Complications and Outcome in Dynamic Plated Single Level Anterior Corpectomy and Fusion Including Two Level Complete Discectomies

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ABSTRACT

Background and Context: The efficacy of iliac crest strut autograft and dynamic plating (ABC: Aesculap, Tuttlingen, Germany) for one level anterior cervical corpectomy/fusion with two level discectomy (1 level ACF) needs to be established.

Purpose: To document fusion (2D-CT and dynamic X-rays) and outcomes (SF-36) following 1 level ACF.

Study Design/Setting: Graft and plate-related complications and outcomes were prospectively evaluated in 86 consecutive patients undergoing 1 level ACF.

Patient Sample: Preoperative MR/CT studies documented contiguous two-level disc disease, spondylosis, stenosis and/or ossification of the posterior longitudinal ligament (OPLL).

Outcome Measures: Fusion was documented on 2D-CT/dynamic X-rays. Outcomes (Odom's Criteria, Nurick Grades and SF-36) were assessed 3, 6, 12, and 24 months postoperatively.

Methods: Patients averaged 48 years of age and exhibited moderate/severe preoperative myelopathy (average Nurick Grade 3.0). All underwent 1 level ACF, and were followed an average of 3.5 years (minimum 2 years).

Results: Two pseudarthroses, 2 delayed strut fractures, and 1 plate/graft extrusion (5.8% total) developed postoperatively; all required secondary posterior fusion. Outcomes 2 years postoperatively revealed mild residual radiculopathy (average Nurick Grades 0.24), 82 good/excellent outcomes (Odom's Criteria), and marked improvement on 6 SF-36 Health Scales. The average time to fusion was 4.7 months.

Conclusions: Successful 2D-CT/dynamic X-ray documented fusion occurred in 94.2% of patients undergoing 1 level ACF performed with iliac crest autograft and dynamic ABC plates. Results were comparable to those cited for fixed-plates in other series.

Key words: anterior cervical corpectomy dynamic plates

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INTRODUCTION

Fusion rates and outcomes were assessed in 86 consecutive patients undergoing single level anterior corpectomy/fusions (i.e. C5-C7) utilizing iliac crest strut autograft and dynamic plates (ABC: Aesculap,

Tuttlingen, Germany). Fusion was documented utilizing sequential 2D-CT studies and dynamic radiographs up to 24 months postoperatively; complications including plate/graft extrusion, pseudarthrosis, and delayed fractures were also identified. Both surgeon (Nurick Grades, Odom's

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Criteria), and patient-based (Short-Form 36) outcomes were also evaluated up to 24 months following surgery.

MATERIALS AND METHODS

We performed a retrospective review of 86 consecutive patients treated with an anterior cervical corpectomy and fusion (Table 1). Their average age was 48. There were 36 females and 50 males, and 28 smokers. Eighteen patients were obese. Preoperatively, patients exhibited moderate/severe myelopathy (average Nurick Grade 3.0, range Grades II-IV). MR and CT studies confirmed contiguous two level disease with retrovertebral extension involving disc herniations, spondylosis, stenosis and/or ossification of the posterior longitudinal ligament (OPLL) (Figs. 1, 2). Single level ACF included partial removal of cephalad/caudad vertebral bodies/end-plates, and total removal of the intervening vertebral body and discs (i.e. C5-C7). All patients received iliac crest autograft struts and dynamic ABC plates. Postoperatively, patients were immobilized in cervico-thoracic orthoses until fusion was documented. Dynamic X-rays and 2D-CT studies, performed 3 months, 4.5 months, 6 months, and up to 12 months postoperatively and interpreted by two independent neuroradiologists blinded to the study design, were utilized to document fusion (Figs. 3-5). Surgery required an average of 3.4 hours. Nurick Grades and Odom's Criteria were assessed 1 and/or 2 years postoperatively by the surgeon. SF-36 outcome questionnaires completed by the patients were administered preoperatively and 3 and 6 months, and 1 and 2 years postoperatively. SF-36 data were reported both quantitatively and qualitatively [minimal improvement 0%-10%, mild improvement 11%-20%, moderate improvement 21%-30%, or marked improvement 31% and above].

