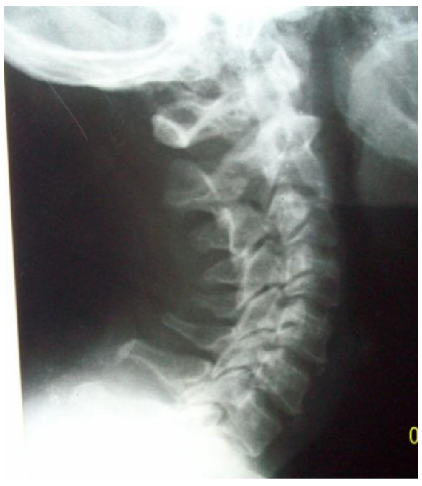
18 months post-operative flexion

Case (I): Male patient 30 year with radiculopathy C4,5/C5,6,
MRI cervical disc prolapse C4,5/C5,6, Two level fusion, solid fusion

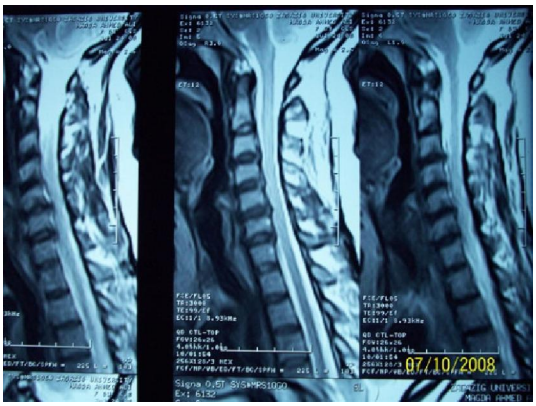
Case II



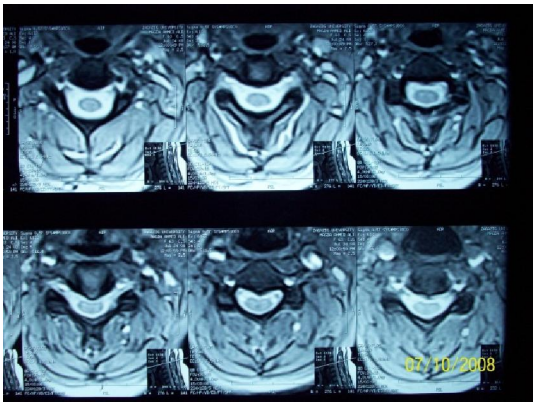
Pre- operative A.P. x- ray



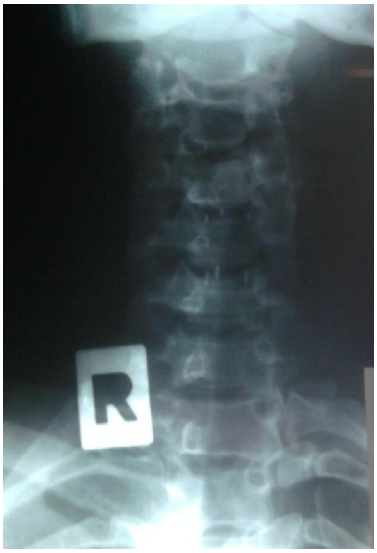
Pre-operative lateral x- ray



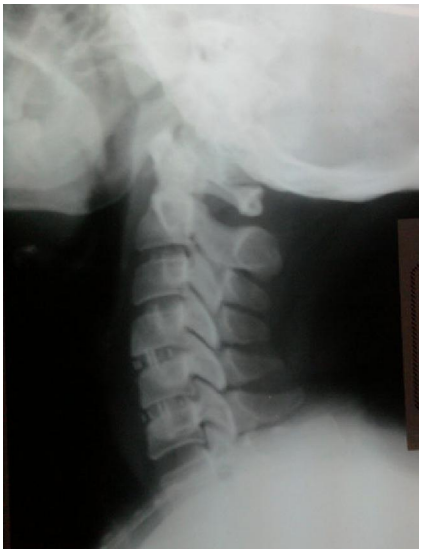
Pre-operative saggital M.R.I



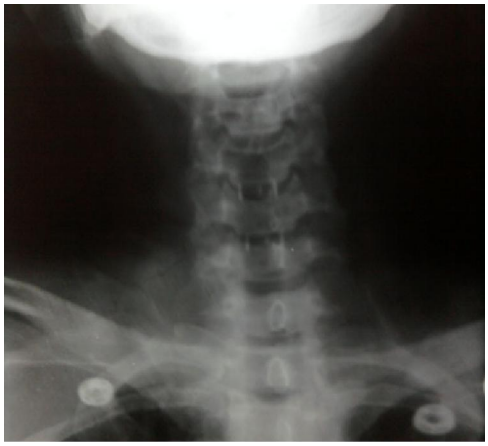
Pre- operative coronal M.R.I



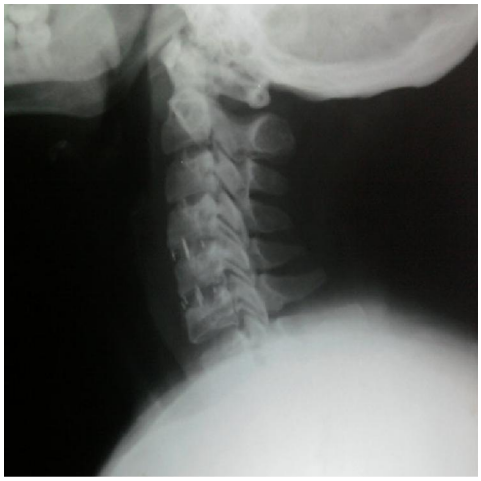
3 months post- operative



3 months post – operative



12 months post- operative



12 months post-operative

Case (II): Female patient 54 year, Radiculopathy C4,5/ C5,6,
MRI cervical disc prolapse C4,5/C5,6
Two level fusion, follow up: solid fusion

