Spinal Cord (2003) 41, 379–384

www.nature.com/sc

Original Article

Fixed *vs* dynamic plate complications following multilevel anterior cervical corpectomy and fusion with posterior stabilization

NE Epstein*[1,2,3,4]

[1]*The Albert Einstein College of Medicine, Bronx, NY, USA;* [2]*North Shore-Long Island Jewish Health System, Manhasset, NY, USA;* [3]*New Hyde Park, NY, USA;* [4]*The Winthrop University Hospital, Mineola, NY 11501, USA*

Study design: Comparison of fixed *vs* dynamic plate complications in cervical surgery.
Setting: New York, USA.
Methods: Anterior cervical plate-related complications were evaluated following 66 anterior cervical corpectomy and fusion (ACF) with posterior stabilization (PWF) procedures performed in patients with ossification of the posterior longitudinal ligament (OPLL). Clinical data were comparable for both patient populations. Patients averaged between 52 and 53 years of age. The male to female ratio was approximately 2:1. Surgery addressed MR and CT documented multilevel OPLL in all patients accompanied by spondylosis and stenosis. Preoperatively average Nurick Grades ranged from 3.6 to 3.7. Anterior cervical corpectomies included an average of 2.6–3.0 vertebral bodies, while PWF covered seven levels. Fixed plates were applied in the initial 38 patients, while the latter 28 patients had dynamic plates (ABC, Aesculap, Tuttlingen, Germany) applied. Halo devices were used until fusion was documented on both X-ray and 2D-CT studies. Patients were followed-up for an average of 5.4 years in the fixed-plated groups, and 2.7 years in the dynamic-plated population.
Results: CT and dynamic X-ray confirmed that fusion occurred an average of 4.5–4.9 months postoperatively. Five (13%) fixed plates (Medtronic, Sofamor Danek, Memphis, TN, USA) failed warranting secondary surgery, while only one (3.6%) dynamic-plated patient developed a pseudarthrosis and required secondary posterior fusion.
Discussion/Conclusion: Higher failure rates follow multilevel ACF as compared with anterior diskectomy and fusion required to resect multilevel OPLL. Vaccaro *et al* observed a 9% failure rate following two-level ACFs and 50% failure rate following three-level ACFs performed with fixed plates. In this series, the plate extrusion rate was reduced to 3.6% when dynamic plates were applied.
Spinal Cord (2003) **41**, 379–384. doi:10.1038/sj.sc.3101447

Keywords: fixed; dynamic; anterior cervical plates

Introduction

In patients with multilevel ossification of the posterior longitudinal ligament (OPLL) involving retrovertebral extension, multilevel anterior corpectomy rather than diskectomy is required to adequately decompress the spinal cord. Nevertheless, high failure rates have been reported following multilevel anterior cervical corpectomy with fusion (ACF) performed utilizing fixed plates.[1–3] Vaccaro *et al*[2] reported a 9% incidence of plate/graft failure following two-level fixed-plated ACFs, and a 50% failure rate for three-level fixed-plated ACFs.[2] In this report, plate-related complications were sequentially monitored following 66 multilevel ACFs accompanied by posterior stabilization (PWF) performed to address multilevel OPLL. The first 38 patients received fixed plates (Medtronic, Sofamor Danek, Memphis, TN, USA), while the final 28 patients received dynamic plates (ABC Aesculap, Tuttlingen, Germany).

*Correspondence: NE Epstein, Long Island Neurosurgical Assoc. P.C., 410 Lakeville Rd Suite 204, New Hyde Park, NY 11042, USA

Materials and methods

Clinical data

Clinical data for the 66 patients undergoing circumferential cervical surgery utilizing fixed and dynamic plates were comparable (Table 1). Patients averaged between 52 and 53 years of age, with more males than females

Table 1 Fixed- *vs* dynamic-plated multilevel circumferential cervical procedures

Data	*Fixed plates (38 patients)*	*Dynamic plates (28 patients)*
Mean age (range)	53 (28–72)	52 (23–70)
Males	24	18
Females	14	8
Preoperative Nurick	3.7	3.8
Postoperative Nurick	0.7	0.5
ACF levels (range)	3.0 (2–4)	2.6 (2–4)
Average PWF levels	7	7
Average time to fusion (range)	4.8 months (3–8 months)	4.5 months (4–9 months)
Average follow-up	5.4 years	2.7 years
Average plate length	80 mm	67 mm
Average operative time	10.0 h	9.5 h
Average units of blood transfusions	3.2	2.5
Dynamic plate migration average (range)	NA	6.4 mm (5–9) cephalad 5.7 mm (4–9) caudad
Plate complications pseudarthrosis	5	1

