

## An Outcomes Analysis of the Treatment of Cervical Pseudarthrosis With Posterior Fusion

Craig A. Kuhns, MD,\* Matthew J. Geck, MD,† Jeffrey C. Wang, MD,\*  
and Rick B. Delamarter, MD‡

**Study Design.** A retrospective review of 33 consecutive patients treated with posterior fusion and selective nerve root decompression for the treatment of pseudarthrosis following anterior cervical discectomy and fusion.

**Objectives.** Use standardized outcome measures to evaluate the results of posterior fusion with selective nerve root decompression as a treatment option for symptomatic pseudarthrosis of the cervical spine.

**Summary of Background Data.** Pseudarthrosis after anterior cervical discectomy and fusion has been recognized as a cause of continued cervical pain and unsatisfactory outcomes. Debate continues as to whether a revision anterior approach or a posterior fusion procedure is the best treatment for symptomatic cervical pseudarthrosis. To our knowledge, standardized outcome measures have not been used to evaluate the results of either surgical treatment option; therefore, it is difficult to evaluate outcomes in these patients, let alone compare surgical treatment options. Data on fusion rates in these two surgical treatment groups suggest a trend of a higher fusion rate with utilization of a posterior revision procedure, but the largest study to date includes the study of only 19 patients treated with a posterior fusion.

**Methods.** Thirty-three consecutive patients with symptomatic pseudarthrosis following anterior cervical discectomy and fusion were treated with selective nerve root decompression and posterior fusion using iliac crest or local bone graft as well as posterior wiring and/or lateral mass plating. The average follow-up period was 46 months (range, 20–86 months). Patients were assessed using physical examination, flexion-extension lateral radiographs, and standardized outcome measures including the SF-36, Arthritis Impact Measurement Scales 2, and Cervical Spine Outcomes Questionnaire.

**Results.** All 33 patients (100%) demonstrated a solid fusion at their most recent follow-up, and all 33 patients noted significant improvement in their preoperative symptoms. No difference in fusion status was noted between those treated with iliac crest *versus* patients treated with local bone graft—all had a solid fusion; 72% of the patients were satisfied with the result of their surgery. Cervical Spine Outcomes Questionnaire pain scales demonstrated 52% of patients reported mild or no

pain at follow-up, whereas 20% described their pain as “discomforting” and 28% of the patients continued to report moderate to severe pain.

**Conclusions.** This is the first study to our knowledge to use standardized outcome measures to assess clinical outcome in patients treated with posterior fusion for pseudarthrosis after anterior cervical discectomy and fusion. Patients and surgeons need to understand the potential for success with this revision procedure but also be aware of the relatively high rate of continued moderate to severe pain observed in this patient population even after a solid fusion is achieved. All of the patients in this study fused with a single posterior fusion procedure, further supporting the relatively higher fusion rates observed in the literature using posterior fusion as a treatment for cervical pseudarthrosis. Our results also support the ability of surgeons to use local bone graft without iliac crest in a posterior fusion for cervical pseudarthrosis and therefore avoid the morbidity associated with iliac crest bone graft harvest.

**Key words:** cervical, pseudarthrosis, posterior fusion, foraminotomy, outcome measures. **Spine 2005; 30:2424–2429**

Anterior cervical discectomy and fusion (ACDF) is a widely used technique for the operative treatment of cervical disc herniation, spondylosis, and stenosis. Despite findings that pseudarthrosis after attempted ACDF can be asymptomatic, pseudarthrosis is recognized as a potentially poor prognostic factor and is thought to be a common cause of persistent neck pain and/or radicular symptoms after ACDF.<sup>1–3</sup> The pseudarthrosis rate after ACDF has been reported as 0% to 20%<sup>2,4–8</sup> for single-level fusions and as high as 50% after multilevel fusions.<sup>6,9–13</sup> The number of fusion procedures has dramatically increased in recent times; therefore, the treatment of pseudarthrosis is an extremely important focus of study.<sup>14</sup>

Pseudarthrosis after ACDF has been treated with both posterior and anterior approaches.<sup>15–20</sup> Rationale for the posterior approach includes the advantages of avoiding the scar tissue and potentially difficult tissue planes encountered in a revision anterior approach, as well as encountering a fresh fusion bed when a posterior approach is used. Contraindications to the posterior approach include those problems that can only be addressed through an anterior approach such as graft migration or kyphosis. Advocates for a revision anterior approach suggest patients experience more stiffness and pain after a posterior approach secondary to disruption of the posterior musculature.

