

# POSTERIOR CERVICAL ARTHRODESIS WITH LATERAL MASS PLATING FOR MULTILEVEL CERVICAL DISEASE

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## ABSTRACT:

**Study Design:** We performed a retrospective analysis of 20 patients with multilevel cervical disease treated with posterior fusion and lateral mass plating with a new fixation system.

**Objectives:** We wished to determine the applicability, safety and clinical efficacy of an instrumentation system applied as a cervical lateral mass plate in the treatment of complex spinal disorders.

**Summary of Background Data:** Cervical disorders involving three or more levels, especially if the posterior elements are deficient, present a difficult reconstruction problem. Segmental fixation with lateral mass plating provides an alternative method to traditional techniques and may be applicable in situations that would otherwise require a halo postoperatively.

**Methods:** Twenty consecutive patients with a minimum 12 month follow-up treated by a single surgeon underwent cervical reconstructive surgery involving three or more levels. All patients had a posterior fusion and fixation with a device applied to the lateral masses of the cervical vertebrae. Patients were reviewed clinically and radiographically to determine the efficacy and safety of this method of fixation.

**Results:** Of the 18 patients with full clinical and radiographic follow-up at a minimum of 12 months, 16 (89%) stated they were clinically improved, 1 (5.5%) stated he was the same, and 1 (5.5%) stated he was worse than before surgery at the most recent follow-up. Sagittal alignment was restored to within 5 degrees of the preoperative lordosis in active extension by both the modified Cobb method and the Gore method. No patient had radiographic nonunion. One patient had a sensory radiculopathy associated with an overpenetrated lateral mass screw that partially resolved after hardware removal. One patient had asymptomatic loosening of a C-7 lateral mass screw.

**Conclusions:** Segmental posterior fixation with lateral mass plating provides more rigid immobilization than traditional techniques, allows restoration and maintenance of spinal alignment, and obviates the need for halo immobilization with a low incidence of neurovascular injury.

**Key Words:** Posterior, Cervical, Arthodesis, Lateral Mass, Plating.

## PRECIS

Twenty patients underwent reconstructive cervical surgery involving three or more levels. All patients had posterior fixation with a device applied to the lateral masses. Segmental fixation provided rigid immobilization and allowed restoration of spinal alignment with a low incidence of neurologic injury.

## INTRODUCTION

Multilevel disease involving 3 or more levels in the cervical spine presents a challenging reconstruction problem. Congenital spinal stenosis, multilevel cervical spondylosis, ossification of the posterior longitudinal ligament, rheumatoid spondylosis, and post-

laminectomy kyphosis are often associated with deficient posterior elements which do not allow traditional spinous process or sublaminar wiring techniques. Alternatives to these traditional techniques which have been introduced include anterior fusion with instrumentation or halo fixation, lateral mass plating, or a combination of the above procedures. Segmental fixation with lateral mass plating provides more rigid immobilization than traditional techniques, allows restoration and maintenance of spinal alignment through contouring of the plate, and obviates the need for a halo orthosis. The purpose of this study was to evaluate the early results of cervical reconstruction of 3 or more levels to determine the applicability, safety and early clinical efficacy of an instrumentation system approved for use in long bones and pelvis, but applied as a cervical lateral mass plate in complex spinal disorders (AXIS Fixation System, Sofamor Danek, Memphis, TN).

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## METHOD

### Study Population

All patients who received lateral mass plates as an adjunct to posterior cervical fusion by the senior author (CES) using the AXIS<sup>TM</sup> Fixation System (Sofamor Danek, Memphis TN.) spanning three or more levels were evaluated. No other inclusion criteria were used. 20 patients were enrolled in the study with a minimum follow up of 12 months.

### Clinical Evaluation

All patients were categorized according to both the disease process and clinical presentation. Radicular symptoms were defined as pain or paresthesias in a dermatomal distribution. Radicular signs were defined as motor weakness to manual muscle testing or decreased sensation to pinwheel pinprick testing in a dermatomal distribution. Myelopathic symptoms were defined as gait abnormalities or inability to control bowel or bladder. Myelopathic signs were defined as the presence of ataxia, sustained ankle clonus, and Babinski's or Hoffmann's signs.

A clinical assessment using a physician-recorded, patient-generated subjective response to the patient's overall condition was recorded at each postoperative visit. Three response categories were available: first, the patient was doing better than before surgery; second, the patient remained the same; third, the patient was doing worse than before surgery.

