Evaluation of Radiological and Neurological Outcomes after Anterior Cervical Corpectomy with Fusion using Expandable Cage Alone and Expandable Cage with Anterior Cervical Plating

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Abstract

Objective After anterior cervical corpectomy expandable cage were used with or without using anterior cervical plate for structural support are being preferred over autologous bone graft and other types of cages. Nowadays, the preferable type of cages and application of anterior cervical plate remain a debatable topic with studies giving divergent results. The purpose of this study is to evaluate the outcomes of expandable cages used alone or expandable cage used with anterior cervical plate following anterior cervical corpectomy.

Materials and Methods This study was conducted on 100 patients from January 2019 to December 2021 and all patients were undergone anterior cervical corpectomy and fusion and divided in two groups with expandable cage only (Group A) and expandable cage with anterior cervical plate (Group B). Various long-term benefits and radiological outcomes were studied in both groups.

Statistical Analysis and Results In this study, 100 patients were included and all patients underwent corpectomy followed by insertion of expandable cage alone or with anterior cervical plate. There was an improvement in C2–C7 Cobb's angle in group B was significantly higher than group A ($p < 0.05$) and decrease in Nurick's scale score in group B was significantly higher than group A ($p < 0.05$). The outcomes were measured with fusion rate (94%), subsidence rate (15%) and change in C2–C7 Cobb's angle was 4 degrees in this study.

Conclusion Expandable cage with or without anterior cervical plate was used after anterior cervical corpectomy for various cervical pathological conditions. In this study, we conclude the long-term benefits and radiological outcomes of two groups as expandable cage was used alone or with additional application of anterior cervical plate. In this study, the results were more in favor of additional application of anterior cervical plate as compared with expandable cage alone and more studies were required in future for more established long-term benefits and drawbacks.

Keywords
- cervical corpectomy
- expandable cage
- anterior cervical plate
- radiological outcomes

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Introduction

Anterior cervical corpectomy and interbody fusion was introduced for anterior decompression of the spinal cord. As anterior cervical discectomies became well accepted, nowadays its extended approaches led to cervical corpectomies.[1] Cervical corpectomy is a ventral cervical spine procedure for safe and effective neural decompression, deformity correction, mechanical stabilization, and single-step neck kyphosis correction. The ultimate goal is neurologic improvement and bony fusion after corpectomy. For that after cervical corpectomy, it is essential to develop the stable vertebral restoration construct. Nowadays, we have various options for anterior column reconstruction, including autologous bone graft taken from fibula or iliac crest, allograft bone and a variety of cages such as expandable cage, mesh cage, and hybrid cage. Because of graft donor site-related complications, we now preferred cage to restore corpectomy defect.[2] However, the choice of type of the implant device for interbody fusion following cervical corpectomy remains a debatable topic with different studies giving divergent results. Moreover, the selection of the implant also depends on the surgeon preference and the type of pathology. Vertebral body reconstruction using various cages are not completely devoid of complications and they also carries a risk of complications such as nonunion, graft displacement, migration, subsidence and adjacent segment degeneration.[3] One of the important goals of interbody fusion is to achieve the appropriate cervical alignment because it allows tolerating the axial load of the head, optimizes forward gaze and supports head and neck movement. Application of anterior cervical plate along with cage also supports the construct.[4] Expandable titanium cages are the latest construct for vertebral body replacement after a cervical corpectomy. Expandable cages have been used successfully to reconstruct the anterior spinal column in the treatment of traumatic cervical spine injury, neoplastic, infectious causes such as Pott's spine, degenerative spine disease and ossification of the posterior longitudinal ligament (OPLL).[5–9] Optimal graft placement and sizing are especially important in the reconstruction following multilevel corpectomy and fusion. Although titanium mesh cage has its own advantages but one technical problem often faced is the preparation of exact size of the implant matching into the corpectomy defect. Size adjustment made by cutting the cage while placement can cause implant mal-alignment predisposing to construct failure. In addition, repeated cage removal in an attempt to correct mal-alignment usually damages the vertebral endplate. To overcome the technical disadvantages of nonexpandable cages, variety of expandable cages have been introduced. Overall, cage placement is much easier with expandable cages and results in less end plate damage from intraoperative placement.[10] Expandable cages allow vertebral height adjustment in situ and deformity correction at same time with property of easy distraction.[4] The sizing of expandable cage is easier compared with a mesh cage. A disadvantage is their smaller caliber for packing bone versus other cage, yet studies indicate high fusion rate.[11] An internal fixation device, usually an anterior cervical plating system, is often used to further secure the construct and whether to use posterior supplemental fixation is also an important consideration.[12] Newer expandable cages come with an integrated plate that obviates the need for any additional anterior plating, and it prevents graft migration. In this study, the outcomes were compared in terms of deformity correction, implant fusion rate, subsidence rate, displacement rate, and re-operation rate.

