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Clinical study

Posterior cervical fusion utilizing cages placed bilaterally in the facets for the treatment of the upper cervical adjacent segment disease in the elderly

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ABSTRACT

This is a retrospective review of 24 elderly patients with upper cervical adjacent segment disease (ASD) after anterior cervical discectomy and fusion (ACDF), treated with posterior cervical fusion (PCF) and stabilized with cages placed bilaterally in the facets. Eight out of 24 patients had PCF with laminectomy (PCLF). Length of stay for PCF alone cohort was 30 ± 11 h, operative time was 44 ± 11 min and estimated blood loss was 46 ± 26 cc. In the PCLF cohort, hospital length of stay was 73 ± 32 h, operative time was 92 ± 18 min, and blood loss was 155 ± 58 cc. The pooled sample showed significant decreases in mean NDI and VAS for neck and arm pain at each follow-up visit (6 weeks, 3, 6, 12 months) compared to baseline ($p < 0.0001$). All 19 patients that returned for an additional visit, after 12 months visit, continued to report an improvement over the baseline VAS and NDI scores. For those patients treated with PCLF, Nurick scores improved by more than one point in 62% of patients. The overall fusion rate was 96%, including all 16 patients treated with PCF alone (fusion defined as less than 2 mm interspinous movement on dynamic X-ray), and in 7 out of 8 patients treated with PCLF (fusion defined as less than 3 degrees angulation). There was one asymptomatic non-union. There were no significant changes in the overall cervical lordosis ($p = 0.436$) or segmental lordosis ($p = 0.449$), and no device-related complications.

1. Introduction

Adults treated with Anterior Cervical Discectomy and Fusion (ACDF) for degenerative disc disease, most commonly at middle cervical spine levels, can develop Adjacent Segment Disease (ASD) of the upper cervical spine as they age. Symptoms of upper cervical foraminal stenosis include headache and pain in the neck and shoulders, while central stenosis results in myelopathy with numb, clumsy hands and spastic gait [13,11,9]. Surgery is indicated for progressive neurologic deficits and debilitating symptoms, but the benefits of surgery should be considered in light of the lengthier hospital stays, excess complications, and higher mortality rates associated with spine surgery in elderly patients compared to general adult patients [5]. There are anatomic considerations as well; while an anterior approach is recommended for ventral pathology and kyphosis, access to the upper cervical segments in the elderly can be challenging due to spinal foreshortening and the location of the jaw. Retraction may result in oropharyngeal dysfunction and perioperative aspiration, which can worsen dysphasia from prior ACDF [2,21]. Retained anterior hardware from prior ACDF may also compromise access to and instrumentation within the upper cervical segments. For these reasons, a posterior approach may be preferred.

PCF with cages placed bilaterally in the facets may be an option to be considered for the treatment of the elderly patients. This technique has been shown to benefit patients with cervical spondylitic radiculopathy [7,6]. In addition, this procedure can be performed with a tissue sparing access incision, which has the potential to reduce operative morbidity and length of stay in the elderly. Good results have also been reported using PCF with cages placed bilaterally in the facets during open laminectomy [10]. While previous reports describe outcomes for general patient population, nothing has been reported on the use of this technique for the elderly. We reviewed a series of 24 patients ages 70–85 with symptomatic upper cervical stenosis from adjacent segment disease treated with PCF with cages placed bilaterally in the facets for symptomatic radiculopathy, or PCLF with cages placed bilaterally in the facets for myelopathy.

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2. Methods

A retrospective study was undertaken at Saint Francis Memorial Hospital, San Francisco, CA. The study was deemed exempt from IRB review under 45CFR46.101 by an independent central IRB (ethical and independent review services, Corte Madera, California). The Central IRB determined that no informed consent was necessary due to the nature of the study being a retrospective chart review with minimal risk to patient safety. Medical records of patients 70 years of age and older, who had prior index ACDF(s), and upper segment ASD treated with target surgery PCF and PCLF with cages placed bilaterally in the facets, were reviewed. All patients treated consecutively between 2014 and 2016 that met inclusion criteria and had minimum 1-year follow-up were included in this study. Patient records were reviewed for demographic characteristics, presenting symptoms, neurologic assessment, MRI findings of myelomalacia, comorbidities, and perioperative metrics. Information on the index ACDF surgery, a total number of ACDF surgeries, fusion levels and instrumentation type were recorded.