4. Discussion:

Anterior cervical discectomy and interbody fusion is an efficacious procedure used to treat a variety of cervical spinal disorders, including spondylosis, myelopathy, herniated discs, trauma, and degenerative disc disease. The success of this procedure relies on through decompression and development of a solid osseous fusion.[1-5, 25, 27,28]

Brown *et al.*[29] reviewed serial X- rays after anterior cervical fusion performed in total of 139 levels in 98 patients and found arthrodesis in 97% of patients who underwent auto-graft procedures. In their series, Savolainen *et al.*[30] found a 98% fusion rate in patients who underwent procedures with auto-graft. According to the results obtained from other series, for single-level discectomy with autogenous bone fusion, ACDF can achieve a 92-100% fusion rate[20] and 70-90% neurologic and symptomatic improvement.[4,5] Although, arthrodesis with autologous iliac crest graft is considered as the biological and biomechanical standard in anterior cervical reconstruction,[9,31] the morbidity of the iliac bone harvest can often tarnish these results.[3, 15, 23-25, 28, 30, 32-34] Silber et al.[15] observed that 26.1% of patients reported pain at the donor site. Summer et al.[24] also reported chronic pain in the donor site in 25% of 290 patients. According to Arrington *et al.*[14], in addition to the minor complications of the donor site (superficial infections, hematoma, cosmetic problems, etc.) there were major complications in 5.8% of cases, requiring therapeutic modifications, surgical revision and prolongation of hospitalization. Castro *et al.*[1] reported a donor site complication rate of 22% in their series. In this study, the donor site morbidity was avoided.

In the Cloward procedure, the best results have been reported for young male patients with soft disc disease, at the single level.[35, 36] Multilevel anterior cervical discectomy and fusion still remains a difficult problem. Autogeneous bone does not maintain spinal instability in multilevel discectomy very well and the graft complication rate in autogenous bone graft in multilevel fusion is higher than at the single level.[3,8, 9,13] Graft collapse with autogenous bone is reported in 20-30% of multilevel fusion[10-12]. Morever, it has been reported this even with solid fusion, kyphosis often develops in multilevel discectomies with autogenous iliac crest graft fusion [10-17]. The literature also reports a consistent rate of 10-12% non- fusion for single- level anterior discectomy and autogenous bone fusion, 20-27% for two- level, and approximately 30-56% for three- level fusions[7-9] It is clear that the success rates decline as the number of level increase.

In the light of these reports, in multilevel ACDF procedures, augmentation with plate fixation, may seem to be preferable. Plate fixation may decrease the micromovement of the cervical spine, enhance the fusion rate, and correct spinal curve to physiological lordosis.[6,15] In ACDF, additional plate fixation has been reported to result in a higher fusion rate, lower reoperation rate, and better pain relief[9,12,13,31] However, in their retrospective study, Das et al.[13] Studied 38 patients who had arthrodesis with cylindrical titanium cages filled with autologous bone graft harvested from the operative site and screw-plate fixation, and they reported the rate of pseudoarrhrosis was 6-8% for one- level and 15-46% for treatment of several levels. Overall in three and four- level discectomies the successful fusion rate decreases 18-82%, even when a cervical spine locking plate is used.[37-39] Moreover. Plate complication rate varies from 2.2-24%[20,34] and includes screw pullout,[21,40] screw breakage,[21] injury of the laryngeal nerve,[8] injury of oesophagus[19] injury of spinal cord or root, injury of vertebral artery, and wound infection.[21] Additionally, the operative time is usually longer.

These complications of classical fusion procedures favoured ongoing development of cage technology. Because of the advantages of these devices, the use of cages in ACDF operations has been increasing in popularity. In parallel with this, there are several different types of interbody fusion cages commercially available.[22-23,33] Cage assisted ACDF has proved to be a safe and effective procedure for the treatment of degenerative disc disease. It has been reported that the cage achieves excellent fusion rates ranging from 95.2-100%[2,25,28,32,33,40,41] In this study, the fusion rate was 96.6% in two levels fusion and 93.3% in three levels fusion, counted by levels of X- ray comparable to the related literature. There were two patients with incomplete fusion, however, no clinical signs or radiographic mobility of pseudoarthrosis were observed during the follow-up period and re-operation was not necessary.

In this study, no cage failure or migration was encountered, even in patients who underwent fusion at more than two levels. The use of the cage was found to preserve the spinal lordosis and the height of the foramina. Bartels et al. reported that the cervical cage effectively increased foraminal height even after 1 year which contributed to decompression of the nerve root.[42] The wedge shape of the device may contribute to restoration of lordosis. Furthermore, the cage structure (two carbon fibers spikes on the upper and bottom frame, in addition to the retention teeth on the surface of the upper and bottom frame) offers a fixation mechanism which is similar to the functions of plate and screws.[28,33] Additionally, bone fusion can be evaluated easily by examining X- rays,

because the cage is radio-transparent. It is also possible to evaluate postoperative MRI or CT scans, because artifacts are negligible.

To minimize the extent of surgery, and to avoid donor site complications, the cage was filled with DBM mixed with autologous blood and microchips of curettage material. The surgical results presented in this study are encouraging and provide an impetus to the use of interbody cage rather than a ventral cervical plate for structural support in the management of multilevel degenerative cervical disc disease.

Conclusion:

Interbody fusion with cages packed with DBM, and autologous blood and microchips of curettage material is a safe and effective procedure in the treatment of multilevel cervical disc disease. It preserves spinal lordosis, and obviates the complications related to graft harvest and screw plate fixation.

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