RESULTS

Major Complications

Dynamic X-rays and 2D-CT studies combined documented fusion an average of 4.7 months postoperatively (range 3.5 mo –12 mo). However, 5

(5.8%) patients exhibited major surgical complications. These occurred within the first 34 cases; none have been encountered among the last 52 patients (Table 2). One patient developed a plate/graft extrusion, 2 smokers developed pseudarthroses, and 2 patients exhibited delayed strut fractures. All 5 required secondary posterior fusion.

Outcomes

Surgeon-Based Outcomes

Nurick Grades revealed mild residual radiculopathy/mild myelopathy one (average Nurick Grade 0.27) and two (average Nurick Grade 0.24) years postoperatively. Two years postoperatively, Odom's Criteria revealed excellent (64 patients), good (18 patients), fair (3 patients did not improve), and poor outcomes (1 patient transiently worse).

SF-36 Patient-Based Outcomes

Short-Form 36 outcomes revealed progressive improvement on 6 of 8 Health Scales by the second postoperative year (Tables 3A, 3B). Three months postoperatively, mild improvement was observed on 1 [Vitality (V)], and moderate improvement on 2 Health Scales [Role Emotional (RE), Bodily Pain (BP)]. Six months following surgery, moderate improvement was seen on 3 [(V), Social Function (SF), (RE)], with marked improvement on 1 (BP) Health Scale. One year postoperatively, moderate improvement was observed on 1 (SF), and marked improvement on 4 [Physical Function (PF), Role Physical (RP), (BP), (V)] Health Scales. By the second postoperative year, marked improvement was observed on 6 of 8 Health Scales [(PF), (RP), (BP), (V), (SF), (RE)].

DISCUSSION

Major complications follow two-level anterior cervical discectomy and fusion (ACDF) or single level ACF performed without plates. In the absence of plates, Epstein documented a 99% fusion rate for 1 level ACDF (78 patients), but a lower 90% fusion rate for two level (84 patients) ACDF (Table 4) [4]. For 48 patients undergoing non-plated single level ACF, secondary posterior fusions were required to address 3 graft/plate extrusions and 2 pseudarthroses (10.4%)

**Table 1: Clinical Data for 86 Patients Undergoing Single Level
Anterior Corpectomy/Fusion (ACF)**

1 Level ACF	ABC Plates (86 Patients)	
Average Age (Range)	48 (31-74)	
Sex: Males Females	Males	50
	Females	36
Levels of Surgery	C4-C6	18
	C5-C7	63
	C3-C5	4
	C2-C4	1
Average Nurick Grades Preoperatively (Range)	Average Preoperative (Nurick Grades II-IV)	3.0
Postoperative Year 1	Average Postoperative	0.27 (1 yr)
Postoperative Year 2 (Range)	Average Postoperative (Nurick Grades 0-II)	0.24 (2 yr)
Odom's Criteria Postoperatively	Excellent	64
	Good	18
	Fair	3
	Poor	1
Average Operative Time Range	Average 3.4 hours (2.5-4.5 hours)	
Average Hospital Stay (Days)	Average 3.31 Days (2-6 days)	
Obesity Weight Over 230 18 Patients	Weight 230-249	10
	Weight > 250	2
	Weight > 260	4
	Weight > 275	1
	Weight > 325	1
Average Time to Fusion (Range)	4.7 mo (3.5-12 mo)	
Follow-Up	Average 3.5 years Range 2 yrs – 4.5 yrs	
Major Complications		
Graft Extrusion	1	
Pseudarthrosis	2	
Delayed Strut Fracture Requiring Surgery	2	