Duration of the target surgery was defined as the time from the start to the end of general anesthesia. Hospital stay was defined as the time from the end of surgery to discharge. Blood loss was obtained from anesthesia records. Surgical complications occurring within 30 days of the surgery were noted. Clinical outcome measures were neurological status, Neck Disability Index (NDI) and visual analog scale (VAS) neck and arms pain scores. Scores were obtained preoperatively and at 6 weeks, 3 months, 6 months, one year, and at the last follow-up. Nurick myelopathy scale score was assigned by an independent neurosurgeon reviewer retrospectively based on chart notes at preop, 6 months and one year [12].

Standing pre-operative cervical X-rays were obtained in all patients. Standing and dynamic films were obtained at one year and at last follow-up beyond one year. Films were independently reviewed by a board-certified radiologist. The sagittal balance was calculated using the preoperative lateral c-spine X-ray, with the last visit used as the postoperative study of choice. Spinal alignment was measured from C2 and C7. Alignment of the fused segments was also determined. For PCF patients, non-union was defined as greater than 2 mm motion between spinous processes on flexion-extension lateral radiographs; For PCLF patients, non-union was defined as angular motion >3 degrees. Presence of bridging bone was assessed.

Within-patient changes in NDI, VAS and segmental lordosis measurements were compared using the Wilcoxon Signed Rank test. A mixed model for repeated measures with baseline included as a fixed covariate was used to estimate means and 95% confidence intervals at each time-point through 12 months follow-up. These models were adjusted for the within-patient correlation using an unstructured variance-covariance matrix. Procedure was included as a fixed covariate. Differences in NDI and VAS by treatment were tested by adding a visit-by-procedure interaction to the model. Comparisons between the PCF and PLCF cohorts were assessed using the Wilcoxon Rank-Sum Test. A p-value ≤ 0.05 was considered significant. All p-values and confidence intervals are 2-sided.

2.1. PCF technique

Tissue-sparing access PCF technique without laminectomy, previously described [8] was performed using the DTRAX™ spinal system (Providence Medical Technology Inc., Pleasanton, CA). Briefly, the patient was positioned prone with the face on a radiolucent support after general anesthesia. Biplanar fluoroscopy was positioned over the neck and adjusted to obtain satisfactory apical and lateral views. An incision was made 2–3 levels below the target level and carried through the subcutaneous tissues and ligamentum nuchae. Paraspinal muscles and fascia were dissected off the midline and displaced laterally. An access chisel was inserted through the incision into the target facet and advanced until it abutted the pedicle of the rostral vertebra. A trephine decorticator was then advanced over the chisel to dissect soft tissue off the lateral lamina and lateral mass to decorticate bone. Decortication was performed using fluoroscopic guidance and direct visualization as needed by removing the access chisel and looking through the hollow trephine decorticator at the lateral mass bone. A guide tube was then placed over the access chisel to maintain facet distraction, provide visualization and serve as a working channel. The access chisel was then removed, and rasps and burrs were inserted through the guide tube to decorticate facet articular surfaces. After joint preparation, CAVUX™ cervical cage (Providence Medical Technology Inc., Pleasanton, CA) was packed with bone graft and inserted through the guide tube into the facet. Bone graft was then inserted through the guide tube over the lateral mass decortication bed. Instruments were withdrawn, paraspinal muscles and subcutaneous tissues were sequentially closed with sutures, and a sterile dressing was applied. The procedure was then repeated on the contralateral side. A case example is presented in Fig. 1. Fig. 1A shows the sagittal MRI of 73 old female patient with anterior C4-C7 fusion with delayed posterior revision for pseudarthrosis. There is adjacent segment disease at C3-4, causing radicular symptoms ten years after the index ACDF. Fig. 1B presents an X-ray of the same patient prior to cage placement; 1-C shows the post-op X-ray image with cervical cages placed at C3-C4. After the procedure, patients were fitted with a soft collar and instructed to wear it 4 weeks.