Materials and Methods

This study was conducted on 100 patients admitted in the Department of Neurosurgery, SMS Hospital, Jaipur, India, from January 2019 to December 2021 and all patients were undergone anterior cervical corpectomy and fusion and divided in two groups. In Group A, 60 patients using expandable cage alone and in Group B, 40 patients using expandable cage with anterior cervical plate. In this study, we compared the procedure-related complications and long-term neurological benefits and radiological outcomes in both groups. Inclusion and exclusion criteria were used in this study as mentioned below: Inclusion criteria: (1) Indications—traumatic spine injury, neoplastic, degenerative spine disease, infectious disease, metabolic conditions (i.e., OPLL), (2) C3-C7 vertebral levels, (3) level of corpectomy—1 or 2 or more vertebral body levels, and (4) expandable cage used alone and used with anterior cervical plate. Exclusioncriteria: (1) Radiologic signs of severe osteoporosis, (2) neck deformity excluding kyphosis, (3) previous history of neck radiation, and (4) mesh cage or hybrid cage. Patient data including indications for procedure, ASA, modified Frankle's classification, Nurick's grading, diabetes mellitus, smoking status, preoperative osteoporosis, corpectomy levels (one/two/three vertebral body level), additional procedures such as anterior cervical plating or posterior instrumentation, type of cage used, and preoperative and postoperative radiographic imaging were collected. Fusion was determined by CT scan or flexion/extension X-rays of cervical spine at 6 months. Postoperative complications were divided in two groups (intraoperative and postoperative complications) and compared in both group A and group B. All patients were followed postoperatively for 6 months and data were collected on the 15th day and 6th month. In both groups, among all patients, neurological, clinical, and long-term radiological outcomes undergoing cervical corpectomy were compared.

Surgical Technique

All patients had anterior cervical corpectomy and decompression performed using a standard transcervical supraclavicular approach. Microsurgical technique was performed during decompression in all cases. Adjacent vertebral endplates and osteophytes were removed using a high-speed drill. Endplates were meticulously prepared after corpectomy. The appropriate implant size was determined by using a calliper to measure the height and width of the corpectomy defect. Autograft bone from the corpectomy and iliac crest was used to fill the expandable cage (►**Fig. 1A,B**

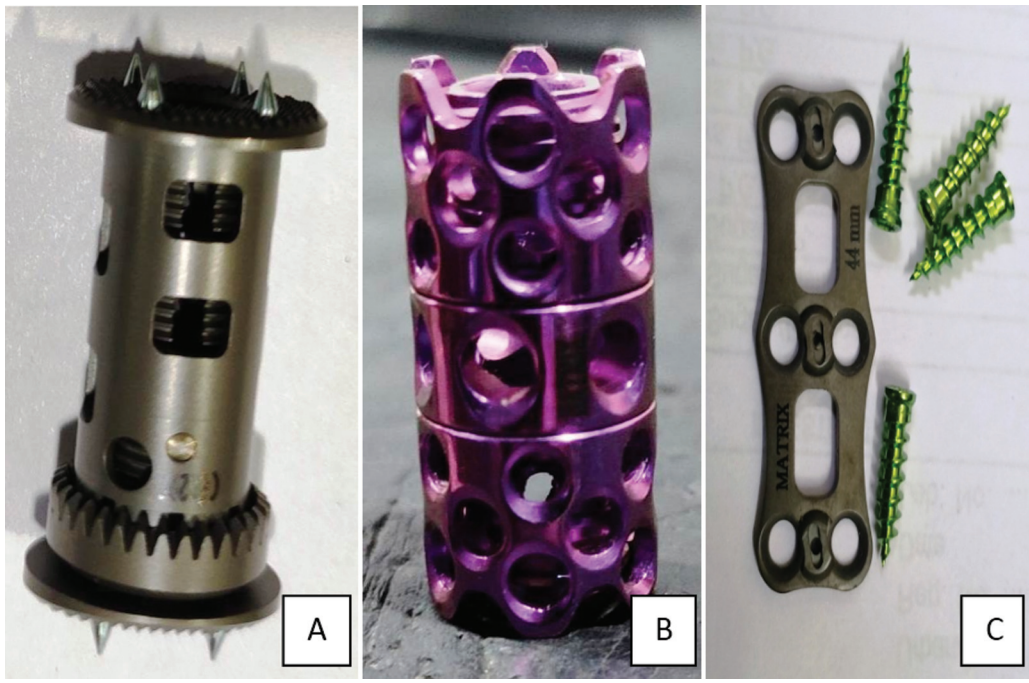

Fig. 1 (**A**) Expandable cage with multiple sharp teeth on both ends, these sharp teeth anchored in adjacent vertebral end plates. (**B**) Expandable cage with blunt end (without sharp teeth). (**C**) Cervical plate with screws.