### Radiographic Evaluation

Preoperative and postoperative flexion/extension lateral radiographs were obtained for all patients. Postoperative radiographs were obtained at 3 months, 6 months, 12 months, and yearly thereafter.

### Sagittal alignment

Sagittal alignment was measured by two methods. Overall lordosis was measured from C2-C7 by the method of Gore. A modified Cobb method was used to measure the lordosis over the fused levels and was calculated as the degree of lordosis from the superior endplate of the vertebral body at the cephalad portion of the fusion to the inferior endplate of the vertebral body at the caudad end of the fusion. In both instances the measurements were made on the extension radiograph preoperatively and at the most recent follow-up interval. The extension radiographs imply the optimal achievable cervical lordosis unless the surgeon elects to perform an osteotomy.

### Radiographic Union

Pseudarthrosis was defined as motion greater than 2 mm on arbitrary points between the lamina at the

base of the spinous processes on the flexion-extension lateral radiographs at six months postoperatively. Because the instrumentation overlies the lateral masses on the AP radiograph and the facet joints were not always clearly visible, radiographic bone trabeculation across the fusion mass was unable to be assessed. Therefore, union was defined as the absence of a pseudarthrosis.

### Hardware Complications

Hardware failure was defined as any evidence of screw or plate loosening or breakage regardless of whether there was plate migration, loss of alignment, or a need for reoperation.

## INSTRUMENTATION SYSTEM

The AXIS<sup>TM</sup> Fixation System was used for lateral mass fixation in all cases. This system is a titanium plate and screw system designed to allow variable screw placement (up to 104 degrees cephalocaudal arc and 60 degrees in the mediolateral arc). This system was FDA approved for use in long bones and the pelvis and not for posterior cervical lateral mass fixation. It is recommended that proper informed consent including this information be obtained prior to its use (as was done for all patients in this study). This system allows placement of fixation from the skull to the thoracic spine including transarticular screws at C1-C2 and vertebral body screw at C7 and below.

## RESULTS

### Study Population

Since 1992, the senior author has treated 37 patients with the AXIS<sup>TM</sup> Fixation System. Twenty patients met the inclusion criteria and formed the study population (Table 1). 80% of the patients had an anterior surgery either concomitantly or staged with the posterior procedure. Patients were ambulated on postoperative day number one and treated with a Philadelphia type collar for six weeks postoperatively. No patient received halo vest support. One patient died in the perioperative period from respiratory complications. One patient was unavailable to return for clinical follow-up. Eighteen patients remained for clinical and radiographic review. The average follow up was 19.6 months (range: 12 to 28 months).

### Clinical Outcome

18/20 (90%) patients had radicular symptoms and 16/20 (80%) had radicular signs on the preoperative clinical exam. 10/20 (50%) had myelopathic symptoms and signs preoperatively. Only 1 patient (5%)