2.2. PCLF technique

Patients with symptomatic cord compression underwent fiber optic or glide scope intubation and then were placed in a 3-pin head holder and put in a prone position with the neck neutral to slightly flexed. A laminectomy was first performed at C2–C5 as necessary. A high speed drill was used to decorticate the lateral mass. Foraminotomy was not performed. Posterior cervical cages were placed bilaterally in the facets using direct visualization with steps as outlined above, but only using a lateral fluoroscopy. Local bone graft was placed over the lateral mass and the wound was closed. A case example is presented in Fig. 2. Fig. 2-A is an image of a cervical MRI in a 75-year old male with ASD at C3-5, after ACDF at C5-6 without hardware that was completed ten years prior to the current procedure. Fig. 2-B and 2-C present post-op lateral

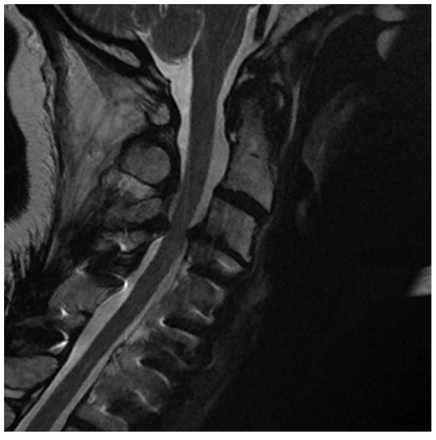

Fig. 1A. T-2 sagittal MRI of 73-year-old female patient with anterior C4–C7 fusion with 10 years ago and delayed posterior revision for pseudarthrosis 8 years ago. Adjacent segment disease at C3–4 ten years after index ACDF.

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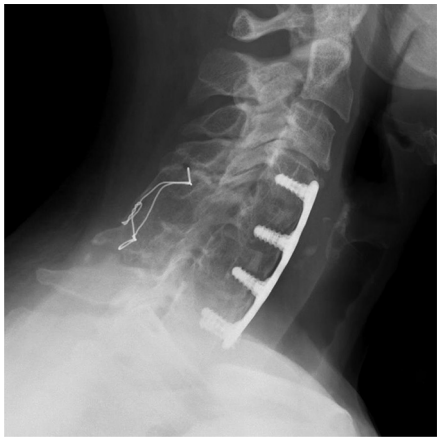

Fig. 1B. Preoperative lateral cervical X-ray before placement of cages at C3–C4.

Fig. 1C. Postoperative lateral cervical X-ray after placement of cages C3–C4. There is no change in spinal alignment.

Fig. 2A. Cervical MRI in 75-year-old male with adjacent segment disease at C3–5 after ACDF at C5–6 ten years earlier.

flexion and extension X-ray images after C3–C5 laminectomy and placement of cages in the facets. After the procedure, patients were fitted with a soft collar and instructed to wear it 4 weeks.

3. Results

Medical charts of 24 patients were available for review. Table 1 presents patient demographics and baseline characteristics. Eleven were male and 13 were female. Sixteen patients were treated with PCF and 8 with PCLF. Last index surgery resulted in fusion at C5–C7

Fig. 2B. Postoperative lateral cervical X-ray after laminectomy and fusion with cages C3–C4 and C4–5. Extension view.

Fig. 2C. Postoperative lateral X-ray, flexion view.

Table 1
Demographics and baseline characteristics.

Characteristic	PCF	PCLF	PCF and PCLF
N	16	8	24
Female – n(%)	7 (44%)	6 (75%)	13 (54.2%)
Caucasian – n(%)	14 (88%)	5 (63%)	19 (79%)
Mean Age at index surgery (years)	73.9 ± 2.9	79.4 ± 5.2	75.8 ± 4.5
Mean Time from initial surgery (months)	16.9 ± 6.4	21.3 ± 6.0	18.3 ± 6.5
Neck Disability Index	31.5 ± 7.1	28.8 ± 9.7	30.6 ± 8.0
VAS Arm Pain	6.3 ± 0.9	4.8 ± 1.8	5.8 ± 1.4
VAS Neck Pain	7.6 ± 1.4	5.0 ± 1.1	6.7 ± 1.8

in 8 patients, C4–5 in 3, C5–6 in 7, C4–6 in 3, and C4–C7 in 3 patients. Six patients had a total of 2 prior ACDF surgeries and 2 had three anterior cervical spine surgeries. Five had spontaneous fused interspaces, of which 3 were adjacent to a surgical fusion. Seventeen index surgeries were allograft bone and plate, 3 were cages and plates, 2 were cages and 2 were anterior discectomy and fusion without hardware.

