

Increased Fusion Rates With Cervical Plating for Two-Level Anterior Cervical Discectomy and Fusion

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Study Design. A retrospective review of all patients surgically treated with a two-level anterior cervical discectomy and fusion with and without anterior plate fixation by a single surgeon.

Objectives. To compare the clinical and radiographic success of two-level discectomy and the effect of anterior cervical plate fixation.

Summary of Background Data. Prior studies of multi-segment fusions have shown decreased fusion rates correlating with the number of increased levels. The use of anterior plates for single-level cervical fusions is controversial. However, their use in multilevel fusions may be warranted because of the increased pseudarthrosis rates.

Methods. Over a 6-year period, 60 patients were treated surgically with a two-level anterior cervical discectomy and fusion by the senior author. Thirty-two patients had cervical plates, and 28 underwent fusions without plates. These patients were followed for an average of 2.7 years. Clinical and radiographic follow-up evaluations were performed.

Results. Of the 60 patients, 7 had a pseudarthrosis. The pseudarthrosis rates were 0% for patients with plating and 25% for those with no plating. This difference was statistically significant ($P = 0.003$). No correlation of pseudarthrosis with gender, age, level of surgery, history of tobacco use, or the presence of prior anterior surgery was found. There was significantly less graft collapse ($P = 0.0001$) in the patients without plates in whom pseudarthrosis developed (1.4 mm) than in those who had fusions with plates (0.3 mm). The amount of kyphotic deformity of the fused segment was 0.4° in patients with plating compared with 4.9° in those without plating who developed a pseudarthrosis ($P = 0.0001$).

Conclusions. The addition of plate fixation for two-level anterior cervical discectomy and fusion is a safe procedure with no significant increase in complication rates. The pseudarthrosis rates are significantly higher in patients treated without plate fixation. No nonunions occurred in the patients treated with plate fixation. There was significantly less disc space collapse and kyphotic deformity with the plated fusions than with the nonplated fusions, in which a pseudarthrosis developed. The complication rates for plated fusions are extremely low and do not differ from those for nonplated fusions. [Key words: anterior plates, cervical, discectomy, fusion, pseudarthrosis, spine] **Spine 2000;25:41–45**

Anterior cervical discectomy and fusion (ACDF), as originally described by Robinson,¹² is a highly suc-

cessful procedure when there is neural compression by disc material or osteophytes. With modified burring of the vertebral endplates, Bohlman et al^{1–3,8} demonstrated even higher fusion rates and successful outcomes. However, with multilevel procedures, the fusion rates decrease and are much lower than with single-level surgeries.⁹ The lower fusion rates have been attributed to the increased number of grafts and interfaces that must consolidate with multilevel surgery, and to the increased stresses on the multiple graft sites and the resultant micromotion.

Attempts to increase the fusion rates with two-level anterior cervical discectomies include the use of complete or subtotal vertebrectomies so that only two osseous surfaces (one single graft) need to heal to obtain a solid fusion.^{7,9} Other methods involve the use of anterior cervical plates across the entire fusion construct to provide increased stability and minimize micromotion at the bone-graft interface.^{4–6,7,13}

The use of anterior cervical plating in spinal surgery has increased recently. Several biomechanical studies have demonstrated the added stability provided by these plates, which theoretically may result in increased fusion rates.^{5,6,10,14} The use of cervical plating for single-level ACDF is controversial. Whereas some studies demonstrate increased single-level fusion rates and decreased reoperation rates with the use of cervical plate fixation, others show decreased fusion rates for single-level fusions with the use of plates because they may hold the disc space in distraction and prevent graft settling, which may be important in graft consolidation.^{4–6,15}

The purpose of this study was to compare the results, complications, and fusion rates for primary, two-level ACDF between patients with and those without anterior cervical plate fixation.

■ Material and Methods

All patients at the authors' institution having a two-level ACDF performed by the senior author were reviewed retrospectively. These patients all had disc herniation at two levels refractory to conservative management, which included the use of anti-inflammatory medications, physical therapy, and a period of rest and immobilization.