The literature contains surprisingly few reports on the treatment of cervical pseudarthrosis after ACDF using

From the \*UCLA Department of Orthopaedic Surgery, UCLA School of Medicine, Los Angeles, CA; †Spine Austin, Austin, TX; and ‡St. Johns Medical Center, Santa Monica, CA.

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Address correspondence and reprint requests to Craig A. Kuhns, MD, Washington University School of Medicine, Department of Orthopaedic Surgery, One Barnes-Jewish Plaza, 600 S. Euclid Ave. Campus Box 8233, St. Louis, MO 63110; E-mail: craigkuhns@yahoo.com

posterior cervical fusion; and to our knowledge, standardized outcome measures have not been evaluated with either an anterior revision procedure or a posterior fusion in this patient population. The largest study of posterior revisions was reported by Farey *et al*<sup>15</sup> and included the treatment of 19 patients with all of their patients reportedly going on to a solid fusion (100% fusion rate). The purpose of our study is to report the results of 33 patients with pseudarthrosis after ACDF who were treated with posterior fusion and selective nerve root decompression. Patients were evaluated clinically and with standardized outcome measures to more objectively and more completely evaluate this surgically treated patient population.

### ■ Materials and Methods

A series of 36 consecutive patients were managed operatively at a single institution because of symptomatic pseudarthrosis after anterior cervical discectomy and fusion. Eight of 36 patients underwent the initial ACDF at and outside institution. All 36 patients underwent an initial ACDF procedure that included bone graft placement as opposed to patients who undergo discectomy alone without bone grafting. Patients were excluded from the study if an ACDF was performed for a nondegenerative indication. Patients were also excluded if kyphosis or graft migration was noted, as these are thought to be indications for an anterior approach. All patients included had to have at least 18 months of follow-up from the revision procedure. Three patients failed to meet the inclusion criteria given that their follow-up was only 12 months. These patients moved from the region and were not able to be contacted, but at the 12-month follow-up, both patients were thought to have a solid fusion and both reported improvement in their preoperative cervical symptoms. Among the 33 patients with adequate follow-up, 12 were men and 21 were women, with an average age of 47 years (range, 28–63 years). Seven patients smoked, and 5 patients had Workers' Compensation claims or litigation pending.

The pseudarthrosis was identified based on radiographic criteria previously established.<sup>15,21</sup> A standard series of cervical radiographs were obtained, including lateral flexion and extension images that were reviewed by an experienced spine surgeon and radiologist. The diagnosis was based on the finding of a radiolucent gap between the graft and the vertebral body at the site of previous bone graft, a lack of bridging osseous trabeculae between the involved vertebrae, and/or more than 2 mm of motion between the affected spinous processes on flexion-extension lateral radiographs.

The initial ACDF was performed at a single-level in 9 patients, two levels in 14 patients, three levels in 9 patients, and four levels in 1 patient. The average time from initial ACDF to the index procedure was 16 months (range, 3–63 months). Most of these patients failed an attempt at nonoperative management, which included anti-inflammatory medication, cervical orthosis, and physical therapy.

All 33 patients evaluated in this study had complaints of axial neck pain, and 18 of these patients were noted to have radiculopathy manifested by arm pain, paresthesias, and/or weakness in a nerve root distribution. The pseudarthrosis was identified at one level in 26 patients and at two levels in 7 patients. Ten patients were noted to have significant adjacent segment disease and had the affected levels incorporated into

the posterior fusion. Seventeen patients underwent a single-level posterior fusion, with 6 at C5–C6 and 11 at C6–C7. Nine patients had a two-level posterior fusion, with 2 at C4–C6 and 7 at C5–C7. Six patients had a three-level fusion, with 1 at C3–C6, 4 at C4–C7, and 1 at C5–T1. There was 1 patient who had a four-level posterior fusion (C3–C7).