Presenting clinical and radiologic findings, as well as co-morbidities are summarized in Table 2 and a breakdown of the

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target cervical levels for each procedure is listed in Table 3. Demineralized bone matrix allograft was used as graft material for PCF in 16 patients. A mixture of allograft and lamina and spinous process bone was used in the 8 patients with PCLF. Median follow-up time for all patients was 18 months (range 12–33 months). All patients completed at least 12 months follow up. One patient died of a hemorrhagic stroke 13 months after surgery. Twenty patients returned for an additional follow up after the 12 months visit. The median follow-up for this visit was 18.5 months (range 13–33 months).

Perioperative metrics for PCF were as follows: mean length of hospital stay of 30 ± 11 h, operative time of 44 ± 11 min, and estimated blood loss was 46 ± 26 cc. In patients treated with PCLF, the hospital length of stay was 73 ± 32 h, the mean operative time was 92 ± 18 min, and blood loss was 155 ± 58 cc. Length of stay, operative time, and blood loss were all significantly less ($p < 0.05$) in the PCF cohort compared to the PCLF. The mean length of stay for the entire cohort was 44 ± 29 h.

There was a clinically significant and sustained decrease in the mean values of NDI and VAS for neck and arm pain at each follow-up through 12 months as compared with the preoperative values for the entire cohort (Table 4, Graph 1). For those 19 patients that had an additional follow up visit after 12 months with NDI data, all presented with sustained improvement in NDI over baseline, with 74% of these patients reporting an improvement of at least 15 points compared to baseline NDI.

In the subset of patients with symptomatic spinal cord compression (8 patients) treated with PCLF, the mean preoperative Nurick grade was 3.3 ± 0.9, which decreased to a mean score of 2.3 ± 0.7 at 6 months and 2.1 ± 1.0 at one year and remained unchanged through the last follow up. Five patients (62%) had improvement of at least one Nurick grade, and in the remainder, Nurick grade was unchanged. Improvement in scores was not statistically significant ($p = 0.67$). Residual hand numbness was the main residual complaint in five patients.

Standing cervical and lateral flexion and extension X-rays were obtained for all 24 patients at a mean follow-up time of 20 months. Twenty three of 24 patients had arthrodesis (96%). All 16 patients treated with PCF were fused at last follow-up as determined by less than 2 mm interspinous movement on dynamic films. In addition, bridging bone was observed on the X-ray in 3 of these patients. Seven patients with PCLF were fused as determined by dynamic films with less than 3 degrees angulation. In addition, two of these had bridging bone visible on the X-ray. One patient treated with C3–C5 PCLF had 4 degrees angulation at C4–C5 on dynamic films. This patient was a smoker. The implant was well positioned in the facet without obvious halo or dislodgement. This patient was doing well clinically, and no additional testing or intervention was performed.

Table 5 presents measurements of segmental and overall cervical lordosis pre-operatively and at 1 year follow up. There was no significant difference in the pre and postoperative segmental ($p = 0.436$) or overall cervical lordosis ($p = 0.449$) at fused levels. In addition, analysis of PCF and PCLF groups detected no significant change in the segmental lordosis.

Table 2
Presenting clinical, radiologic findings and co-morbidities.

Findings/co-morbidities		No. of Patients
Headache and neck pain		2
Radicular symptoms		14
	Pain/numbness	11
	Deltoid weakness	3
Cord symptoms		8
	Numb clumsy hands	8
	Spastic gait	6
Myelomalacia on MRI		4
Comorbidities		
	Diabetes	4
	BMI > 30	2
	Smoking	2

Table 3
Target surgery.