NA = not Applicable, ACF = anterior corpectomy with fusion, PWF = posterior wiring and fusion

being affected. Preoperative evaluations included both MR and CT documentation of severe OPLL characterized by multilevel retrovertebral extension. Prior to surgery, patients exhibited moderate to severe myelopathy (average Nurick Grade of 3.7–3.8). Postoperatively, patients were immobilized in halo devices until fusion was documented on both X-ray (plain and dynamic) and 2D-CT studies performed in a serial fashion. Operative procedures averaged between 9.5 and 10.0 h in duration, and required from 2.5 to 3.2 units of blood (625–725 cc).

Circumferential procedures

In all, 66 circumferential cervical procedures included two- to four-level (average 2.6–3.0 levels) ACF with simultaneous PWF (average seven levels from C2–T1). Multilevel corpectomy rather than diskectomy was required as OPLL extended the full length of the intervening vertebral bodies. Fixed plates were placed in the initial 38 patients. However, plate-related complications led to the adoption of dynamic ABC plates for the latter 28 patients. The slotted design of the dynamic plate allowed for up to 10 mm of cephalad and 10 mm of caudad plate migration. The theoretical biomechanical advantages of the dynamic plate included less stress shielding, allowance for greater graft settling and compression, with a subsequent reduction of graft/plate-related complications. Fixed-plated patients were followed-up for an average of 5.4 years, while dynamic-plated individuals were followed-up for an average of 2.7 years (minimum of 24 months).

Fusions

Fresh frozen fibula strut allografts, placed into like-sized partial perforations in cephalad and caudad vertebral

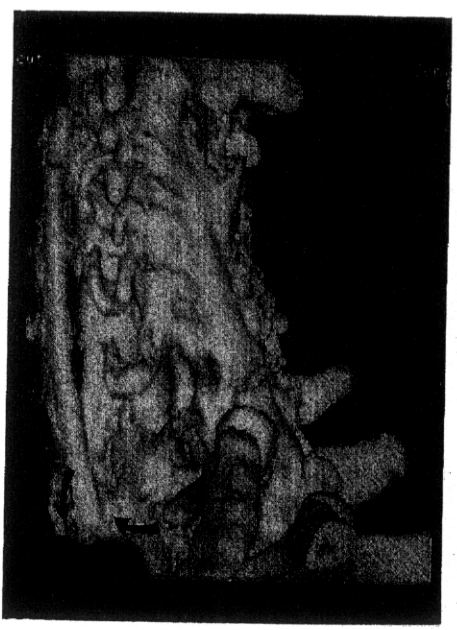

Figure 1 Case 1: At 6 weeks following a C3–C7 ACF with C2–T1 PWF performed with a fixed plate/fixed screw plating system, the 2D-CT study had demonstrated anterior/inferior plate extrusion with pistoning of the screws into the C7–T1 interspace. Since the iliac crest graft remained in partial continuity with the C7 vertebral body, the construct was allowed to fuse *in situ*. On this 6 month postoperative lateral 3D-CT examination, the inferior plate was fully incorporated into anterior bony-callous formation (curved arrows). As she was asymptomatic, no further surgery was performed

end plates, were employed in all 66 anterior fusions. Two major advantages of fibula allograft over iliac crest autograft included its straight contour and its greater strength following 'gardening' because of its cortical makeup. Alternatively, the extensive 'gardening' required of curved autogenous iliac crest graft, if employed over several vertebral segments, often left a markedly weakened construct. Posterior fusions were completed with split fibula allografts wired using braided titanium cables to the base of respective spinous processes, and supplemented with iliac crest autograft, cancellous allograft bone chips, and demineralized bone matrix.

