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The Value of Anterior Cervical Plating in Preventing Vertebral Fracture and Graft Extrusion After Multilevel Anterior Cervical Corpectomy with Posterior Wiring and Fusion: Indications, Results, and Complications

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Summary: Anterior cervical plates were added to anterior corpectomy and fusion (ACF) with posterior wiring and fusion (PWF) to prevent vertebral fracture and graft extrusion in patients with ossification of the posterior longitudinal ligament and spondylostenosis. From January 1989 to March 1997, 22 patients had an average 2.5-level ACF without plates and an average 5-level PWF with halo placement (average follow-up, 4 years). From April 1997 to October 1998, 22 patients had an average 2.8-level ACF with Orion plating and an average 5.4-level PWF with halo devices (patients were followed for an average of 11 months). Vertebral fracture and graft extrusion requiring revision developed in three (14%) patients without plates within 24 hours of surgery, whereas neither of these occurred in patients with plates (by Fisher's test: nonsignificant p value = 0.2326). Ultimately, all 44 patients had fusion. Thus far, vertebral fractures and graft extrusions have not been observed for 22 patients undergoing plated circumferential cervical surgery. **Key Words:** Anterior plates—Circumferential cervical surgery.

Of 22 patients who had simultaneous circumferential anterior and posterior cervical surgery for ossification of the posterior longitudinal ligament (OPLL) and spondylostenosis between January 1989 and March 1997, vertebral fractures and graft extrusions developed in 3 (14%) of them. To determine if this complication could be prevented, anterior cervical plates were added prospectively to similarly circumferential procedures performed from April 1997 to October 1998.

MATERIALS AND METHODS

Twenty-Two Patients without Plates from January 1989 to March 1997

Twenty-two patients without plates had circumferential surgery for OPLL and spondylostenosis (Table 1) (6). The 13 men and 9 women in this series were an average 57 years old (range, 30 to 70 years). Patients had average 2.5-level anterior cervical corpectomies with fusion (ACF) using iliac crest (21 patients) or fibula (1 patient) autografts, accompanied by average 5-level posterior wiring and fusion (PWF) with halo placement (Table 2). Five patients also had cervical laminectomies (average 3.2 level) with facet wiring and fusion to treat extensive laminar shingling, arthrosis, and spondylostenosis. Their average preoperative Nurick grade was 3.5, with all but one demonstrating grade III to V (moderate to severe myelopathy): 1 grade V, 10 grade IV, 10 grade III, and 1 grade II. Patients were followed for an average of 4 years after operation (range, 2 to 9 years).

Twenty-Two Patients with Plates Since April 1997

Orion anterior cervical plates were added prospectively to 22 circumferential procedures performed to treat OPLL and spondylostenosis (Table 1). The 16 men and 6 women

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TABLE 1. *Circumferential surgery in 22 nonplated and 22 plated patients*

Data	22 Nonplated patients	22 Plated patients
Average Age (yr)	57	56
Range	30–70	42–73
Sex		
Male	13	16
Female	9	6
Average anterior corpectomy levels	2.5	2.8
Range	1–3	2–4
Average levels of posterior wiring/fusion	5.0	5.7
Range	3–7	4–10
Number of laminectomies	5	1
Average # levels	3.2	4
Halo braces	22 (1 removed)	22 (2 removed)
Average preoperative Nurick grade*	3.5	3.5
Average postoperative Nurick grade*	0.5	0.5
Average follow-up	4 years	11 months
Range	2–9 years	3–18 months
Average operative time (hr)	10.0	8.5
Range	8–14	6–13
Average units transfused blood	3.5	2.7
Range	1–8	0–10
Average time to extubation (days)	2.3	1.1
Range	1–12	1–6
Vertebral fractures/graft extrusions	3 (14%)	0
Number of deaths†	1	1
Average time to fusion (months)	4	3.4
Range	2–7	3–5

*Nurick Grade = No myelopathy (0), mild myelopathy (I), mild/moderate myelopathy (II), moderate myelopathy (III), moderate/severe myelopathy (IV), and severe myelopathy (V).

†Deaths were due to myocardial infarction.

were an average of 56 years old (range, 42 to 73 years). Surgery included average 2.8-level ACF using iliac crest autografts (20 patients) and fibula grafts (1 allograft and 1 autograft). Posterior wiring and fusion was performed over an average of 5.7 levels, and halo braces were routinely applied. One patient had a 4-level laminectomy followed by facet wiring and fusion (Table 2). Before operation, the average Nurick grade was 3.5, except in two patients who had grade III to V disease (moderate to severe myelopathy): 4 grade V, 4 grade IV, 12 grade III, and 2 grade II. Patients were followed for an average of 11 months (range, 3 to 18 months).