	Levels	No. of Patients
PCF		
	C3–4	11
	C3–C5	5
PCLF		
	C2–C4	1
	C3–4	3
	C3–C5	4

4. Adverse events

One patient with laminectomy had an epidural hematoma and required reoperation for clot evacuation. This patient received low molecular weight heparin 48 h post procedure. This patient required 6 days of hospitalization and required a two-week course of inpatient rehabilitation to treat neurologic deterioration. The patient improved and Nurick score returned to baseline by 3 months post-procedure. Other adverse events were a urinary tract infection in 1 patient and 1 patient with laminectomy who was reintubated for aspiration and treated for pneumonia. There was one readmission for medical reasons. Four patients treated with PCLF required a nursing care unit. There were no device related serious adverse events during the follow-up.

5. Discussion

ACDF has gained wide acceptance as the gold standard for the treatment of cervical degenerative disc disease in the past half-century, so the number of patients who will develop adjacent segment disease in the upper cervical spine in advanced age will increase. The general aging of the population and longer life after ACDF procedures are both likely to exacerbate this trend, so safe and effective treatment for spinal stenosis in elderly patients is an unmet need [5]. The upper cervical spine has several unique challenges that often preclude an ACDF for recurrent radiculopathy or myelopathy. The jaw location and anterior retraction up to C2 and C3 and C4 may result in acute oral pharyngeal dysfunction, aspiration, and long-term swallowing problems. Posterior approaches are technically easier in the upper neck. PCLF is preferred for those patients treated with multiple ACDF's. Xu [23] reported a retrospective review of 888 patients who had an ACDF. One hundred and eight required a second surgery, and 27 required a third ACDF procedure whereas posterior approaches were associated with a lower incidence of adjacent segment disease and reoperation rate.

This study reports a series of 24 patients older than 70, who developed upper cervical stenosis from C2–C4 after prior ACDF (s). Eight had multiple prior ACDF procedures. PCF with cages, placed bilaterally in the facet, using tissue sparing access technique, for axial neck pain and radiculopathy (16 patients), and PCLF with cages for myelopathy (8 patients), were included in the study. Overall perioperative metrics for PCF and PCLF were favorable. The overall mean length of stay for the entire cohort was 46 ± 12 h, which compares favorably with other reported series. Shin et al. [15] reviewed 2667 patients treated with PCF using the American College of Surgeons National Surgical Quality Improvement Program database and, reported a mean length of stay of 3.92 days. Increased length of stay was found to be associated with dependent functional status, diabetes, preoperative anemia, American

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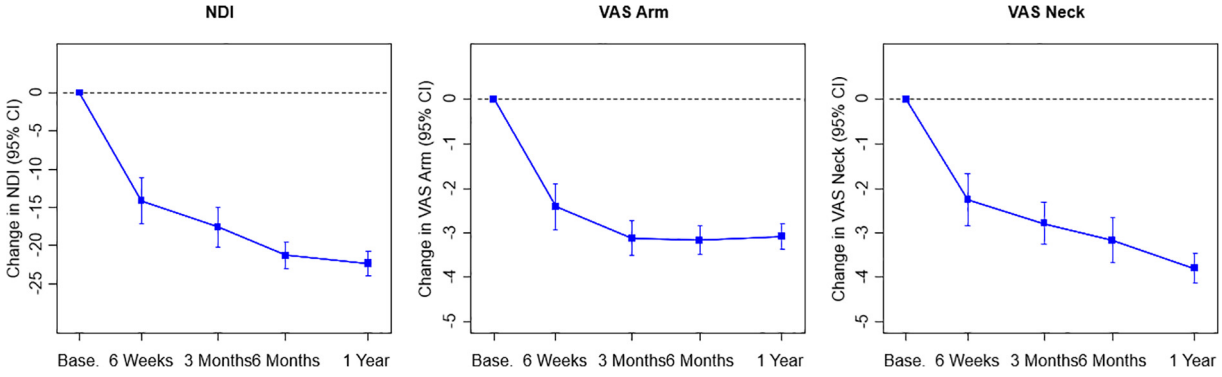
Table 4
Tabulation of changes in NDI and VAS through 1 year follow up for 24 patients.