Table 2: Major Complications Requiring Secondary Surgery For 5 (5.8%) of 86 Patients Undergoing Single Level Anterior Corpectomy/Fusion Utilizing Dynamic Plates

Case Number:	Age/Sex	Time to Complication	Treatment of Complication
Graft-Plate Complication	1st Operation Weight if Obese	Contributory Factors Smoker Obesity	
1. Fracture/Extrusion of Graft	48 Male C5-C7 ACF 260 lbs	2 weeks postoperatively Smoking Obesity	2 Level ACF Posterior Fusion Halo Application
2. Pseudarthrosis	36 Male C5-C7 ACF 280 lbs	6 months postoperatively Smoking Obesity	Posterior Fusion
3. Pseudarthrosis	50 Male C2-C4 ACF 185 lbs	6 months postoperatively Smoker Non-Compliance with Bracing	Posterior Fusion
4. Delayed Fracture	34 Female C4-C6 ACF 150 lbs	2 years postoperatively Lupus Steroids started 1 year postoperatively	Posterior Fusion
5. Delayed Fracture	39 Male C5-C7 ACF Smoker 260 lbs	3 months postoperatively Smoker Obesity Trauma	Posterior Fusion

ACF = Anterior Corpectomy/Fusion

Figure 1: Ossification of the posterior longitudinal ligament extended from the lower third of the C3 vertebra to the C4-C5 interspace. This patient required a C3-C5 anterior corpectomy and fusion with iliac crest arthrodesis and ABC plating.

Figure 2: Transaxial CT scan demonstrating coalescing ossified pearls within hypertrophied posterior longitudinal ligament resulting in severe ventral cord compression.

Figure 3: Lateral radiograph 6 months postoperatively demonstrating 8 mm of cephalad but only 2 mm of caudad plate migration (arrows).

Figure 4: Six-month postoperative 2D midline sagittal CT scan in the same patient from Fig. 3 demonstrating cephalad (multiple arrows) and caudad (single arrow) iliac crest graft fusion. Note the superior 8 mm and inferior 2 mm ABC plate migration over the screw heads.

Figure 5: Parasagittal 2D-CT scan obtained 6 months postoperatively in another patient revealing 7 mm of cephalad and 3 mm of caudad ABC plate migration over the screw heads.

Figure 6: Delayed mid-strut fracture occurring 3 months following application of a fixed plate in a prior series warranted secondary posterior fusion. The 2D-CT shown here, obtained four months following the secondary surgery, posterior fusion, demonstrated near complete healing of the mid-strut fracture.

Table 3A: SF-36 Preoperative and Postoperative (3 mo, 6 mo, 1 and 2 years) Outcome Data for 86 Patients Undergoing 1 Level ACF Utilizing Dynamic Plates

Preop*/ Postop^ Data Points % Improved	Physical Function	Role Physical	Bodily Pain	General Health	Vitality	Social Function	Role Emotional	Mental Health
Preop* Baseline	41.0	14.1	34.4	68.8	39.9	43.2	37.5	60.3
3 mo Points % Improved	36.6 (-4.4) -10.7%	8.7 (-5.4) -17%	44.7 (+10.3) +30%	70.1 (+1.3) +1.9%	46.8 (+6.9) +17.6%	46.2 (3.0) +6.9%	46.6 (+9.1) +24.3%	64.6 (4.3) +7.1%
6 mo Points % Improved	44.1 (+3.1) +7.6%	11.7 (-2.4) -1.7%	46.8 (+12.4) +36%	70.6 (+1.8) +2.6%	47.9 (+8.0) +20.3%	55.3 (+12.1) +27.8%	47.5 (+10.0) +26.7%	67.7 (+7.4) +12.3%
1 year Points % Improved	55.2 (+14.1) +34.1%	23.1 (+9.0) +64.3%	56 (+21.6) +62.8%	74.4 (+5.6) +10.2%	54.3 (+14.4) +36.1%	53.2 (+10) +23.1%	44.4 (+6.9) +18.4%	66.2 (+5.9) +9.8%
2 yr Points % Improved	58.3 (+17.3) +42.1%	26.4 (+12.3) +87.2%	58 (+23.6) +68.6%	79 (+10.2) +14.8%	57 (+17.1) +42.9%	60 (+16.8) +38.9%	50.3 (+12.8) +34.1%	68.5 (+8.2) +13.6%

mo = Months, Preop* = Preoperative, Postop^ = Postoperative

[5].