Magnetic Resonance and Computed Tomographic Studies

All patients had magnetic resonance and computed tomographic (CT) examinations (12,20) (Figs. 1 to 8). Although magnetic resonance scans best showed the longitudinal extent of cord compression and intrinsic cord disease, two-dimensional CT, three- dimensional CT, and myelo-CT studies provided three-dimensional images of the location and extent of OPLL.

Fusion

Two-dimensional or three-dimensional CT studies were performed 2 months after operation and repeated every 1 or 2 months for as long as 6 months or until bony bridging with trabeculation and a lack of lucency at the graft–vertebral body interface could be identified. If these initial two signs of fusion were present, flexion and extension lateral radiographs were performed to confirm the lack of significant motion (stability): less than 3.5 mm of translation, less than 20 degrees of rotation, and less than 2 mm of displacement between the tips of the spinous processes at the fusion site (13,19). If fusion was shown, halo devices were removed. Kyphosis was also documented when more than 11 but less than 20° of angulation or rotation were observed (19).

TABLE 2. *Extent of anterior corpectomy with fusion and posterior wiring and fusion for 22 nonplated and 22 plated patients*

Number/levels ACF, LAM, PWF	Nonplated patients	Plated patients
4 ACF (1 patient)		
C2–C7 ACF	0	1
PWF C2–T1		
3 ACF (14 patients)		
C3–C7 ACF	8	12
PWF C3–T1		
C3–C7 ACF	2	1
LAM C3–C6		
PWF C2–T1		
C3–C7 ACF	0	1
C0–C2 takedown		
PWF C0–T2		
C2–C6	3	0
PWF C2–C6		
C4–T1	1	0
LAM C4–T1		
PWF C4–T1		
2 ACF (7 patients)		
C3–C6 ACF	0	1
PWF C3–C6		
C4–C7 ACF	5	6
PWF C4–C7		
C2–C5	1	0
PWF C2–C5		
C5–T1	1	0
LAM C5–T1		
PWF C5–T1		
1 ACF		
C3–C5	1	0
LAM C3–C5		
PWF C3–C5		

ACF = anterior corpectomy and fusion, LAM = Laminectomy, PWF = posterior wiring/fusion.

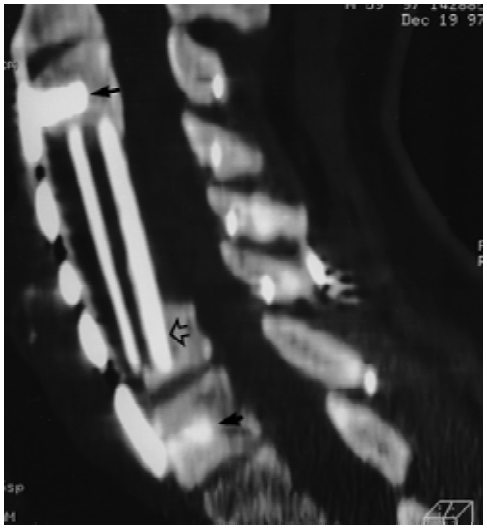

FIG. 1. Lateral two-dimensional midline sagittal CT scans obtained 1.5 years after C3–C6 ACF/PWF C3-C7 resulting in vertebral fracture of C6 and subsequent C3–C7 Orion plating (case 1). A 59-year-old man had a nonplated C3–C6 ACF (fibula) with C3–C7 PWF. When the anterior cortex of C6 fractured within 24 hours of surgery, the fragment was removed while the graft was left in place because it was lodged in the C6 body. An Orion plate was added from C3–C7. Eighteen months later, the two-dimensional midline sagittal CT showed adequate localization of the plate (double arrows) and fibula graft (open arrow), whereas other views continued to confirm fusion, which was originally demonstrated 4 months after operation.

FIG. 3. A three-dimensional coronal CT shows solid fusion 1.5 years after C3–C7 PWF (case 1). On this three-dimensional coronal CT scan obtained 1.5 years after a C3–C7 spinous process, braided cable wiring and autograft fusion, solid fusion masses (arrows) may be visualized bilaterally fully covering the facet joints and the laminae.