Patients with continued symptoms were offered surgical treatment consisting of an ACDF as originally described by Robinson.¹² All disc material was removed, along with endplate osteophytes, back to the posterior longitudinal ligament and the uncovertebral joints. Autogenous iliac crest bone graft

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Table 1. Odom's Criteria

Excellent	All preoperative symptoms relieved; abnormal findings improved
Good	Minimal persistence of preoperative symptoms; abnormal findings unchanged or improved
Fair	Definite relief of some preoperative symptoms; other symptoms unchanged or slightly improved
Poor	Symptoms and signs unchanged or exacerbated

was placed into the disc space after the endplates were removed with a high-speed burr.

Some of the patients were plated with an anterior vertebral body plate spanning the interspace fusion. Plate fixation was purely the choice of the operating surgeon and accomplished in a chronologic manner. The early patients were treated without plates, whereas the patients with more recent surgeries all had plate fixation. There were no significant differences between the groups. After surgery, all patients were treated with the same protocol consisting of immobilization with a hard cervical collar for 6 to 8 weeks. Radiographs were taken at 2 and 6 weeks after surgery, and then at monthly intervals until the fusion was judged to be solid or the presence of a pseudarthrosis was identified.

Follow-up radiography and clinical examinations were performed by the surgeon, and the medical records were reviewed extensively. Fusion was judged by the absence of motion between the spinous processes on flexion-extension lateral radiographs, the absence of a radiolucent gap between the graft and the endplate, and the presence of continuous bridging bony trabeculae at the graft-endplate junction. A pseudarthrosis was judged radiographically by the absence of bridging osseous trabecular bone from the vertebral bodies to the graft, motion on dynamic radiographs, and the presence of a lucent line at the graft-vertebral body junction. A pseudarthrosis was judged to be present after either a minimum follow-up assessment of 1 year had been carried out with the appropriate radiographic signs or the patient had undergone revision surgery. This was determined by the senior author. Clinical symptoms and neurologic findings were documented on follow-up assessment, and further cervical surgery also was documented. Hardware and graft complications were reviewed as well. All medical records, office charts, and radiographs were reviewed, and the information was entered into a spreadsheet database.

Outcomes were subjectively graded on the basis of patient symptoms at final follow-up assessment, use of pain medications, work status, and a subjective rating of the pain level. These were graded by Odom's criteria as listed in Table 1.¹¹

■ Results

A total of 60 consecutive patients (26 men and 34 women) who underwent adjacent two-level ACDF performed by the senior author between 1990 and 1996 were entered into the study. Thirty-two of these patients had fusions performed with the use of cervical plates, and 28 underwent fusions without the use of a plate. The average age of the patients was 47.6 years (range, 25–90 years), and did not differ significantly between patients treated with or without cervical

plates. Follow-up time averaged 2.7 years (range, 1–6 years). Plates were used in more patients who had surgery more recently than in patients who had undergone surgery farther in the past.

A pseudarthrosis developed in 7 of the 60 patients. No pseudarthrosis occurred in patients with a cervical plate. All seven pseudarthroses occurred in patients without plate fixation. The overall rate of pseudarthrosis in the group with an anterior cervical plate was 0%, whereas the rate of pseudarthrosis in the group without an anterior cervical plate was 25%. This difference was statistically significant ($P = 0.003$). No statistical correlation of pseudarthrosis with gender, age, level of surgery, or history of tobacco use was found.

When radiographic data between the two groups of patients was compared, differences were discovered. These differences are summarized in Table 2. The average amount of graft collapse for patients with plating was 0.3 mm (range, 0–4 mm) as compared with 0.6 mm (range, 0–6 mm) for all patients without a plate. This difference was not significant according to a nonparametric rank-sum test ($P = 0.256$). However, when the amount of collapse in patients with a plate (0.3 mm) and in those without a plate who developed a pseudarthrosis (1.4 mm) was compared, a statistically significant difference ($P = 0.0001$) was observed. In comparisons between patients with a plate (0.3 mm) and those without a plate who successfully fused (0.3 mm), no difference was found. In comparing patients without a plate, the difference between those who fused (0.3 mm) and those who did not (1.4 mm) also is statistically significant ($P = 0.0005$). The success of