Table 1. Patient Data

Patient	Sex	Age	Litigation	Workman's Compensation	Days in Hospital	Levels	Number of Levels	Anterior Surgery Levels	Primary Diagnosis	Symptom Duration (Months)	Preoperative Cobb Angle	Postoperative Cobb Angle	Preoperative Gore Angle	Postoperative Gore Angle	Clinical Status	
1	J.B.A.	male	53	yes	no	6	C3-C7	4	C3-C7	Cervical Spondylosis	24	-4	-12	4	2	Unchanged
2	M.E.B.	male	57	no	no	5	C3-C7	4	C3-C7	Cervical Spondylosis	18	28	2	40	20	Worse
3	M.L.B.	female	51	no	no	5	C2-C5	3	C2-C7	Cervical Spondylosis	12	20	24	30	30	Improved
4	M.W.B.	male	45	yes	no	3	C4-C7	3	None	Cervical Spondylosis	24	11	15	22	34	Improved
5	E.C.D.	male	59	no	yes	9	C3-C7	4	C3-C7	Cervical Spondylosis	24	9	6	N/A	N/A	Improved
6	V.G.	female	68	no	no	6	C4-C7	3	C4-C7	Cervical Spondylosis	24	10	10	30	30	Improved
7	H.H.	male	54	no	no	4	C3-C7	4	C3-C7	Cervical Spondylosis	3	42	32	34	30	Improved
8	F.L.P.	male	28	no	no	10	C2-T1	6	C3-C6	trauma	1	N/A	-2	N/A	N/A	Improved
9	W.H.K.	male	50	no	no	6	C3-C7	4	C3-C7	Cervical Spondylosis	36	18	16	28	26	Improved
10	N.C.L.	male	61	no	no	4	C3-C7	4	None	Cervical Spondylosis	8	7	5	18	20	Improved
11	G.P.	male	57	no	yes	5	C3-C7	4	C3-C7	Cervical Spondylosis	8	N/A	N/A	N/A	N/A	Improved
12	R.L.P.	male	37	no	no	8	C3-C6	3	C3-C6	Cervical Spondylosis	12	13	14	50	38	Improved
13	M.C.R.	female	81	no	no	8	C3-C7	4	C3-C7	Cervical Spondylosis	12	16	11	32	34	Improved
14	R.N.S.	male	56	no	no	7	C3-T1	5	C3-T1	Cervical Spondylosis	24	N/A	N/A	N/A	N/A	Improved
15	D.S.	male	41	no	no	6	C3-C7	4	C3-C7	Cervical Spondylosis	18	-6	-10	N/A	N/A	Improved
16	D.B.	female	67	no	no	21	Occiput-T1	8	Occiput-T1	Rheumatoid Arthritis	24	50	48	48	48	Improved
17	M.P.	female	73	no	no	9	C3-T1	5	C3-C7	Cervical Spondylosis	24	14	18	30	30	Improved
18	E.P.	female	82	no	no	7	C2-C7	5	C2-C7	Cervical Spondylosis	12	N/A	N/A	N/A	N6A	Deceased
19	E.E.P.	male	33	no	no	6	C3-C6	3	C3-C6	Cervical Spondylosis Ossified Posterior Longitudinal Ligament	48	8	-1	30	24	Improved
20	J.V.S.	male	68	no	no	3	C2-T2	7	C2-T2		96	N/A	N/A	N/A	N/A	Worse



who had an excellent clinical response to preoperative facet injections had axial neck pain as his only surgical indication. Postoperatively, 9/18 (50%) patients had persistent radicular symptoms and 9/18 (50%) patients had persistent radicular signs. Only 1 patient (5.5%) had persistent myelopathic symptoms while 3/18 (16%) had myelopathic signs.

16/18 (89%) patients stated they were significantly improved postoperatively, 1 patient (5.5%) stated he was the same, and 1 patient (5.5%) stated he was worse at the most recent follow-up. Two patients (11%) had increased neurologic deficit postoperatively. Both patients had sequential anterior and posterior decompressions and fusion on the same day. One patient (5.5%) had the fifth and sixth cervical roots involved and one patient (5.5%) had only fifth nerve root involvement. Of these last two patients, one patient (5.5%) stated his surgery significantly improved his pain and he would be willing to have the surgery again if necessary. The other patient had persistent pain and felt the surgery worsened his condition.

#### **Radiographic Outcome**

##### **Sagittal Alignment**

Although films were available for all patients, adequate films were available for only 13 patients preoperatively and postoperatively. With the exception of one patient who did not have a preoperative extension lateral, all other patients radiographs were inadequate because of the inability to see the lower vertebral body secondary to overlapping of the shoulder musculature. Extension tomograms were not performed and "swimmer's" view radiographs were not used because of the difficulty obtaining maximal extension with the patient's arm over his head. The average preoperative lordosis from C2-C7 in extension was  $30.5 \pm 11.5$  degrees (range: 4-48 degrees). The average lordosis at most recent follow up was  $28.5 \pm 10.4$  degrees (range: 2-48 degrees). Compared to their preoperative extension film, 3 patients (23%) had a loss of greater than 5 degrees of lordosis postoperatively, 9 patients (69%) had a lordosis within ten degrees of their preoperative value, and 1 patient (8%) had increased cervical lordosis of greater than 5 degrees postoperatively. These differences were not significant ( $p > 0.05$ , student's test).

Fifteen patients had adequate radiographs to assess the lordosis by the modified Cobb method over the fusion levels. The discrepancy between this number and the above number is that two patients had fusions that ended at C6 and the inferior endplate could be seen.

The average preoperative sagittal alignment over the levels fused on the extension lateral film by this method was  $15.7 \pm 14.5$  degrees (range: -6 to 50 degrees). The average postoperative alignment for these patients over the same levels was  $12 \pm 14.7$  degrees (range: -12 to 48). Three patients (20%) had a kyphotic angulation with the greatest angulation being 12 degrees. These differences were not significant ( $p > 0.05$ , student's t-test). No patient developed late kyphosis or change in alignment.