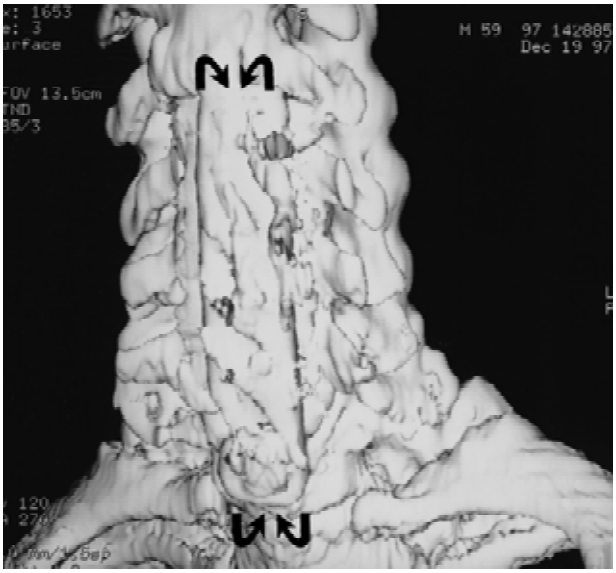

FIG. 2. An anterior coronal three-dimensional CT study obtained 1.5 years after operation confirmed incorporation of the anterior Orion plate (case 1). The anterior Orion plate (double arrows), seen on this coronal three-dimensional CT scan obtained 1.5 years after operation, became fully incorporated into the anterior fusion mass.

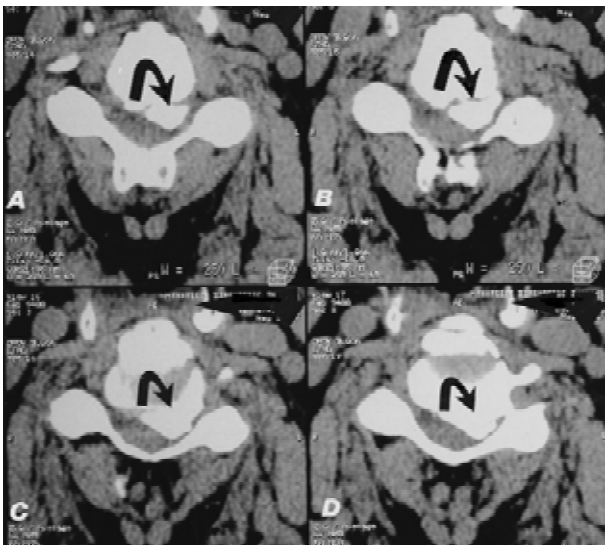

FIG. 4. A preoperative transaxial noncontrast CT study shows massive continuous OPLL at the C4–C5 level in a patient with C3–C7 disease (case 2). **A:** At the C4–C5 disk space, a solid mass of OPLL (arrow) fills the ventral and left side of the spinal canal, causing marked cord and C5 root compression. **B:** The mass of OPLL (arrow) nearly touches the lamina at the C4–C5 disk space. **C:** In the C4–C5 inferior disk space, the OPLL mass (arrow) more clearly extends across the midline. **D:** In the C4–C5 inferior disk space, the OPLL mass (arrow) nearly obliterates the left side of the spinal canal and foramen, resulting in significant right-sided cord and nerve root compression.