Instrument	Time-point	Value (Mean ± SD)	Change (Mean ± SD)	95% CI for Change		Signed Rank p-value
NDI	Baseline	30.6 ± 8				
	6 Weeks	16.4 ± 7	−14.2 ± 11	−17.2	−11.2	<0.0001
	3 Months	13 ± 6.3	−17.6 ± 10.4	−20.3	−15.0	<0.0001
	6 Months	9.3 ± 4.2	−21.3 ± 9.5	−23.1	−19.5	<0.0001
	1 Year	8.2 ± 4	−22.4 ± 9.7	−24.0	−20.7	<0.0001
VAS Arm	Baseline	5.8 ± 1.4				
	6 Weeks	3.4 ± 1.2	−2.4 ± 1.6	−2.9	−1.9	<0.0001
	3 Months	2.7 ± 0.9	−3.1 ± 1.4	−3.5	−2.7	<0.0001
	6 Months	2.6 ± 0.8	−3.2 ± 1.9	−3.5	−2.8	<0.0001
	1 Year	2.7 ± 0.7	−3.1 ± 1.7	−3.4	−2.8	<0.0001
VAS Neck	Baseline	6.7 ± 1.8				
	6 Weeks	4.5 ± 1.4	−2.3 ± 2.1	−2.8	−1.7	<0.0001
	3 Months	3.9 ± 1.1	−2.8 ± 1.9	−3.3	−2.3	<0.0001
	6 Months	3.5 ± 1.3	−3.2 ± 1.7	−3.7	−2.7	<0.0001
	1 Year	2.9 ± 0.8	−3.8 ± 1.9	−4.1	−3.5	<0.0001



Graph 1. Graph of NDI and VAS through 1 year follow up for 24 patients.

Table 5
Segmental and overall cervical lordosis changes from baseline to last follow up.

Instrument	Time-point	Degrees (Mean ± SD)	Change (Mean ± SD)	Signed Rank p-value
Overall Lordosis	Baseline	11.9 ± 5.2		
	Endpoint	11.7 ± 4.8	−0.2 ± 1.3	0.4360
Segmental Lordosis	Baseline	2.0 ± 0.8		
	Endpoint	2.2 ± 0.8	0.1 ± 0.8	0.4492
Seg. Lord. PCF	Baseline	2.2 ± 0.8		
	Endpoint	2.3 ± 0.8	0.1 ± 0.6	0.5000
Seg. Lord. PCLF	Baseline	1.7 ± 0.8		
	Endpoint	2.0 ± 0.8	0.3 ± 1.3	0.9999

Society of Anesthesiologist Class 3 or 4, and a number of levels fused. Sekhon [14] reported on 50 cases of posterior cervical decompression for spondylotic cervical stenosis. The length of stay in this report was 5–10 days and operative time was 2–3 h. Reduced length of stay, reduced blood loss and shorter operative time in this series could be attributed to the minimal access approach used in the 16 patients treated with PCF. Mean length of stay for this cohort was 30 ± 11 h, or 1.3 days. Length of stay, operative time and blood loss were significantly decreased compared to the PCLF cohort in which a standard open approach was used. The novel tissue sparing technique [24] results in less soft tissue dissection. Smith [18] reported a reduction in perioperative morbidity in a study of PCF revision of pseudoarthrosis after ACDF. Length of stay in that study was 1.4 days versus 4–5 days with traditional open surgery. In the 8 patients treated with PCLF a standard open approach was used and the length of stay was longer at 3 days. These patients were myelopathic and precarious neurologic status also likely contributed to a longer hospitalization.

The target surgery was effective and generally well-tolerated. The mean NDI and VAS scores were significantly improved at all follow-up time points. These results are similar to NDI and VAS scores reported by McCormack et al. [7] in a prospective study of 60 patients with cervical spondylosis and stenosis treated with posterior expandable cervical fusion cages. Comparable improvement in VAS and NDI scores were reported by Smith et al. [18] in a retrospective review of 25 patients with pseudoarthrosis after ACDF treated with posterior cervical cages placed bilaterally in the facets, and in select cases, anterior revision. Dynamic X-ray showed fusion in 23 patients (96%) at a mean follow-up of 18 months. Nurick scores improved by more than one point in 5 out of 8 patients with myelopathy. Benefit in myelopathy scores was modest and did not reach statistical significance. Incomplete recovery on Nurick myelopathy score for cohort was attributed to advanced age, myelomalacia on preoperative MRI in 4 patients (50%), and post-operative wound hematoma requiring reoperation in one patient.