##### **Radiographic Union**

No patient had greater than 2 mm of motion on flexion extension lateral films and all were considered to have a fusion.

##### **Hardware Complications**

One patient had a symptomatic sensory radiculopathy which partially resolved after removal of the hardware 13 months postoperatively. One patient had a loose C7 lateral mass screw noticed radiographically at 6 weeks and remains unchanged and asymptomatic at 26 months postoperatively (Fig. 3).

#### **DISCUSSION**

The treatment of multilevel cervical disease secondary to spinal stenosis, cervical spondylosis, ossification of the posterior ligament, rheumatoid spondylosis and postlaminectomy kyphosis remains controversial. Several different methods of decompression and reconstruction have been advocated.

##### **Anterior Decompression and Reconstruction**

Several authors have published their experience with anterior decompression and reconstruction. In 1976, Whitecloud and LaRocca, published their initial experience with corpectomy and fibular strut graft reconstruction for multilevel cervical spondylosis. They used a notched fibular graft without instrumentation and treated the patients with a rigid collar for 12 week postoperatively. While the initial union rates were excellent, they deteriorated to 41% for allograft and 27% for autograft fibular struts in long-term follow-up. Furthermore, three grafts dislodged. No mention of clinical outcome was made in either study.

Hanai, in 1984, reported on 30 patients treated with anterior corpectomy and strut graft reconstruction using iliac crest autograft. They reported improvement in the Japanese Orthopaedic Association (JOA) postoperative scores for all patients and 100% radiographic union. All patients were kept supine for four to six weeks postoperatively and then treated with a rigid cervical brace for an additional six months.



Harsh, et al, in 1987, reported on 20 patients with ossification of the posterior longitudinal ligament treated with anterior corpectomy and strut reconstruction with allograft and autograft fibula or iliac crest bone graft. Patients were immobilized in a rigid collar or halo for 3 months postoperatively. Clinical results were improved in 17 patients and radiographic union occurred in all 20 patients.

Kojima, et al, in 1989, reported on 45 patients with either multilevel cervical spondylosis or ossification of the posterior ligament treated with anterior corpectomy and strut graft reconstruction. Autograft iliac crest was used for bone graft and a halo was applied for twelve weeks postoperatively. Clinical results were good in 87% of the patients and radiographic union occurred in all patients. Five patients had graft extrusions, of which 4 required a reoperation.

Zdeblick and Bohlman in 1989 reported on anterior decompression and strut grafting for cervical kyphosis and myelopathy. Of 14 patients, all had an initial clinical improvement and all went on to radiographic union. Three patients had graft extrusions in spite of two-post cervical orthosis or halo immobilization for 8-12 weeks postoperatively.

Okada, et al, in 1991, reported on 37 patients with cervical myelopathy treated with anterior decompression and strut graft reconstruction with either iliac crest or fibula with an average follow-up of 49 months. Twenty-nine patients showed clinical improvement. In spite of halo vest use, 1 patient had a graft dislodgement and 3 patients had a delayed union necessitating a second operation.

#### Posterior Decompression

Several authors have also reported on their experience with posterior decompression without reconstruction for the treatment of these multilevel problems. Crandall and Gregorius, in 1977, reported on swan neck deformity after multilevel laminectomy for cervical spondylotic myelopathy. Because of the extensive deformity associated with posterior decompression without fusion other techniques for multilevel decompression were sought. Kimura, et al, in 1984, published their results with "canal-expansive laminoplasty" for multilevel disease on 24 patients. The patients were kept at bed rest for two weeks and then wore a Minerva type orthosis for six weeks. Twenty-two patients had good or excellent clinical results and no patient developed a clinical deformity at an average of 1.5 years postoperatively.

Maurer, et al, in 1991, reported on 10 patients with

cervical spondylotic myelopathy treated with posterior decompression and Luque rectangular instrumentation and fusion. At an average ten month follow-up, 9 of ten patient were clinically improved and all patients had radiographic union without evidence of hardware failure.

Snow and Weiner, in 1993, reported on 90 patients treated with bilateral cervical laminectomy for cervical myelopathy. 77% of the patients had an improved clinical outcome. No mention of postoperative immobilization or radiographic outcome was made.