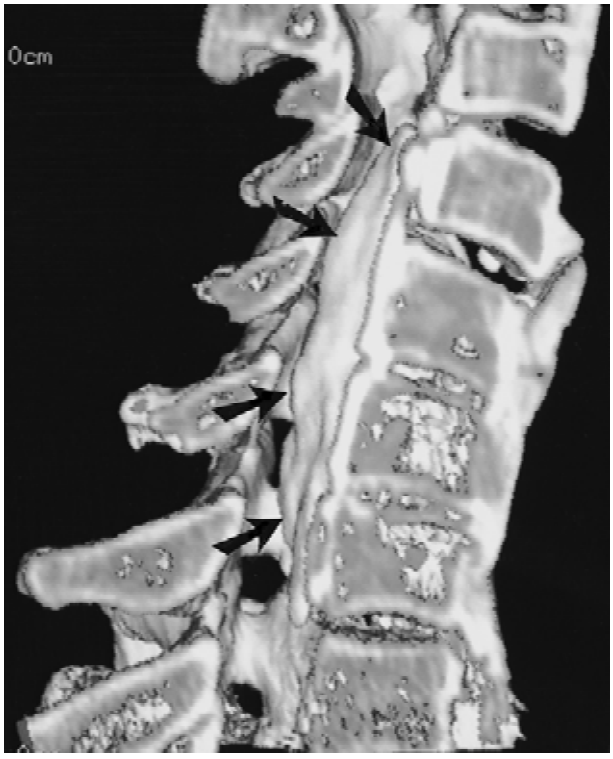

FIG. 5. A preoperative three-dimensional, left-sided, parasagittal CT scan shows massive continuous C3–C7 OPLL with ossification of the posterior and anterior longitudinal ligaments (case 2). The left sided three-dimensional parasagittal CT study readily shows the massive extent of continuous OPLL from the C3–C7 levels (arrows). Also observe the presence of continuous ossification of the anterior longitudinal ligament.

Surgery

Multilevel ACF, with or without plating, and posterior fusion using braided cable wiring (spinous process or facet) or posterior plating, have been described (2–11,13–18,21). In this study, the first 22 circumferential procedures were completed without anterior plates, whereas the next 22 patients were plated prospectively (using the Orion system) in an attempt to avoid vertebral fractures and graft extrusions. The posterior fusions, completed using spinous process or facet braided-cable wiring and fusion techniques, with autogenous iliac crest grafts supplemented with demineralized bone matrix. The purpose of the posterior fusion was to enhance stability immediately, limit pseudarthrosis, and potentially shorten the time to fusion (1,6).

Bracing

All 44 patients were originally placed in halo devices. However, within 3 days of surgery, head shape caused the halo head ring to slip in one patient from each group; both

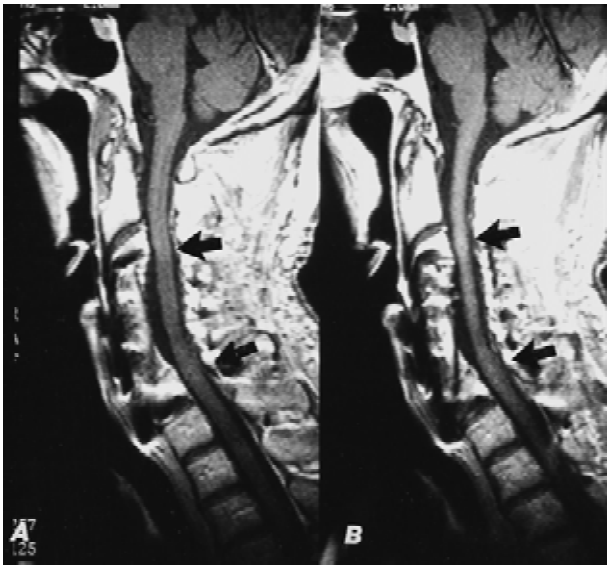

FIG. 6. The 3-month postoperative midline and paramedian sagittal T1-weighted MR study confirms adequate decompression after C3–C7 ACF with Orion plate placement and C3–T1 PWF (case 2). **A:** A midline MR shows adequate cord decompression (arrows) 3 months after operation. **B:** The paramedian sagittal T1-weighted MR also readily confirms the extent of cord decompression (arrows).

FIG. 7. A midline, sagittal, two-dimensional CT performed 3 months after operation shows adequate C3–C7 iliac crest graft fusion and Orion plate placement, with C3–T1 braided cable wires remaining within the base of the spinous processes posteriorly (case 2). This midline, sagittal, two-dimensional CT scan shows anterior fusion of the C3–C7 iliac crest autograft and adequate localization of the Orion plate (open white arrows) and screws (black arrows). Note the braided cables within the base of the spinous processes from C3–T1 posteriorly.

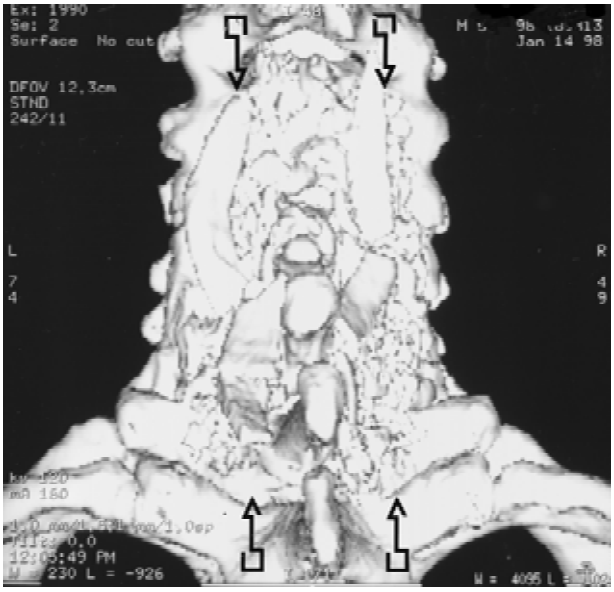

FIG. 8. A three-dimensional CT shows posterior C3–T1 fusion (case 2) 3 months after the original surgery. The autogenous iliac crest bone applied during the posterior wiring and fusion clearly shows progressive incorporation and fusion (arrows).