Fusion criteria

Fusion was confirmed on static and dynamic X-rays and 2D-CT studies obtained 3, 6, and up to 12 months

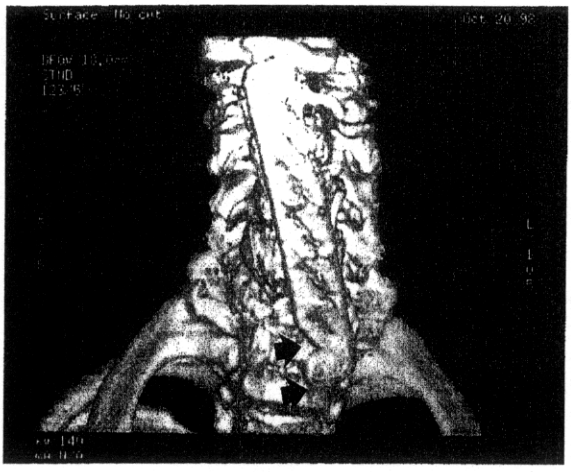

Figure 2 Case 2: At 6 weeks following a C2–C7 ACF/C2–T1 PWF performed with a fixed plate/fixed screw plating system in a patient with severe cerebral palsy, the plate extruded inferiorly into the left side of the C7–T1 interspace. However, the strut was still in continuity with the caudal C7 vertebral body. After 6 months, once the parasagittal 3D-CT study confirmed strut fusion to the surrounding bony callous, the anterior plate was removed for persistent dysphagia

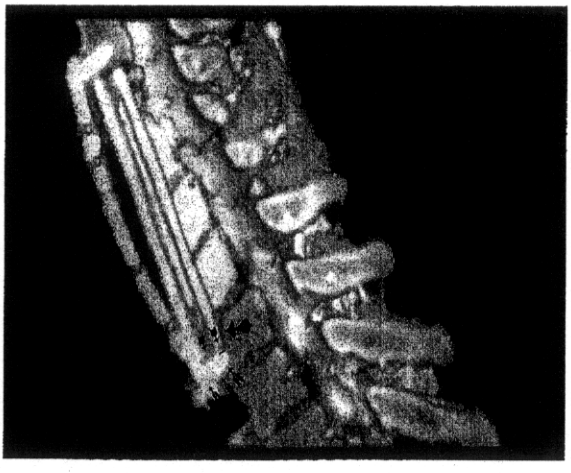

Figure 3 Case 3: A 48-year-old female with severe OPLL originally had a C2–C7 ACF with C2–T1 PWF employing a fixed plate/variable screw plating system with a fibula strut. The graft (large single arrow) and plate extruded anteriorly and inferiorly 1 month postoperatively as demonstrated on this midline sagittal 3D-CT study. Also, note the extrusion of the screw beyond the screw/plate locking mechanism (multiple arrows). Her second surgery required anterior graft replacement from C2 to C7 with application of another fixed plate/variable screw plating system now applied from C2 to T1

postoperatively. Static X-ray and 2D-CT fusion criteria included a lack of bony lucency, presence of bony trabeculation at the graft/vertebral interface, and on 2D-CT, bone growing into the central fibula shaft. Dynamic X-rays confirmed the lack of translation and less than 1 mm of motion between the tips of adjacent spinous processes.

Results

Clinical outcomes

Postoperatively, patients improved nearly 3 Nurick Grades exhibiting only mild residual radiculopathy or myelopathy (mean scores 0.5–0.7). Fusion was documented on X-ray and 2D-CT studies an average of 4.5–4.8 months (range 3–9 months) postoperatively. Both neurological and radiographic outcomes were similar for all three groups.

Figure 4 Case 3: Five months following the second surgery, the plate and graft failed inferiorly and it appeared that the posterior graft was resorbing. She then had a third procedure that included fibula strut replacement and application now of a 103 mm dynamic plate from C2 to C7. She remained in the halo device for another 8 months at which point, as demonstrated on this lateral radiograph and confirmed on multiple CT studies, she successfully fused. Note the cephalad plate/screw migration of 2 mm (triple arrows), the adequate locale of the fibula strut, and how the plate was bent anteriorly (double arrows) to help hold the graft in place. One can also readily visualize the braided titanium cables (four arrows) employed to wire the bilateral split fibula struts to the base of each spinous process, the fusion being supplemented with autogenous iliac crest graft

Plate-related failures

Five (13%) of 38 patients receiving fixed plates encountered inferior plate-related failures. Four occurred between 1 month and 6 weeks postoperatively, while one failed a second time 4 months postoperatively (Figures 1–4). One partial inferior graft extrusion fused *in situ*, while another required plate removal 6 months later for persistent dysphagia (Figures 1 and 2). Three others required repeated anterior ACF for plate/graft replacement accompanied by secondary posterior surgery. Note that 10 patients undergoing fixed plated ACF/PWF showed severe cephalad or caudad plate migration, which did not warrant second operations (Figures 5 and 6). In contrast, one (4%) of 28 patients undergoing a dynamic-plated circumferential cervical procedure developed a delayed pseudarthrosis 6 months