#### Anterior and Posterior Coparison Papers

While no report of a randomized clinical trial comparing the results of anterior decompression and reconstruction with either posterior decompression alone, or posterior decompression and reconstruction together has been published, several authors have published retrospective reviews of their own patient outcomes from the various surgeries.

Yonenobu, et al, in 1985, published a report on 95 patients. Twenty-four underwent extensive laminectomy, 50 underwent anterior interbody fusion, and 21 underwent anterior corpectomy and strut grafting. All patients received three weeks of bed rest and all were provided "external neck support" for three months or until anterior union. In three level decompressions, the clinical outcome was improved in the corpectomy group ( $p < 0.05$ ) compared to either the multilevel interbody group or the laminectomy group. There were 3 graft dislodgements and 5 nonunions in the corpectomy group. There was late deterioration in the laminectomy group secondary to cervical instability in 5 patients.

Herkowitz, in 1988, reported on 45 patients with multilevel cervical spondylotic radiculopathy with minimum two year follow up. Eighteen patients underwent anterior fusion, 12 patients had laminectomy, and 15 patients underwent laminoplasty. Clinical success was 92% for anterior interbody fusion, 66% for cervical laminectomy and 86% for cervical laminoplasty. Complications included 37% pseudarthrosis in the anterior interbody group but no reoperations. In the laminectomy group, 3 patients developed cervical kyphosis within two years of surgery, 2 of whom underwent anterior fusion. In the laminoplasty group, two patients developed closure of the hinge requiring reoperation.

Epstein, in 1993, reported on the results of surgical decompression for ossification of the posterior longitudinal ligament. Twenty-six patients underwent three



level anterior corpectomy and reconstruction with autogenous iliac crest graft and 10 patients underwent laminectomy. Six patients were treated with halo orthoses postoperatively after anterior corpectomy. Four of these required posterior wiring to achieve union. - All patients who underwent corpectomy and strut graft, and 7 patients who underwent laminectomy, improved by at least one Ranawat grade. One patient in the laminectomy group underwent an anterior procedure 10 months postoperatively for persistent ventral OPLL.

From this literature review four conclusions can be drawn. First, multilevel spinal reconstruction is a challenging problem. Second, no consensus exists for treatment of this problem. Third, anterior cervical corpectomy with strut grafting has a significant number of graft related complications including extrusion and non-union even when postoperative spinal immobilization is performed with a halo. Fourth, extensive laminectomy without attempted fusion or fixation leads to a significant number of kyphotic deformities in the postoperative period.

The literature lacks any large series with concomitant anterior and posterior reconstructions, anterior reconstruction with plating, or with posterior decompression and reconstruction with fusion and instrumentation. Consequently, a universal approach to these difficult problems cannot be advocated on the basis of published series.

Because of the complications of graft extrusions anteriorly with long constructs even with halo orthoses postoperatively and kyphotic deformity with posterior decompressions without reconstruction, the senior author (CES) has performed posterior facet grafting and lateral mass fixation for multilevel decompressions. The decision to approach the patient posteriorly or anteriorly was individualized depending on the underlying disease process, and the extent of disease, and was not the subject of this paper. The purpose of this paper was to present the early results of a technique of posterior cervical fixation that can be used in multilevel reconstructions. This method can be used either alone or when combined with an anterior procedure even when the posterior elements are deficient, either because of previous surgery, or the anticipated need for surgical decompression.

#### CONCLUSIONS

Posterior segmental fixation with lateral mass plating provides a more rigid immobilization than tradi-

tional techniques, allows restoration and maintenance of spinal alignment, and obviates the need for halo immobilization. In addition, this method has a low incidence of neurovascular injury.

The AXIS™ Fixation System allows the surgeon to accomplish these goals by providing rigid segmental fixation with great variability in screw placement to accommodate for changes in bone architecture.

The early clinical results are encouraging regarding the applicability, safety, and early efficacy of this fixation system in multilevel cervical reconstruction. This series has certain limitations which preclude direct comparisons of this to other methods of reconstruction. This data is introduced to familiarize the reader with a technique which is available, safe, and provides an internal fixation method to enhance fusion in situations where no other method may be appropriate. Whether posterior stabilization and fusion is more efficacious than anterior reconstruction with instrumentation cannot be known at this time. However, this paper provides information on an approach that may be used for comparison in future studies.

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