The surgical procedure included a standard midline posterior approach. Twenty-one patients had lateral mass plating, and all but 2 of these patients had supplemental spinous process tension band wiring using Rogers' wiring technique.<sup>7</sup> Twelve patients had wiring without plate fixation. Foraminotomies were performed in 18 patients and were reserved for patients who had evidence of nerve root compression on imaging and concurrent radiculopathy. The spinous processes, laminae, and facets were decorticated with a high-speed bur. Iliac crest bone graft was placed posterolaterally in 13 of 33 patients, and local bone graft was used in the remaining 20 patients. Iliac crest bone graft was reserved for those patients who smoke or had extension of their fusion secondary to adjacent segment disease.

After surgery, patients were maintained in a rigid cervical collar for 6 weeks or more, based on incorporation of bone graft. Clinical and radiographic evaluation, including flexion-extension radiographs, was performed at postoperative visits as part of routine follow-up (Figure 1). The average duration of

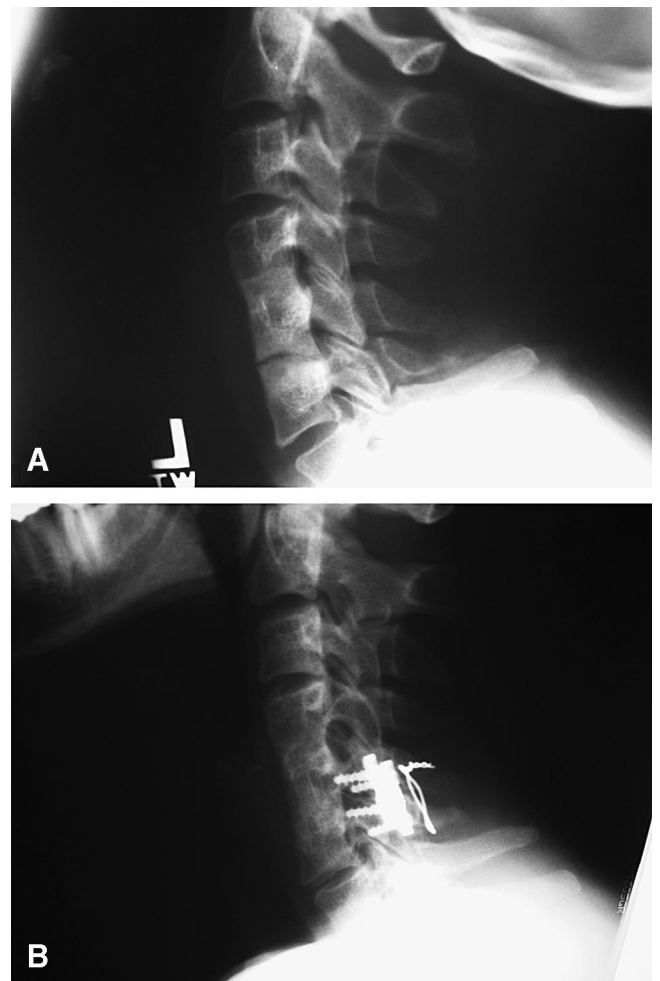


Figure 1. **A**, Preoperative lateral radiograph of pseudarthrosis at C5–C6 after previous C4–C5, C5–C6 ACDF. **B**, Lateral radiograph after posterior procedure demonstrating fusion at C5–C6.

follow-up after the revision surgery was 46 months (range, 20–86 months). Clinical results were evaluated for improvement in preoperative symptoms, fusion rate, and complications.

Attempts were made to have all patients complete outcomes questionnaires, which were either self-administered and mailed in, or administered by telephone. Twenty-five of 33 patients (76%) completed these previously validated questionnaires including the “upper extremity” and “hand” scales of the Arthritis Impact Measurement Scales 2 (AIMS2) standardized questionnaire,<sup>22,23</sup> the Medical Outcome Score Short Form-36 (SF-36),<sup>24,25</sup> and select measures from the Cervical Spine Outcomes Questionnaire (CSOQ).<sup>26</sup> The average time from the index procedure to completing the questionnaire was 50 months (range, 21–86 months).