were placed in cervicothoracic orthoses. A third patient with plates, who was mentally challenged with severe cerebral palsy, lunged his way out of the halo device 48 hours after operation and received a cervicothoracic orthosis.

Anesthesia and Somatosensory Evoked Potential Monitoring Protocols

All circumferential cervical operations were performed using awake nasotracheal fiberoptic intubation, awake positioning, and continuous intraoperative somatosensory evoked potential monitoring (2). Patients were routinely kept intubated the night after surgery and were assessed fiberoptically for extubation the first day after operation by an attending anesthesiologist (6).

RESULTS

Twenty-Two Patients without Plates

Operative Parameters

On average, these circumferential procedures required 10 hours, 3.5 units of transfused blood, 375 ml cell-saver blood, and 4,000 ml crystalloid (Table 1). Patients were typically extubated 2.3 days (range, 1 to 12) after operation, with the delay largely caused by vertebral fractures and graft extrusions in three patients who required repeated operations to replace grafts.

Neurologic Status

After operation, all patients without plates improved an average of −3 Nurick grades, exhibiting a mean postoperative grade of 0.5, midway between grade 0 (radiculopathy) and grade I (mild myelopathy): 13 grade 0, 6 grade I, and 3 grade II (6). No patient showed neurologic deterioration.

Fusion

Fusion was confirmed on dynamic radiographs and CT studies an average of 4 months after operation (range, 2 to 7 months) and have been followed an average of 4 years after operation (range, 2 to 9 years).

Complications

One death and five major and five minor complications were observed. A fatal myocardial infarct occurred in a 56-year-old patient with severe cardiovascular disease 48 hours after operation. Three major complications were attributed to vertebral fracture with graft extrusion that occurred within 24 hours of surgery and warranted immediate repeat operation (7). The fourth and fifth major complications, recurrent OPLL requiring secondary circumferential surgery 5 years after an initial two-level ACF, and a cerebrospinal fluid fistula, both occurred in the same patient. Five minor complications included three transient root deficits (two at C5, one at C7) that resolved during 3 postoperative months, one episode of deep venous thrombosis less than 3 days after surgery, and one case of dysphagia that lasted for 1 month after operation.

Twenty-Two Patients with Plates

Operative Parameters

Circumferential surgery required an average of 8.5 hours. The shortened operation was attributed to the greater experience of the surgical team (Table 1). Average transfusion requirements were reduced to 2.7 (range, 0 to 10) units of blood and 153 ml cell-saver blood, whereas the average crystalloid requirement was 3,400 ml. Patients were extubated an average of 1.1 days after operation (range, 1 to 6 days): 19 on the first day, 2 on the second day, and 1 on the sixth day because he required a second, more extensive anterior procedure to remove residual OPLL.

Neurologic Status

These 22 patients with plates also improved an average of −3 Nurick grades after surgery. Their average postop-

erative grade was 0.5: 15 were grade 0, 4 grade I, and 3 grade II. All patients showed some degree of improvement, and none deteriorated.

Fusion

Fusion occurred an average of 3.4 months (range, 3 to 5) after operation (confirmed on flexion–extension radiographs and two-dimensional and three-dimensional CT studies), and patients were followed an average of 11 (range, 3 to 18) months.