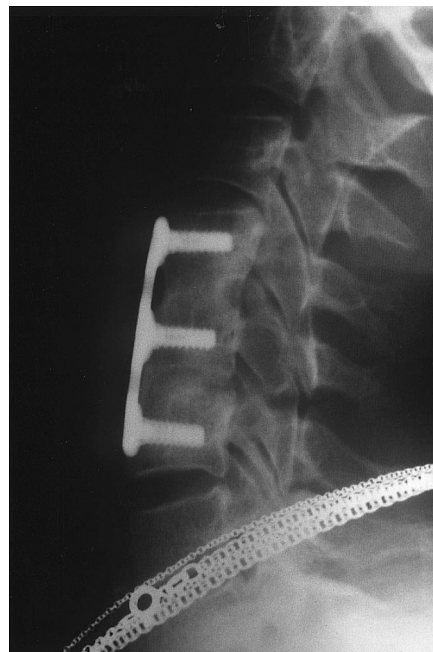


Figure 1. Lateral postoperative radiograph of a two-level anterior cervical discectomy and fusion using plate fixation with excellent preservation of anatomic alignment.

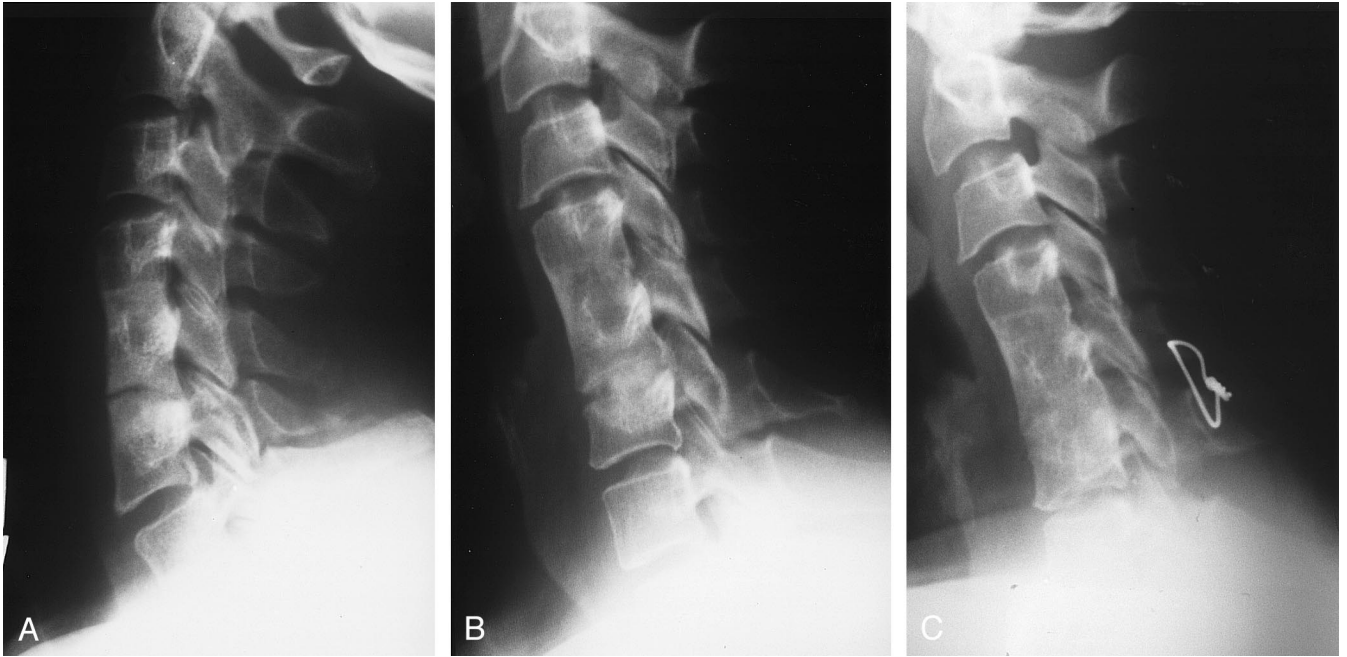


Figure 2. **A**, Immediate postoperative radiograph of a two-level anterior cervical discectomy and fusion without plate fixation, showing initial preservation of anatomic alignment. **B**, The same patient after the development of a pseudarthrosis at the lower fusion level. Note the collapse of the graft and the resultant kyphotic deformity at the level of the nonunion. **C**, Radiograph taken after posterior fusion, demonstrating healing of the pseudarthrosis. Note the residual collapse and kyphosis even after successful fusion.

the arthrodesis appears to decrease the amount of collapse significantly (Figure 1).