**CSOQ.** The CSOQ “Pain Severity,” “Physical Symptoms,” and “Functional Disability” measures were used to evaluate patient outcome. Pain severity is assessed using standardized questions related to neck or arm pain. Responses are based on a 6-point scale with adjectives to describe pain (none, mild, discomforting, distressing, horrible, and excruciating). The “Physical Symptoms” measures were used to evaluate the presence of symptoms other than pain, such as numbness, clumsiness, weakness, or tingling in extremities. “Functional Disability” was assessed using questions indicating how much of the patients’ usual activities they were able to perform. Their choices of responses were “all,” “most,” “some,” and “none.” CSOQ measures have scales adjusted to range from 0 to 100 with lower scores indicating a more favorable outcome.<sup>20</sup>

**AIMS2.** The AIMS2 “hand and finger function” and “arm function” scales were specifically selected from this questionnaire and administered because of their relevance to the index procedure. The potential range of scores on AIMS2 scales is from 0 to 10, with a lower score indicating a more favorable functional status.

**SF-36.** SF-36 is a generic health status questionnaire that consists of 36 items and assesses eight health dimensions. A physical and mental component score is derived. The physical component scale ranges from 8 (low level of function) to 73 (high level of function). The mental component scale ranges from 10 (poor state of mental health) to 74 (excellent state of mental health).

**Statistical Analysis.** Statistical comparisons were made for continuous data using the two sample *t* test and the Fisher’s exact test where appropriate. The results for the entire group were presented with means and standard deviations. Estimated 95% confidence intervals can be obtained by taking the mean  $\pm$  2 standard errors (standard deviation divided by the square root of the sample size).

## ■ Results

A solid posterior fusion was obtained in all 33 patients. At the most recent follow-up, all patients reported improvement in preoperative symptoms.

Twenty-five of the 33 patients (76%) completed outcomes questionnaires with their results shown in Table 1. There was no significant difference between patients who completed questionnaires and the rest of the pa-

**Table 1. Outcomes Measures**

Measure	Mean $\pm$ Standard Deviation
Short Form-36*	
Physical component	35.9 $\pm$ 12.2
Mental component	46.2 $\pm$ 11.8
CSOQ†	
Neck pain	46.0 $\pm$ 36.2
Shoulder-arm pain	35.2 $\pm$ 34.4
Physical symptoms	56.0 $\pm$ 36.3
Functional disability	28.2 $\pm$ 31.4
AIMS2‡	
Hand and finger function	1.86 $\pm$ 2.64
Arm function	1.42 $\pm$ 2.26

\*SF-36 Physical Component scores range from 8 (low level of function) to 73 (high level of function), and Mental Component scores range from 10 (poor state of mental health) to 74 (excellent state of mental health).

†CSOQ measures have scales adjusted to range from 0 to 100, with lower scores indicating a more favorable outcome.

‡AIMS2 scales range from 0 to 10, with a lower score indicating a more favorable functional status.

tients in the study with regards to age, gender, smoking status, Workers’ Compensation status, preoperative symptoms, ACDF levels or number of levels, pseudo-level, time to revision, and revision procedure ( $P > 0.29$  for each).

Eighteen of the 25 patients (72%) who completed questionnaires reported being satisfied with the results of their posterior revision surgery. Four patients (16%) reported they were “not sure” if they were satisfied and 3 (12%) reported not being satisfied with their result. Results from CSOQ Pain Severity Scale revealed that 13 of these 25 patients (52%) reported mild or no pain and 5 patients (20%) described their pain as “discomforting.” Seven patients (28%) continued to report moderate to severe pain in the neck and/or arms with descriptions of their pain as either “distressing,” “horrible,” or “excruciating.” Only 3 of these 7 patients who reported moderate to severe pain were unsatisfied with the result of their surgery.

Each of the 7 patients who reported moderate to severe pain at follow-up had post-revision advanced cross-sectional imaging. All 7 patients were noted to have a solid fusion mass on computed tomography. Three of these 7 patients had no further surgical intervention. Two of the 7 patients with moderate to severe post-revision pain underwent instrumentation removal. Both of these patients reported only modest improvement in their pain after instrumentation removal. The remaining 2 of these 7 patients underwent unilateral foraminotomies at the levels of their posterior fusions. This procedure was performed at 14 months after the posterior revision procedure in both patients. Further improvements in radicular symptoms were reported, but both of these patients remained dissatisfied with the outcome of surgery. Cross-sectional imaging was repeated in both of these patients after the foraminotomies and failed to demonstrate any further neurologic compression.