Complications

One death and three major and four minor complications were observed. One 73-year-old man with severe cardiovascular disease died of a myocardial infarct 3 weeks after operation. One major complication was a cerebrospinal fluid fistula successfully managed with pericardial-dural grafting, cryoglue, and a lumboperitoneal shunt. The second major complication was residual OPLL documented on an immediate postoperative CT scan that required repeated intervention 5 days after the first procedure. This occurred in a 6′ 4″, 280-pound man whose original 13-hour surgery included a plated C3–C7 ACF, C0-C2 takedown of a 12-year-old fusion for an odontoid fracture, and C0-T2 U loop fusion (only in series). Five days later, the original 20-mm trough was extended to 26 mm, and the patient maintained his original improvement from Nurick grade V to grade II. The third major complication was inferior plate extrusion that occurred 4 months after a four-level procedure accompanied by halo placement in a patient with cerebral palsy but normal intellectual function. Posterior fusion occurred at 3 months and anterior fusion at 5 months, and the plate was removed 6 months after operation. Four minor complications included one transient C5 paresis (2 months), two episodes of deep venous thrombosis, and one superior vena cava thrombosis that warranted filter placement.

DISCUSSION

As increasingly extensive anterior decompressions are being performed to address the full extent of OPLL, more vertebral fractures and graft extrusions are observed (7, 15,16). Saunders et al. (15) performed 31 four-level ACFs without plates for spondylotic myelopathy. Of these, 25 patients were placed in external orthoses for 6 months (Philadelphia-type collar), whereas 6 wore halo vests. Two patients developed graft extrusions less than 48 hours after surgery that warranted emergent repeat operations, and a third patient was treated successfully with 6 weeks of traction followed by 24 weeks in a halo device (15). Vaccaro et al. (18) studied the vertebral fracture and graft rate after two- or three-level plated ACF performed for degenerative, traumatic, or neoplastic disease. They found that 3 of 33 (9%) patients who had two-level plated ACF developed vertebral fracture and graft extrusion, whereas 6 of 12 (50%) patients undergoing three-level plated ACF developed the same complication. The vertebral fracture and graft extrusion rate did not appear to occur with greater frequency in patients immobilized in hard cervical collars compared with halo braces. The high failure rate appeared to correlate with failure to correctly lock screws to the plate and the use of peg-in-hole bone grafting techniques. One recommendation to emerge from this study was to consider posterior fixation in the future.

In fact, circumferential surgery consisting of ACF with plates and posterior fixation (largely plates) was previously shown to be effective in the management of trauma, tumor, and degenerative disease (9–11). These procedures were successful in the treatment of 17 of 100 patients with trauma and degenerative disease (9). In another series, 24 of McAfee and Bohlman's patients who had trauma or tumors were adequately treated with average 6.9-hour circumferential procedures (10). McNamara et al.'s (11) six patients with three-column traumatic injuries also did well after 7.7-hour circumferential approaches.

In our own study, vertebral fractures and graft extrusions have not been observed after the addition of anterior plates to circumferential cervical procedures. However, the value of adding plates to these procedures as yet represents a trend rather than a significant difference. Using Fisher's exact test to analyze results in the patients with or without plates (three immediate failures in the nonplated group and no failures for the plated group), a nonsignificant probability value of 0.2326 is obtained. If the one plate revision is included as a failure of the plated group, the probability value is 0.6069 but is still not significant. Furthermore, the 100% fusion rate has been maintained and the time to fusion reduced. Although this interval appears to have diminished from approximately 4 to 3 months, differences in unequal sampling, inherent problems in the nonrandomized design of this trial, factors such as improved surgeon technique over time, and other statistical problems are recognized as potentially important sources of covariance that have not been accounted for in this study (6,8–11,17).

Only one complication has resulted: the need for elective plate removal as a result of inferior loosening. Neither complications nor deaths have increased, and operative time and transfusion requirements have decreased (Table 1). Outcomes remain nearly identical for both groups. No cord injuries and fewer root injuries have been observed in our plated series, data that compare favorably with the 2%

to 10% frequency of cord injury and 2% to 17% rate of root injury reported in other studies (14,21).

Complications, exclusive of vertebral fracture and graft extrusion, seen in other multilevel ACF procedures were similar in frequency to our own (15). We observed two cerebrospinal fluid (CSF) fistulas and four transient root deficits in 44 circumferential approaches, whereas Saunders et al. (15) noted one CSF fistula and four root injuries among 31 patients having ACFs. Two repeated operations were performed for recurrent OPLL in our 44 patients, 5 years and 5 days after operation, whereas 1 of Saunders and colleagues' 31 patients required additional surgery for recurrent spondylosis 6 months later.

Mortality rates were also similar for the multilevel ACF series. The major comorbid factors that contributed to death were age more than 70 years, severe myelopathy, and significant cardiovascular disease (15). Three (9.7%) of Saunders and colleagues' (15) patients died of cardiovascular events within 3 weeks of surgery, findings that are similar to our own two (4.5%) deaths.

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