The average amount of kyphotic deformity of the fused segment was 0.4° (range, $0\text{--}2^\circ$) for patients with cervical plates, and 1.6° (range, $0\text{--}18^\circ$) for patients with no plates. This difference was not significant ($P = 0.459$). However, in comparing the amount of deformity between patients with a plate (0.4°) and those without who developed a pseudarthrosis (4.9°), a statistically significant difference was found ($P = 0.0001$). In comparisons between patients with a plate (0.4°) and those without who successfully fused (0.5°), essentially no difference was observed. When patients without a plate were compared, the difference between those who fused (0.5°) and those who did not (4.9°) also was statistically significant ($P = 0.0001$). The success of arthrodesis appears to decrease the amount of kyphotic deformity significantly.

Table 2. The Amount of Graft Collapse and Kyphotic Deformity Sorted According to the Use of a Cervical Plate and the Presence of a Fusion

	Collapse (mm)	Kyphosis ($^\circ$)
Plate + fused	0.3	0.4
No plate + fused	0.3	0.5
No plate + pseudarthrosis	1.4	4.9

The difference between the patient with no plate and a pseudarthrosis and all the other groups is statistically significant for both collapse and kyphosis.

Each pseudarthrosis occurred at the lower cervical fusion level, which was at C5–C6 or C6–C7. These two levels were the most common levels to be involved in the surgeries. All patients with a pseudarthrosis were moderately symptomatic and required further surgery to obtain osseous union. Overall, 25% of the patients without cervical plates had subsequent spinal surgery. These procedures were performed specifically to address the nonunion. The patients with plate fixation did not have any subsequent spinal procedures after the index operation. There were no complications related to the use of cervical plating.

A pseudarthrosis developed in 2 of the 6 smokers (33.3%), whereas a nonunion occurred in 5 of the 52 nonsmokers (9.6%). A pseudarthrosis developed in both of the smokers without cervical plates, but in none of the smokers with cervical plates.

Before surgery, all the patients had radiculopathy, with or without some component of axial neck pain. Of the 60 patients, 43 had subjective decreased sensation in the distribution of the compressed nerve root. A decreased reflex corresponding to the compressed nerve occurred in 23 patients, whereas 19 had at least a grade of weakness that corresponded to the compression.

No new deficits occurred as part of the surgeries. Postoperatively at final follow-up assessment, three patients had remaining weakness of at least one grade, whereas four had subjective residual decreased sensation. Radic-

Table 3. Results of Surgery Sorted According to Odom's Criteria

	Excellent	Good	Fair	Poor
Plate + fused	38% (12)	50% (16)	12% (4)	0% (0)
No plate + fused	29% (6)	57% (12)	10% (2)	4% (1)
No plate + pseudarthrosis	14% (1)	14% (1)	58% (4)	14% (1)

Note the percentage of good/excellent results is similar between the patients who fused, regardless of the use of a cervical plate. Inferior results are shown for the patients with a nonunion.

ulopathy developed in one patient at a level adjacent to the new onset adjacent segment disease, but did not require surgical intervention.

The results of the surgeries graded by Odom's criteria are listed in Table 3. The results in the patients with plates are markedly similar to those in the patients who fused without plates. The patients in whom a pseudarthrosis developed, all without cervical plates, demonstrate results inferior to those in patients who fused.

■ Discussion

Anterior cervical discectomy and fusion is a highly successful procedure with high fusion rates and excellent clinical results from the use of standard techniques without internal fixation.^{1-3,8,12} The application of internal fixation, in the form of rigid plating in other areas of the skeleton, have resulted in improved fusion rates because of added stability.

Interestingly, the literature is confusing as to the benefits of anterior cervical plating for single-level fusion. Previous studies have demonstrated increased fusion rates for single-level fusions with the use of cervical plating.⁵ However, some studies have demonstrated decreased fusion rates with plating for single-level fusions.⁴ The plate is believed to hold the disc-graft complex rigidly, which does not allow for small amounts of collapse and subsequent graft compression. This compression is thought to be necessary to promote fusion. Therefore, the plate may hold the complex in a slight amount of distraction, thus leading to decreased fusion rates.