and ►**Fig. 2C**). Expansion of the cage can be done by either an expansion instrument or an expansion wrench. First, cage was expanded up to the length of dead space and the bone filling was done and then distracted and bone filled cage was inserted into the grafting site and final distraction was performed. As expansion of the cage occurs, increasing stiffness of endplate purchase can be felt and visualized. In this respect, a tight fit of the cage into the corpectomy defect can easily be achieved and deformity correction is possible. Once expansion of the cage was completed to satisfaction, the end piece can be secured to the central core using a locking set screw thereby preventing further collapse of the expansion. In 60 patients, we used expandable cage only without anterior cervical plate support and in 40 patients, we used anterior cervical plating with variable angle screws to additional fixation (►**Fig. 1C**, **2C**). If posterior column integrity is compromised, an additional posterior stabilization was also performed.

Radiographic Evaluation

Expandable cage-related complications were monitored using radiography: cage migration, dislodgement, progressive

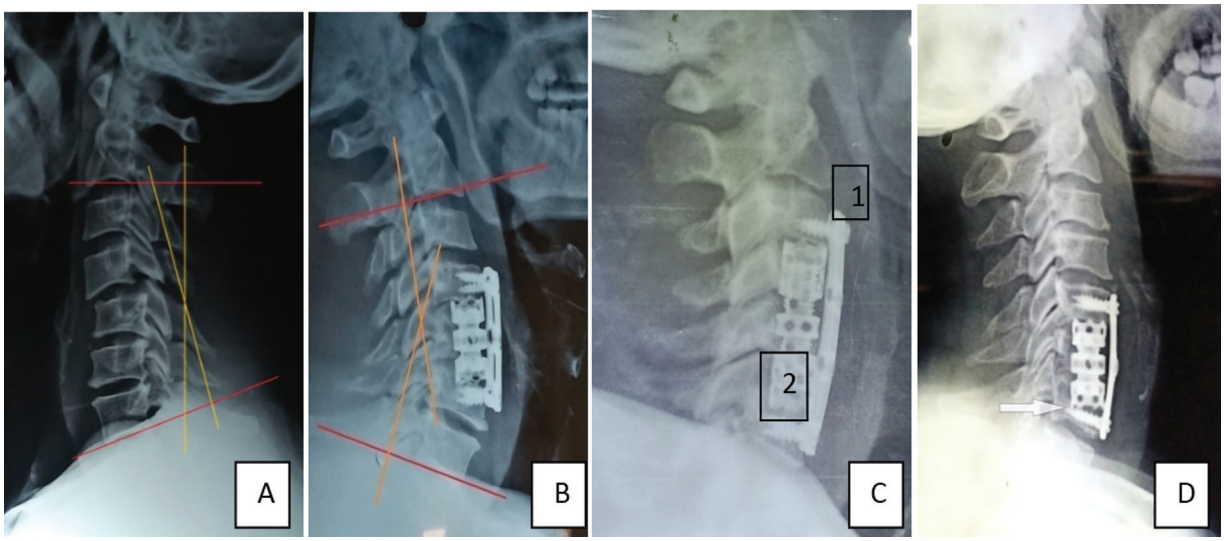

Fig. 2 (**A**) Preoperative evaluation of cervical lordosis and kyphotic deformity by measurement of the C2-C7 Cobb's angle. (**B**) Postoperative evaluation of correction of cervical lordosis and kyphotic deformity by measurement of the C2-C7 Cobb's angle. (**C**) Multiple level corpectomy with anterior cervical plate; well-placed expandable cage and plate showing fusion; 1-anterior cervical plate with variable angle screws, 2-expandable cage. (**D**) expandable cage subsidence at lower end plate (*white arrow*).