Improved fusion rates were documented for one and two level ACDF utilizing fixed plates [2, 10, 12]. Caspar, Geisler, Pitzen et al., observed that 9% of non-plated but only 2% of fixed-plated patients required secondary surgery to address postoperative pseudarthrosis or other plate/graft related failures (Table 4) [2]. For 2 level ACDF, Wang, McDonough, Endow et al., observed a 25% frequency of pseudarthrosis without plates, and 0% pseudarthrosis rate with fixed plates (Table 4) [12].

Single strut grafting for 1 level ACF equaled or appeared superior to two interbody grafts utilized to

perform 2 level ACDF [9, 10, 13]. High success rates with fewer major complications (graft/plate extrusion, pseudarthrosis) were reported for fixed-plated one level ACF embedded in multilevel corpectomy series (Table 4) [3, 11]. Reported frequencies included 98.8% fusion and 1.2% incidence of pseudarthrosis, and 86.6% fusion, 12.6% 'stable' fibrous unions, 2 (0.8%) unstable pseudarthroses, and 5.4% hardware failure [3, 11].

Few studies document failed 1 or 2 level ACDF or 1 level ACF utilizing fixed plates. Bose observed that 7 of 97 patients required secondary revisions and 19 demonstrated hardware failures [1]. The author

Table 3B: Scaled SF-36 Outcomes for 1 Level ACF Postoperatively

Timed Data Postop [^]	Physical Function	Role Physical	Bodily Pain	General Health	Vitality	Social Function	Role Emotional	Mental Health
3 mo Postop	Worse	Worse	Moderate	Minimal	Mild	Minimal	Moderate	Minimal
6 mo Postop	Minimal	Worse	Marked	Minimal	Moderate	Moderate	Moderate	Mild
1 yr Postop	Marked	Marked	Marked	Mild	Marked	Moderate	Mild	Minimal
2 yr Postop	Marked	Marked	Marked	Mild	Marked	Marked	Marked	Mild

Worse (<0%), Minimal (0%-10%), Mild (11%-20%), Moderate (21%-30%), Marked (31%+) Improvement, Postop[^] = Postoperative

previously encountered a high failure rate where fixed plates were utilized to perform fifteen 1 level ACF; 5 pseudarthroses, 1 plate extrusion, and 2 delayed graft fractures [6, 7] (Figs. 6).

In this series, iliac crest autograft with dynamic plating of 1 level ACF resulted in a low (5.8%) major complication rate. All occurred within the first 34 cases; none were encountered among the last 52 patients. Increased experience with grafting and plating techniques likely contributed to this success. The application of dynamic plates to 1 level ACF did not adversely impact surgeon-based (Odom's Criteria, Nurick Grades) or patient-based (SF-36) outcomes. Two years postoperatively, patients exhibited mild residual radiculopathy/myelopathy (average Nurick Grade 0.24), 82 of 86 exhibited excellent/good outcomes (Odom's Criteria), and patients improved on 6 of 8 SF-36 Health Scales. Of interest, on the SF-36, patients exhibited the greatest degree of postoperative improvement within the first postoperative year, a finding similarly noted among patients undergoing multilevel dynamic-plated circumferential procedures [8].

It would appear that iliac crest autograft combined

with dynamic plating of single level ACF resulted in rates of fusion and outcomes equivalent, and in the author's prior experience, better than those cited in other fixed-plated series (Table 4).