The pseudarthrosis rates for single-level cervical fusions are low. Multilevel discectomies have decreased fusion rates because of the increased number of graft-bone surfaces that must heal and the increased instability and micromotion that results from multilevel disc excision.⁹ The pseudarthrosis rates for multilevel discectomies can range up to 54% for three-level procedures.⁹

In the current study, patients without cervical plate fixation experienced a higher pseudarthrosis rate. The pseudarthrosis rate for cervical plating was 0%, whereas the rate for patients without plating was 25%. This difference was statistically significant. The use of a cervical plate does appear to significantly affect the pseudarthrosis rate for primary adjacent two-level ACDF. Although plate fixation appears to be

controversial in single-level fusions, the use of cervical plates appears to be justified in two-level surgeries by significantly improved results.

In this study, significantly less graft collapse and resultant kyphosis of the fusion segment occurred in the patients treated with cervical plating than in patients without plates in whom a pseudarthrosis developed. There were no significant differences between the patients with a plate and those without a plate who fused successfully. Therefore, if successful osseous union occurs, the plate is not necessary to preserve the normal anatomic lordotic curvature of the cervical spine and prevent disc space-graft collapse. The benefits of the plate, in regard to collapse and kyphosis, appear to lie in the increased union rate that protects against deformity. Because no nonunions occurred in the patients with plates, it is not definitively known if the plate would preserve alignment in the presence of a pseudarthrosis.

The actual significance of preserving the normal contour of the cervical spine is not known. A kyphotic posture of the cervical spine may lead to the development of adjacent segment degeneration. However, a longer follow-up period is needed to confirm a relationship.

Although there are always potential hardware complications associated with the use of spinal instrumentation, the complication rate for cervical plating is extremely low. In this study, there were no complications associated specifically with the use of cervical plates. The overall complication rates for patients with plates and those without were exactly the same.

The fusion rates for two-level ACDF are significantly higher with the use of an anterior cervical plate. Cervical plating should be considered for patients undergoing a two-level adjacent ACDF to decrease the pseudarthrosis rate. The lower cervical level appears to be the most common site for a nonunion. The complication rates are not increased with the use of a cervical plate.

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Point of View

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This article provides more data to help determine the appropriate role of internal fixation for anterior cervical arthrodesis procedures. It is a solid clinical study that has strengths and weaknesses. My criticisms would be the lack of an outcome vehicle for evaluating the true clinical results of the procedure, which could be obtained through one of several validated questionnaire methods. It appears that the study was a retrospective chart review, with the primary surgeon, rather than a third party, evaluating the patient's clinical progress. The primary surgeon also evaluated the radiographs and determined union *versus* nonunion. It might have been preferable to have one of the other authors make this determination to ensure that the results were as objective as possible.

The greatest strength of this study is that it comprised a homogenous set of patients undergoing two-level anterior cervical discectomy and fusion procedures. Most of the literature on this subject is a mixed bag of single- and multilevel arthrodesis operations, which makes it difficult to sort out the data. Though the groups are not randomized or concurrent, the authors looked at the demographic data, and the patient populations were comparable. The fact that one surgeon did all of the procedures also provides a consistency of surgical technique, which strengthens the study.

I believe that this report provides good evidence of the ability of anterior plating on two-level anterior cervical

discectomy and fusion procedures to yield an increased union rate. The results of this study also show that bone grafts alone do not collapse or settle significantly, as long as a solid arthrodesis is achieved. This is an important point to remember in the near future; if bone morphogenetic proteins can overcome the pseudarthrosis problem, then internal fixation may not always be needed.

The authors have shown that pseudarthroses will result in some bone resorption and loss of height plus loss of lordosis. The clinical importance of the magnitude of these values is less clear. In this study, all pseudarthrosis patients were symptomatic enough to desire another operation. This finding is different from that of an earlier study on a large group of patients with cervical radiculopathy, where two thirds of the patients with pseudarthrosis had symptoms, but only 25% of those had enough problems to warrant operative repair.¹

The current study is straightforward and retrospective and can help guide us in the optimal care of our patients with cervical spine disorders. We need to await future prospective studies with concurrent groups of patients to help determine issues of return to work and cost effectiveness of current operative procedures.

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