instability, and plate and screw dislodgement. Serial postoperative imaging was obtained on the 15th day and 6 months, postoperatively. Dynamic flexion–extension cervical spine radiographs were obtained after 6 months to evaluate stability, which will be defined as less than 3 mm of translatory movement and a less than 5 degree change in angulation between flexion and extension. On plain radiograph fusion was defined as less than 1 mm of interspinous process motion on a more than 150% magnified image with more than 4 mm of motion at an adjacent, unoperated level. Fusion was considered to be achieved by the absence of lucency at the cage end caps and vertebral endplates, or extra cage bridging bone formation or the absence of instability on dynamic X-rays. Reduction of kyphosis (change in C2–C7 Cobb's angle) was determined between preoperative and postoperative radiographs (►**Fig. 2A,B**). Sagittal alignment was measured before surgery, immediately after surgery and at a final follow-up. The sagittal alignment was derived by the Cobb method of measurement. The lines of measurement were taken from the superior endplate of the cephalad vertebra fused and the inferior endplate of the caudal vertebra fused. The subsidence or settling of the cage was observed from the radiographic studies in a sequential fashion. The subsidence of the bone graft was diagnosed by a loss of graft height of 2 mm or more detected on radiographs (►**Fig. 2D**). The subsidence (mm) was a combined measurement of the distance of the cage intrusion into the upper and lower end plates.

Results

In this study, 100 patients were included and all patients underwent corpectomy followed by the insertion of expandable cage only in 60 patients (Group A) and expandable cage with anterior cervical plate in 40 patients (Group B). In this study, 76 patients were male and 24 patients were female and the mean age of patients were included in study was 51.78 ± 16.74 years in group A and 41.68 ± 15.60 years in group B. Eighty four (Group A 53 and Group B 31) patients were under ASA grade 1 or 2. Fourteen patients had history of smoking and 16 patients had history of DM. Various indications for the reconstruction of anterior column in both groups by expandable cage with or without anterior cervical plate were included in as 53 patients of traumatic cervical spine disease, 34 patients of cervical degenerative spine disease, 6 patients of cervical Pott's spine, 6 patients of ossified posterior longitudinal ligament, and 1 patient of multiple myeloma. Corpectomy was done in 83 patients at single level, in 15 patients at two vertebral body levels and in two patients at three vertebral body levels for above mentioned indications. Patients were classified according to Modified Frankel's classification as grade A (38%), B (20%), C (6%), D (24%), and E (12%) (►**Table 1**). Variable parameters such as change in C2–C7 Cobb's angle and Nurick's scale scores were compared in all patients, preoperatively and postoperatively, in both groups. There were significant changes in cervical lordosis, reduction of kyphosis and sagittal balance were evaluated by calculating C2–C7 Cobb's angle by radiological or X-ray cervical spine pre- and postoperatively. In our study, preoperatively mean C2–C7 Cobb's angle was 17.96 ± 6.54 degree in Group A and 18.33 ± 7.90 degree in group B and postoperatively mean C2–C7 Cobb's angle was 21.48 ± 6.2 degree in group A and 22.68 ± 5.10 degree in group B. There was an improvement in C2–C7 Cobb's angle in group B was significantly higher than group A ($p < 0.05$). Nurick's scale was calculated by clinical neurological examination of patient preoperatively and compared with improvement in Nurick's scale grading after cervical spinal cord decompression by anterior cervical corpectomy with interbody fusion using expandable cage with or without plate for various cervical pathological conditions. As per the evaluation and observations, decrease in Nurick's scale in group B was significantly higher than group A ($p < 0.05$); (►**Table 2**). In our study, all patients were evaluated for implant fusion, cage subsidence, procedure-related complications and implant-related complications. Great vessels injury, trachea-esophageal injury and pneumothorax during surgery were not reported and five patients (group A [3.33%], group B [7.5%]) had iatrogenic dural tear during surgery and only one in group B (2.5%) patient had thyroid retraction injury along with recurrent laryngeal nerve injury with postoperative hoarseness of voice, which was managed conservatively. In this study, dysphagia was noted in 11 patients (group A [5%], group B [20%]) in immediate postoperative period which was later recovered and the incidence of dysphagia was more in postoperative period in group B as compare with group A ($p < 0.043$). There was no case reported for large local wound hematoma in immediate postoperative period for life threatening tracheal compression or shortness of breath although three cases of small hematoma were reported (3%). Total five (group A [3.33%], group B [7.5%]) patients had soft tissue swelling, which was later confirmed as CSF collection at wound site presented as soft tissue swelling, they were managed by medical management and insertion of lumbar drain for CSF diversion and later on wound was healed and lumbar drain was removed. Wound infection was reported in six patients (group A [5%], group B [7.5%]) and five patients were recovered by higher antibiotics and regular dressing and one patient had undergone for implant removal (2.5%) in group B. On radiological evaluation after 6 months by dynamic flexion-extension cervical spine X-ray or CT cervical spine, demonstrated by bridging bone between the vertebral bodies or by the absence of motion on dynamic radiographs, good fusion of expandable cage alone in 78.3% of patients and there was significantly better fusion of expandable cage with anterior cervical plate in 95% of patients ($p < 0.045$). Cage subsidence was reported in 15 cases (group A [21.67%], group B [5%]) and subsidence was more in group A as compare with group B ($p < 0.045$), there was a cage settling into adjacent vertebral end plate (Fig. 4), which was evaluated by radiological comparison of cage settled into adjacent lower or upper endplate of vertebrae. In our study, 14 patients (group A [16.67%], group B [10%]) were undergone revision surgery, in group A, 10 patients had revision because of structural failure and cage migration. One patient re-explored for fusion failure due to high mobility of cage with cord