Figure 5 Case 4: At 2 months following a C3–C7 ACF/PWF performed in a 72-year-old female employing the fixed plate/variable screw system, superior fixed plate/variable screw plate migration was observed with partial pistoning of the grafts into the cephalad and caudad vertebrae. Nevertheless, as she remained asymptomatic, she was maintained in the halo device until fusion occurred 6 months later. On the 6-month postoperative 2D-CT study, the fibula strut was solidly fused at both graft/vertebral body interfaces, while the plate remained partially affixed to the cephalad C3 vertebra

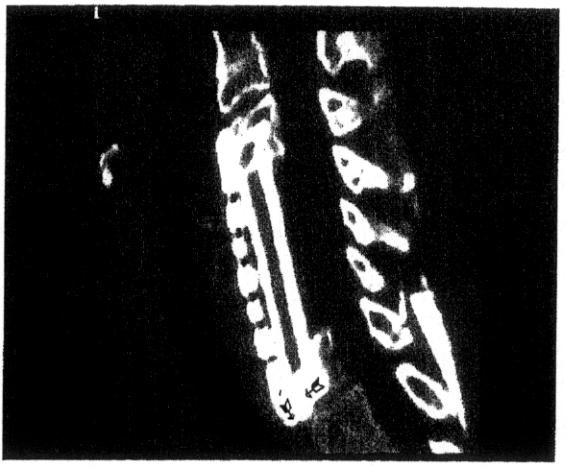

Figure 6 Case 5: A 44-year-old male, two pack/day smoker, had a C3–C7 ACF/PWF performed employing a fixed plate/variable screw system. Within 1 month of surgery, inferior strut, plate, and screw migration (arrows) lodged the inferior screws against the inferior C7 vertebral end plate. After 6 months, he demonstrated successful fusion without further plate/graft motion

postoperativley, and required a second PWF; he fused within 4 postoperative months. The extent of cephalad and caudad plate migration using dynamic plates documented on the 6-month postoperative lateral radiographs, revealed an average of 6.4 mm (range 4–10 mm) of cephalad, and 5.7 mm (range 4–9 mm) of caudad migration.

Discussion

Anterior surgery for spondylosis and/or OPLL has successfully addressed cervical myelopathy.[1,4–19] Fessler *et al*[20] observed an average increase of 1.24 Nurick Grades following anterior decompression for cervical myelopathy compared with a lesser 0.07 Nurick Grade following laminectomy. In this series, patients improved neurologically an average of 3 Nurick Grades irrespective of the type of plate used, the degree of improvement directly correlated with the extent and severity of preoperative neurological compromise.

High failure rates are reported for multilevel anterior corpectomy and fusion performed to address OPLL, where multilevel diskectomy with fusion would not provide sufficient ventral exposure and decompression.[1,2,4–13,16,19,21–23] Three (9.7%) of Saunder's 31 nonplated four level ACF developed acute graft-related complications, the addition of halos in a subset of patients proving of no greater value in avoiding these problems.[3] Macdonald *et al*[22] observed a perioperative morbidity and mortality rate surrounding both nonplated and fixed-plated 2–4 level ACF of 22%. Vaccaro *et al*[2] observed that a 9% graft extrusion rate followed 2 level ACF, and a 50% failure rate following 3 level ACF performed utilizing fixed-plated systems, irrespective of whether a halo device was utilized. High failure rates led to the adoption of the posterior 'tension band' to enhance stability.[1,2,13,16,19,22] In a biomechanical study, Kirkpatrick *et al*[24] showed that the posterior fusion reduced the sagittal range of motion by 62% compared with 24% using anterior strut grafting alone, and 43% for anterior strut grafts with plates. In an earlier series, out of 22 patients undergoing multilevel ACF utilizing iliac crest autograft without anterior plates but with PWF and halo devices, three (13.6%) patients exhibited immediate postoperative graft extrusions.[12] As this complication rate was unacceptable, leading to reoperations, prolonged intubations and other complications, anterior cervical plates were next adopted. Fixed plates were employed in the next 38 cases, five (13%) of whom developed plate/graft failures, while only one (3.6%) of 28 dynamic-plated patients in the later series demonstrated a construct failure.[13,16,19] The success of dynamic plates was largely attributed to their X-ray-documented ability to migrate both cephalad and caudad, thus minimizing graft shielding while facilitating graft compression.[19]

Conclusions

Postoperative graft/plate complications following multilevel ACF with PWF performed to address multilevel OPLL with retrovertebral extension were adequately reduced utilizing dynamic but not fixed plating systems.