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One concern of posterior cervical cages is the potential to cause kyphosis. Several studies suggest that kyphosis does not occur with placement of the implants in the facet [4,20,7,3,17]. Overall and segmental spinal alignment were unchanged in this series. PCF is adjunctive to laminectomy for patients with symptomatic cord compression to prevent iatrogenic kyphosis. There was no change in overall or segmental alignment in the eight patients treated with laminectomy, but these results cannot be extrapolated to all patients. Patients in this series had end-stage spondylosis, with stiff hypolordotic spines and only the C3–4 and C4–5 levels were instrumented. Posterior cervical cages placed bilaterally in the facets would not be anticipated to restore lordosis and would not be appropriate in a patient with symptomatic cervical kyphosis. Additional follow-up will be needed to assess long-term lordosis with posterior cervical cages.

Traditional posterior surgery for radiculopathy entails a foraminotomy which requires direct manipulation over the nerve root. This may result in iatrogenic transient or permanent palsies. The C5 root is particularly vulnerable with foraminotomy [1]. Cervical facet distraction with implants has been shown to substantially increase the size of the neural foramen to effect nerve root decompression [16]. It has been postulated [19] that an indirect decompression with facet distraction may reduce the incidence of this complication. There were no cases of C5 root palsy in this small study and the authors are not aware of any reports of C5 root palsy after PCF when cages are properly positioned in the facet. No conclusions regarding C5 root palsy can be drawn from this study; a larger study would be needed to assess the risk of C5 root palsy with various surgical techniques. As demonstrated in the biomechanics study [22], the posterior cervical cages provide similar decreases in range of motion when compared to lateral mass fixation, and have the benefit of avoiding bone removal for root decompression, which may compromise screw purchase. The authors believe that for those patients with radiculopathy and substantial motor deficits or grade 2/5, a direct decompression with foraminotomy is preferred. However, the vast majority of patients with symptomatic stenosis do not present with substantial radicular deficits.

Limitations for this study include its small size and retrospective nature. Median follow up of 20 months is likely to underestimate the true incidence of non-unions, which may increase with duration of follow-up. CT scans, which are more definitive in assessing bone healing, were not performed. One surgeon (BM) has a financial interest in the implant used which is a potential source of bias. However, VAS and NDI scores were completed by patients independent of the surgeon. Radiographic parameters were also independently reviewed.

The incidence of the upper cervical spine adjacent segment disease in the elderly is increasing due to the popularity of ACDF in middle-aged adults and general aging of the population. PCF and PCLF may be preferred in many instances. Cages placed bilaterally in the facets promote bony fusion, maintain spinal alignment and were associated with good clinical outcomes in this small series of elderly patients.

6. Disclosure statement

Bruce McCormack, M.D. has a financial interest in the company that manufactures the instrumentation. The other surgeons (LC and FE) declare no financial interest or other conflicts of interest related to this work.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jocn.2019.01.018.