Table 1 Comparative study of epidemiological parameters

Variable		Group A ($n=60$) Expandable cage only		Group B ($n=40$) Expandable cage with anterior cervical plate		Total ($n=100$)
		Number	Percentage	Number	Percentage	
Sex	Male	45	75	31	77.5	76
	Female	15	25	9	22.5	24
DM	Yes	8	13.33	8	20	16
	No	52	86.66	32	80	84
Smoking	Yes	10	16.33	4	10	14
	No	50	83.33	36	90	86
Diagnosis	Traumatic cervical injury	32	53.33	21	52.5	53
	Degenerative spine disease with or without OPLL	22	36.66	12	40	34
	Ossified Posterior longitudinal ligament only (OPLL)	2	3.33	4	10	6
	Multiple Myeloma	0	0	1	2.5	1
	Cervical Pott's spine	4	6.66	2	5	6
Level of corpectomy	Single	50	83.33	33	82.5	83
	Multiple ($\geq$ 2 levels)	9 (2 level)	15	6 (2 level)	15	15
		1 (3 level)	1.66	1 (3 level)	2.5	2
ASA grade	1	35	58.33	16	40	51
	2	18	30	15	37.5	33
	3	3	5	5	12.5	8
	4	4	6.66	4	10	8
Modified Frankel's classification	A	24	40	14	35	38
	B	14	23.33	6	15	20
	C	4	6.66	2	5	6
	D	13	21.66	11	27.5	24
	E	5	8.33	7	17.5	12
Mean age (y)		51.78 ± 16.74		41.68 ± 15.60		

Table 2 Comparative study of change in C2-C7 Cobb's angle and Nurick's scale score

Variables	Group A ($n=60$) Expandable cage only			Group B ($n=40$) Expandable cage with anterior cervical plate		
	Pre-operative	Post-operative	*p*-Value	Pre-operative	Post-operative	*p*-Value
Cobb's angle (degree)	17.96 ± 6.54	21.48 ± 6.2	$t=3.03$, df $=59$ **$p<0.05$**	18.33 ± 7.90	22.68 ± 5.10	$t=7.9$, df $=39$ **$p<0.001$**
Change in C2-C7 Cobb's angle (degree)	3.52			4.35		
Nurick's scale score	2.68 ± 1.16	2.26 ± 1.02	$t=2.11$, df $=59$ **$p<0.05$**	2.55 ± 1.87	1.90 ± 1.98	$t=3.9$, df $=39$ **$p<0.001$**

compression in group A. In group B, three patients were undergone revision surgery for cage migration, implant structural failure and malpositioned screws which were used for plate fixation. There was no case reported for adjacent segmental disease, tracheo-esophageal fistula, implant explantation, cage over distraction or further neck deformity in long term follow up period in group B but in group A, cage over-distraction and persistent neck deformity in two patients and adjacent segmental deformity in one patient was noted (►**Table 3**).

Table 3 Comparative study of various complications occurs in both groups

Complications		Group A ($n = 60$) Expandable cage only		Group B ($n = 40$) Expandable cage with anterior cervical plate		*p*-Value	Total ($n = 100$)
		Number	Percentage	Number	Percentage		
Intraoperative complications	Bleeding/great vessel injury	No case reported		No case reported		–	
	Tracheal injury					–	
	Esophageal perforation					–	
	Pneumothorax					–	
	Nerve injury (Vagus/RLN)			1	2.5	–	1
	Iatrogenic Dural tear	2	3.33	3	7.5	0.64	5
	Thyroid injury	No case reported		1	2.5	–	1
Early post-operative complications	Dysphagia	3	5	8	20	**0.043**	11
	RLN palsy/Hoarseness of voice	1	1.67	1	2.5	0.662	2
	Hematoma	2	3.33	1	2.5	0.72	3
	Soft tissue swelling	4	6.67	2	5	0.932	6
	CSF Leak from wound	2	3.33	3	7.5	0.64	5
	Surgical site infection	3	5	3	7.5	0.932	6
Late post-operative complications	Tracheo-esophageal fistula	No case reported		No case reported		–	–
	Implant structural failure	10	16.67	3	7.5	0.302	13
	Persistent neck deformity	2	3.33	No case reported		–	2
	Implant subsidence	13	21.67	2	5	**0.045**	15
	Cage over-distraction	2	3.33	No case reported		–	
	Fusion failure	13	21.67	2	5	**0.045**	15
	Implant or cage migration	4	6.67	2	5	0.932	6
	Revision surgery	10	16.67	4	10	0.518	14
	Adjacent segmental disease	1	1.67	No case reported		–	1