References

1 Epstein NE. Circumferential surgery for the management of cervical ossification of the posterior longitudinal ligament. *J Spinal Disord* 1998; **11**: 200–207.
2 Vaccaro AR, Falatyn SP, Scuderi GJ, Eismont FJ *et al*. Early failure of long segment anterior cervical plate fixation. *J Spinal Disord (US)* 1998; **11**: 410–415.

3 Saunders RL, Pikus HJ, Ball P. Four-level cervical corpectomy. *Spine* 1998; **23:** 2455–2461.
4 Epstein NE. Diagnosis and surgical management of ossification of the posterior longitudinal ligament. *Contemp Neurosurg* 1992; **22:** 1–6.
5 Epstein NE. Ossification of the posterior longitudinal ligament: diagnosis and surgical management. *Neurosurg Q* 1992; **2:** 223–241.
6 Epstein NE. The surgical management of ossification of the posterior longitudinal ligament in 51 patients. *J Spinal Disord (US)* 1993; **6:** 432–454.
7 Epstein NE. The surgical management of ossification of the posterior longitudinal ligament in 43 North Americans. *Spine* 1994; **19:** 664–672.
8 Epstein NE. Ossification of the posterior longitudinal ligament in evolution in 12 patients. *Spine* 1994; **19:** 673–681.
9 Epstein NE. Advanced cervical spondylosis with ossification into the posterior longitudinal ligament and resultant neurologic sequelae. *J Spinal Disord* 1996; **9:** 477–484.
10 Epstein NE. Vertebral body fractures following extensive anterior cervical surgical procedures for ossification of the posterior longitudinal ligament. *Neuro-Orthop* 1997; **21:** 1–11.
11 Epstein NE. Evaluation and treatment of clinical instability associated with pseudarthrosis after anterior cervical surgery for ossification of the posterior longitudinal ligament. *Surg Neurol (US)* 1998; **49:** 246–252.
12 Epstein NE. Complications following surgical procedures of ossification of the posterior longitudinal ligament in the cervical spine warranting additional surgical correction. *Neuro-Orthoped* 1998; **22:** 85–97.
13 Epstein NE. The value of anterior cervical plating in preventing vertebral fracture and graft extrusion following multilevel anterior cervical corpectomy with posterior wiring/fusion: indications, results, and complications. *J Spinal Disord* 2000; **13:** 9–15.
14 Epstein NE. Anterior cervical diskectomy and fusion without plate instrumentation in 178 patients. *J Spinal Disord* 2000; **13:** 1–8.
15 Epstein NE. The management of 1 level anterior cervical corpectomy with fusion employing Atlantis hybrid plates: preliminary experience. *J Spinal Disord* 2000; **13:** 324–328.
16 Epstein NE. Anterior approaches to cervical spondylosis and OPLL: review of operative techniques and assessment of 65 multilevel circumferential procedures. *Surg Neurol* 2001; **55:** 313–324.
17 Epstein NE. Reoperation rates for acute graft extrusion and pseudarthrosis following one level anterior corpectomy and fusion with and without plate instrumentation: etiology and corrective management. *Surg Neurol* 2001; **56:** 73–81.
18 Epstein NE. Posterior cervical approaches in the management of spondylosis and ossification of the posterior longitudinal ligament'. *Surg Neurol* 2002; **58:** 194–208.
19 Epstein NE. The efficacy of anterior dynamic plates in complex cervical surgery. *J Spinal Disord* 2002; **15:** 221–229.
20 Fessler RG, Steck JC, Giovanini MA. Anterior cervical corpectomy for cervical spondylotic myelopathy. *Neurosurgery (US)* 1998; **43:** 257–265.
21 Eleraky MA, Llanos C, Sonntag VK. Cervical corpectomy: report of 185 cases and a review of the literature. *J Neurosurg (US)* 1999; **90** (1 Suppl): 35–41.
22 Macdonald RL, Fehlings MG, Tator Ch, Lozano A *et al.* Multilevel anterior cervical corpectomy and fibular allograft fusion for cervical myelopathy. *J Neurosurg (US)* 1997; **86:** 990–997.
23 Meding JB, Stambough JL. Critical analysis of strut grafts in anterior spinal fusions. *J Spinal Disord (US)* 1993; **6:** 166–174.
24 Kirkpatrick JS, Levy JA, Carillo J, Moeini SR. Reconstruction after multilevel corpectomy in the cervical spine. A sagittal plane biomechanical study. *Spine* 1999; **24:** 1186–1190.