References

[1] Bydon M, Xu R, De la Garza-Ramos R, et al. Adjacent segment disease after anterior cervical discectomy and fusion: incidence and clinical outcomes of patients requiring anterior versus posterior repeat cervical fusion. Surg Neurol Int 2014;5(Suppl 3):S74–8.
[2] Frempong-Boadu A, Houten JK, Osborn B, et al. Swallowing and speech dysfunction in patients undergoing anterior cervical discectomy and fusion: a prospective, objective preoperative and postoperative assessment. J Spinal Disord Tech 2002;15(5):362–8.
[3] Goel A, Shah A. Facetal distraction as treatment for single- and multilevel cervical spondylotic radiculopathy and myelopathy: a preliminary report. J Neurosurg Spine 2011;14(6):689–96.
[4] Kasliwal MK, Corley JA, Traynelis VC. Posterior cervical fusion using cervical interfacet spacers in patients with symptomatic cervical pseudarthrosis. Neurosurgery 2016;78(5):661–8.
[5] Lagman C, Ugiliweneza B, Boakye M, Drazin D. Spine surgery outcomes in elderly patients versus general adult patients in the united states: a marketscan analysis. World Neurosurg 2017;103:780–8.
[6] Lenzi J, Nardone A, Passacantilli E, Caporlingua A, Lapadula G, Caporlingua F. Posterior cervical transfacet fusion with facetal spacer for the treatment of single-level cervical radiculopathy: a randomized, controlled prospective study. World Neurosurg 2017;100:7–14.
[7] McCormack BM, Bundoc RC, Ver MR, Ignacio JMF, Berven SH, Eyster EF. Percutaneous posterior cervical fusion with the DTRAX Facet System for single-level radiculopathy: results in 60 patients. J Neurosurg Spine 2013;18(3):245–54.
[8] McCormack BM, Eyster E, Chiu J, Siemionow K. Minimally disruptive posterior cervical fusion with DTRAX cervical cage for single level radiculopathy – results in 10 patients at 1-year. Spine Res 2016.
[9] McCormack BM, Weinstein PR. Cervical spondylosis. An update. Western J Med 1996;165(1–2):43–51.
[10] Bou Monsef JN, Siemionow KB. Multilevel cervical laminectomy and fusion with posterior cervical cages. J Craniovertebral Junction Spine 2017;8(4):316–21.
[11] Nakajima M, Hirayama K. Midcervical central cord syndrome: numb and clumsy hands due to midline cervical disc protrusion at the C3–4 intervertebral level. J Neurol Neurosurg Psychiatry 1995;58(5):607–13.
[12] Nurick S. The pathogenesis of the spinal cord disorder associated with cervical spondylosis. Brain: A J Neurol 1972;95(1):87–100.
[13] Romano JG, Bradley WG, Green B. High cervical myelopathy presenting with the numb clumsy hand syndrome. J Neurol Sci 1996;140(1–2):137–40.
[14] Sekhon LHS. Posterior cervical decompression and fusion for circumferential spondylotic cervical stenosis: review of 50 consecutive cases. J Clin Neurosci 2006;13(1):23–30.
[15] Shin JI, Kim JS, Steinberger J, DiCapua J, Cho SK. Patient factors contributing to prolonged postoperative length of stay and increased rate of readmission after elective posterior cervical fusion. Clin Spine Surg 2018;31(1):E55–61.
[16] Siemionow K, Janusz P, Glowka P. Cervical cages placed bilaterally in the facet joints from a posterior approach significantly increase foraminal area. Eur Spine J 2016;25(7):2279–85.
[17] Siemionow K, Janusz P, Phillips FM, et al. Clinical and radiographic results of indirect decompression and posterior cervical fusion for single-level cervical radiculopathy using an expandable implant with 2-year follow-up. J Neurol Surg 2016;77(6):482–8.
[18] Smith W, Gillespy M, Huffman J, Vong V, McCormack BM. Anterior cervical pseudarthrosis treated with bilateral posterior cervical cages. Operative Neurosurg (Hagerstown, Md.) 2017;14(3):236–42.
[19] Tan LA, Gerard CS, Anderson PA, Traynelis VC. Effect of machined interfacet allograft spacers on cervical foraminal height and area. J Neurosurg Spine 2014;20(2):178–82.
[20] Tan LA, Straus DC, Traynelis VC. Cervical interfacet spacers and maintenance of cervical lordosis. J Neurosurg Spine 2015;22(5):466–9.
[21] Veeravagu A, Cole T, Jiang B, Ratliff JK. Revision rates and complication incidence in single- and multilevel anterior cervical discectomy and fusion procedures: an administrative database study. Spine J 2014;14(7):1125–31.
[22] Voronov LI, Siemionow KB, Havey RM, Carandang G, Patwardhan AG. Biomechanical evaluation of DTRAX(®) posterior cervical cage stabilization with and without lateral mass fixation. Med Devices (Auckland, N.Z.) 2016;9:285–90.
[23] Xu R, Bydon M, Macki M, et al. Adjacent segment disease after anterior cervical discectomy and fusion: clinical outcomes after first repeat surgery versus second repeat surgery. Spine 2014;39(2):120–6.
[24] McCormack B, Dhawan R. Novel instrumentation and technique for tissue sparing posterior cervical fusion. J. Clin. Neurosci. 2016;34:299–302.

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