Discussion

Anterior cervical single or multilevel (≥ 2 levels) corpectomy was done for cervical pathological conditions. Recently, there has been a rapid increase in the commercial availability and the clinical use of expandable cages or non-expandable cages with additional anterior cervical plating for VB replacement in the cervical spine after corpectomy because of donor site related complications and poor structural reconstruct. Expandable cage can be used alone or also it can be used with additional anterior cervical plate system. Anterior cervical plating system can give multiple technical benefits to structural reconstruct. Therefore, the purpose of this study was to compare, the biomechanical properties of expandable cages with or without anterior cervical plating used for better neurological and radiological outcomes, correction of cervical spine lordosis, change in segmental angle, correction of kyphotic deformities, subsidence, and fusion rate.

In our study, fusion rate in both study group was 85% (expandable cage alone—78.33% and with anterior cervical plate—95%), which is almost similar to the study done by Pojskic et al, Brenke et al, Art et al, Hassan Allouch et al, Cappelletto et al, Byvaltsev et al, and Tohamy et al.[13–19] The placement of expandable cage is very smooth and avoids any major damage to the vertebral endplates. It is an instinctive thought that subsidence should be lower in the cervical spine because of less axial loading in contrast to the dorsal and lumbar spine. Biomechanical studies reported that the cervical spine is in fact more susceptible to subsidence than any other region. Subsidence depends on several factors: (i) surgical preparation of the vertebral bodies, (ii) bone density, (iii) modulus of elasticity of the material in implant (closer the modulus is to that of bone, lesser is the probability of subsidence), (iv) type of footprints and diameter of the implant (lower is the chance of subsidence when greater is the contact area), (v) application of anterior cervical plate with cage, and (vi) proportion of distraction on the adjacent vertebrae.[10] Subsidence occurs minimally with expandable cages because of its greater diameter and dull edged footplates. Hence, the preference should be to use implant with the largest diameter possible. In addition, the end-plates integrity may further prevent the chance of future subsidence of the cage.[9,20] Additional anterior cervical plating with expandable cage also beneficial to decrease rate of cage

Table 4 Comparative analysis of postoperative outcomes with previous studies

	Pojskic, 2020	Brenke, 2015	Art, 2008	Allouch, 2020	Cappelletto, 2020	Byvaltsev, 2021	Tohamy, 2022	Current study
Total numbers of patients	86	50	60 (Cervical cases: 41)	69	39	78	31	100
1) Expandable cage only	58	34	1	16	10	78	31	60
2) Expandable cage with anterior cervical plating	28	16	40	53	0	0	0	40
Mean age (y)	61.3	61	54	61.9	55	58	66.5	47.74
Favorable neurological outcomes	91.6%	66%	89%	90%	90%	93.5%	–	94%
Fusion rate	86%	88%	93%	94.1%	90%	92.3%	100%	(a) Group A – 78.33% (b) Group B – 95%
Cage subsidence	24.4%	14%	42.7%	–	low	low	5.68–14.71%	(a) Group A – 21.67% (b) Group B – 5%
Correction of lordosis or khyphosis/C2–C7 Cobb's angle change	1.8°	5°	3.3 ± 13.9°	–	1.3°	5.8°	4°	(a) Group A – 3.52° (b) Group B – 4.35°