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Table 4: Major Complications With and Without Fixed-Plates in Clinical Series Involving Single or Multilevel Anterior Discectomy/Fusion (ACDF) or Anterior Corpectomy/Fusion (ACF)

Author	Plated/Non-Plated # Patients	Number of Surgical Levels/Type of Surgery	Summary of Operations	Fusion Rate %
Eleraky ⁸	Plated 87 70 28	1 ACF 2 ACF 3 ACF	Plated 1-3 ACF	98.8%
Mayr ⁹	Plated 133 96 88 1	1 ACF 2 ACF 3 ACF 4 ACF	Plated 1-3 ACF	99.2%
Caspar ³	Non-Plated 210	1-2 ACDF	Non-Plated 1-2 ACDF	91%
	Plated 146	1-2 ACDF	Plated 1-2 ACDF	98%
Epstien ¹	Non-Plated 84	2 ACDF	Non-Plated 2 ACDF	90%
Kaiser ⁵	Non-Plated 289	1-2 ACDF	Non-plated 1-2 ACDF	72%
	Plated 251	1-2 ACDF	Plated 1- 2 ACDF	91%
Wang ⁴	Non-Plated 28	2 ACDF	Non-Plated 2 ACDF	75%
	Plated 32	2 ACDF	Plated 2 ACDF	100%

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Reviewer's comment : Isao Yamamoto, M.D.
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Dr. Epstein has presented an interesting series of patients treated with a single-level anterior corpectomy and fusion (ACF) with dynamic plate. She points out good clinical results for the treatment of two-level disc disease, spondylosis, stenosis and/or OPLL.

The current study demonstrates that the fusion rates for single-level corpectomy with plate fixation are extremely high, however, there are always potential hardware complications associated with the usage of plate. As Bose (reference 1) and Epstein (reference 6) mentioned, plate related morbidity decreased significantly with experience and even their earlier results were not always satisfactory. In my poorly personal experience, I don't use plate fixation in one-level corpectomy. Therefore, I think, particularly inexperienced surgeons should cautiously select the usage of plate for the single-level corpectomy.

I need to await future prospective study comparing ACF with or without plate.

Reviewer's comment : Hiroshi Takahashi, M.D.
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ABC plate is a dynamic cervical plate for anterior decompression and fusion. The screws and plate can adapt in height for settling due to resorption of the bone graft. This paper presented the follow-up results of 86 cases with cervical spondylosis or cervical OPLL for 2 years after the one level corpectomy and anterior fusion with iliac bone and ABC plate. Bony fusion was observed 4.7months in an average after the operation, and final outcome showed excellent in 74%, good in 21%, fair in 3%, poor in 1%. Major complications occurred in 5 cases i.e. plate graft extrusion in 1case, pseudoarthrosis in 2cases, delayed strut fixation in 2cases. The author compared their results with those of other reports of the similar operations without plating or with fixed plate. Finally, the author stressed the advantage of this dynamic ABC plate. Probably, the subscribers of this Japanese journal want to know moreover about the details of the complications and the technical knack on using ABC plate to avoid them. The author stressed that the complication occurred in the first 34cases and after she got used to this plating system, no complications happened. However there remained still some doubt about the intrinsic problems of this Plating system. And also we want to know about the problems of the adjacent disc degeneration in further long-term follow up. Nevertheless, the operative results were acceptable and particularly I am very much impressed the fact that the average hospital stays were 3.31days. In this paper, the results of the study using SF-36 were also stated. The scaled outcome of SF-36 at 3months showed worse in physical function and role physical, though moderate or minimal improvement were written in the other items. However, at 2 years after the operations, finally 6 of the 8 items of SF-36 showed marked improvement, showing great satisfaction of the patients. As to the papers of Japanese authors, we should also report patient satisfaction scale as SF-36 in addition to the follow-up results from surgeon's stand point.