subsidence with load diversion by plate. One of the subsidence prevention features of expandable cage is limited footprint surface area which leads to less fusion due to inadequate graft–host bone contact and in turn increases the risk of implant failure as compare with other nonexpendable cage so anterior cervical plating is useful.[21] Cage subsidence in our study was 15% (expandable cage alone—21.67% and with anterior cervical plate—5%), similar findings were also reported by Brenke et al (14%) and Tohamy et al (5.68–14.71%), while in a study done by Pojskic et al and Art et al cage subsidence was relatively higher (24.4% and 42.7%, respectively).[13–19] Previous studies have reported that expandable cages allow for improvement in cervical lordosis but no large comparative studies done evaluating the effect on cervical lordosis.[3] In our study, change in C2-C7 Cobb's angle ranges from 3.52° to 4.35° similar to the study done by Brenke et al (5°), Tohamy et al (4°), and Byvaltsev et al (5.8°), and more change as compared with studies done by Cappelletto et al (1.3°), and Pojskic et al (1.8°), and these changes are may be as it allows the expansion of the cage in-situ and optimal fitting into the corpectomy defect, leading to the correction of kyphosis/lordosis or change in C2-C7 Cobb's angle, restoration of vertebral height, and sagittal alignment in single stage. They have wide footprints that disseminates axial load evenly.[3,9] The change in segmental angle was calculated as a difference between the segmental angle prior to surgery and the segmental angle post-surgery at the last follow-up visit. This greater mean difference suggests that the expandable cage with anterior cervical plating is better than the expandable cage alone in terms of correcting the deformity, restoring the cervical lordosis and maintenance of cervical lordosis. Failure in restoring cervical lordosis can lead to uneven distribution of axial load over adjacent vertebral end plates and strain over neck paraspinal muscles. As per the comparison of correction of cervical lordosis by measuring segmental angle in cervical spine, it is likely in favour of good correction with the application of anterior cervical plating with expandable cage as compared with cage alone (►**Table 4**). As per the study done by Liu et al, postoperative wound or epidural hematoma is reported as a rare and fatal early complication after anterior cervical spine surgery. Many case reports and larger studies investigating overall complication rates have demonstrated the incidence of postoperative hematoma to be 0.1% to 9.9%. However, the incidence of hematoma after anterior cervical spine surgery remains controversial.[22] In this study, hematoma was seen in 3% of cases, which is similar to the results reported by Pojskic et al, Brenke et al, and Byvaltsev et al (►**Table 5**).

In present study, implant migration or displacement was seen in 6% of cases, which is almost similar to the results reported by Pojskic et al (10.5%), Cappelletto et al (2.6%), and Byvaltsev et al (1.3%) (►**Table 5**). Implant displacement is one of the most dreaded complications of multilevel ($\geq$ 2 levels) of cervical corpectomy. The risk of displacement is proportional to the level of the corpectomy. The displacement of graft is low with one level and up to some extent in two level corpectomy with or without plating. Graft displacement is significantly higher in three or more levels of corpectomy. Theoretically, it is assumed that the rate of graft displacement can be decreased by placing a plate over graft.[23] Plate fixation increases the stability of the graft by reducing the range of motion and also decreases the probability of pseudo-arthrosis.[24] Another study done by Brenke et al suggested that expandable cage can be used for cervical spine vertebral body replacement and that the complication rate significantly increases when implemented for a multilevel corpectomy ($\geq$ 2 levels); however, in this study there was a significant difference in cage displacement following multilevel ($\geq$ 2 levels) of corpectomy, followed by vertebral body reconstruction using expandable cage alone as compare with additional anterior cervical plate, however more number of studies were required to appropriate evaluation of rate of complication after multilevel ($\geq$ 2 levels) corpectomy. In this recent study, authors considered expandable cage not to be

Table 5 Comparative analysis of complications with previous studies

Variables	Pojskic, 2020	Brenke, 2015	Cappelletto, 2020	Byvaltsev, 2021	Tohamy, 2022	Current study
Total numbers of patients	86	50	39	78	31	100
Implant migration	9 (10.5%)	–	1 (2.6%)	1 (1.3%)	–	6 (6%)
Revision surgery	13 (15.1%)	12 (24%)	1 (2.6%)	–	–	14 (14%)
RLN injury	3 (3.5%)	–	–	–	–	1 (1%)
Hematoma	4 (4.7%)	3 (6%)	–	3 (3.8%)	–	3 (3%)
Adjacent segmental disease	9 (10.5%)	–	–	2 (2.6%)	–	1 (1%)
Esophageal injury	0	1 (2%)	–	–	–	–
Surgical site infection	–	–	–	1 (1.3%)	–	6 (6%)
Dysphagia	–	–	–	–	19 (61.4%)	11 (11%)

an ideal implant for multilevel ($\geq$ 2 levels) corpectomy if used alone so it should be additionally support with anterior cervical plating.[14] One feasible reason mentioned was the limited cage and bone interface when the expandable cage is placed over long segments.[25] Insertion of expandable cage requires a precise adjustment of implant height in situ according to the size of corpectomy with firm contact between footplates and vertebral endplates, to prevent cage migration. To achieve this firm and secure fit into the defect, some over-distraction is required. So, inadequate distraction in view of misjudgment of cage height can result in weak compressive forces over endplates and may lead to cage migration.[24] As compare with dull edges of footprints of expandable cage, sharp footprints of mesh cage usually subside into the vertebral end plate at the time of fixation providing a more firm placement than expandable cages. For the above-mentioned reason, we should prefer the additional anterior cervical plate to prevent cage migration during neck motion while using expandable cage alone. In both groups, implant-related factors (displacement or migration and subsidence) led to the majority number of revision surgery. Other less common causes were epidural hematoma, pseudoarthrosis, infection, and delayed union or fusion failure. In this study, revision surgery was required in 14% of cases, similarly revision surgery was required in 15% of cases in a study done by Pojskic et al while in a study done by Brenke et al around one-fourth (24%) of cases required revision surgery and only 2.6% of cases required revision surgery in a study done by Capelletto et al[13,14,17] (►**Table 5**). Spivak et al also emphasized that combined plating should be considered in the severely unstable cervical spine and application of anterior plate also improves the fusion rate of expandable cage, but it can cause stiffness of neck movement in extension. Sometimes plate application can lead to reverse the graft load or excessive load to cage leads to failure of multilevel ($\geq$ 2 levels) reconstruct.[26]

In this study of 100 patients, postoperative dysphagia was in 11 patients (11%). It was more common in group B (20%) as compare with group A, which was later recovered. Tohamy et al suggested that newer stand-alone cages without an anterior plate may avoid some of the complications seen with conventional methods, especially dysphagia. Dysphagia can range from mild discomfort to inability of control of the muscles used for swallowing. Persistent dysphagia can result in serious medical complications, potential significant morbidity and possible mortality. Although the exact cause of postoperative dysphagia is unknown, it has been speculated that the profile of the plate, adhesions, and scar tissue have an impact on the esophagus. The outcomes after plate application to support the construct were good in multilevel ($\geq$ 2 levels) corpectomy except postoperative dysphagia.[19] (►**Table 5**)

A recent study done by Hassan et al suggested that patients with and without plates had no outcome differences but due concerns regarding postoperative stability, loss of lordosis, and subsidence or migration of the implant cages, they are commonly used with supplemental fixation such as pedicle screw systems or anterior plates. Anterior plates are commonly used to stabilize corpectomy constructs in single or multiple ($\geq$ 2 level) implant migration or displacement. Sometimes, post-laminectomy kyphosis, osteoporosis, oncologic reconstructions, and severe deformity also may be indications for ventral cervical plating after corpectomy.[16] Grubb et al also used a C5 corpectomy model in human and porcine cervical spines to determine the stabilizing effect of different anterior plate systems.[27] Kandziora et al demonstrated that all stand-alone implants were not able to restore normal stability of the motion segment in extension. Therefore, anterior stabilization performed using stand-alone nonexpandable or expandable cages is not suitable for VB replacement in the cervical spine.[28] Punjabi et al suggested the cages plus anterior stabilization and cages plus anteroposterior instrumentation significantly increased stiffness in all test modes compared with the intact motion segment. Therefore, the cage plus anterior or combined anteroposterior stabilization provide sufficient stiffness for vertebral body replacement and should be preferred over a stand-alone implant. In comparison with the stand-alone implants,

additional anterior plating demonstrated a further increase in stiffness of up to 254%, especially in extension. This was due to the position of the anterior plate, mimicking the stabilizing effect of the anterior longitudinal ligament. Although additional anterior plating significantly increased positive biomechanical results, additional posterior stabilization increased rotational stiffness up to 102%. Therefore, additional posterior instrumentation should be considered in severe rotational instability of the cervical spine.[29]

The limitations of this study include its small sample size. Small sample size is not enough to evaluate the different outcomes and early or late complications. Further studies with long-term follow-up are required to assess the effect of such cages and anterior cervical plate. We can take the decision of additional plating or dorsal stabilization tailored to individual patient characteristics such as overall stability, bone quality and underlying pathology.

Conclusion

We conclude the limitations of expandable cage alone in terms of cage migration, fusion rate, adjacent segmental disease, failure of multilevel ($\geq$ 2 levels) construct, subsidence as compare with expandable cage used with additional anterior cervical plate. The application of anterior cervical plate in construct support with expandable cage and long-term benefits such as good structural support to multilevel ($\geq$ 2 levels) reconstruct, improved fusion rate, to restore normal stability while motion in extension of cervical spine, less chance of cage subsidence, prevention of the adjacent segmental disease and prevention of the migration of expandable cage but application of plate can leads to various postoperative complications which were mentioned earlier such as dysphagia, neck stiffness and reversal of graft load leads to failure of multilevel ($\geq$ 2 levels) construct. The limitations of this study include its small sample size and it is not enough to evaluate the percentage of the postoperative complications in such a population. Further studies with long-term follow-up are required to assess the effect of such cages with plate on the adjacent level.

Conflicts of Interest
None declared.

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