Only 1 other patient in this series has had a subsequent cervical spine surgery for structural pathology,

and this was performed at an adjacent level to treat myelopathy secondary to a herniated disc.

No infections or complications related to lateral mass plates or posterior wires were noted. There was one complication in this series that included a retained fragment of a surgical drain requiring operative removal before discharge home from the hospital.

## ■ Discussion

There remains no randomized prospective study evaluating anterior *versus* posterior revisions in patients with symptomatic pseudarthrosis after ACDF. Debate over whether an anterior or posterior revision fusion procedure is better to address pseudarthrosis after ACDF continues. Accepted contraindications to a posterior revision approach include the presence of graft dislodgement or kyphotic deformity, which are typically better addressed by anterior approaches. Excluding patients with these findings, a posterior fusion procedure appears to be a very attractive surgical option in treating patients with cervical pseudarthrosis.

### Fusion

In the current study, which is the largest reported series of posterior revisions to our knowledge, all 33 patients (100%) went on to a solid fusion. This exceptional fusion rate is supported by other reports in the literature. The largest series other than the index study is that reported by Farey *et al*<sup>15</sup> in 1990. They reported on 19 patients with pseudarthrosis after ACDF that were treated with a posterior fusion and decompression procedure. All 19 patients (100%) reportedly fused with an average follow-up of 44 months.

In 1992, Brodsky *et al* reported on 34 patients with pseudarthrosis after ACDF.<sup>18</sup> Seventeen patients underwent a posterior revision and 17 had an anterior revision procedure. Sixteen (94%) of the patients in the posterior group went on to solid fusion and 13 (76%) of the patients in the anterior revision group fused. Posteriorly treated patients demonstrated superior fusion rates.

In 1995, Lowery *et al* reported results of treating 17 patients with a posterior revision procedure and 20 patients with a revision anterior procedure.<sup>17</sup> The posterior revision procedure included plate fixation and yielded a solid fusion in 16 of the 17 patients (94%). A solid fusion was obtained in only 9 of the 20 patients (45%) who underwent an anterior revision procedure using plate fixation.

Also in 1997, Phillips *et al* reported on 22 patients who underwent revision surgery for pseudarthrosis after ACDF.<sup>21</sup> All 6 patients (100%) who underwent a posterior fusion procedure were noted to have a solid fusion. Sixteen patients underwent a revision anterior fusion procedure using plate instrumentation, and 2 of these patients failed to fuse (88% fusion rate). These 2 patients who failed to fuse with the anterior revision subsequently fused after a posterior procedure.

As demonstrated in the aforementioned studies, excellent fusion rates are consistently demonstrated with a

posterior approach and the majority of reports in the literature suggest an overall higher rate of fusion with a posterior procedure compared with a revision anterior fusion. A few reports do suggest that a comparable fusion rate may be achieved using a revision anterior fusion procedure, the most notable of which was reported by Zdeblick *et al*.<sup>19</sup> They reported on the operative treatment of 35 patients with failed anterior cervical discectomy and fusion. Twenty-three of these patients were noted to have pseudarthrosis without graft dislodgement and were treated with revision anterior decompression and bone grafting. All 23 of these patients (100%) reportedly went on to solid osseous fusion.

The second study supporting revision anterior fusion was reported by Coric *et al*.<sup>27</sup> They reported on 18 patients who underwent anterior revision using plate fixation and bone grafting. A solid fusion was reported in all 18 patients (100%) with an average follow-up of 22 months (range, 12–42 months). An obvious shortcoming of this study was pointed out by the authors. The authors acknowledge their study population as being potentially skewed given that only 1 patient had anterior instrumentation at the time of their initial ACDF and 4 of the 18 patients included in the study were revised after having an anterior discectomy without fusion.

A study by Tribus *et al*<sup>20</sup> less clearly supports an anterior revision approach as the optimal treatment of cervical pseudarthrosis. This study reported the results of 16 patients with cervical pseudarthrosis who underwent anterior revision using plate fixation. With an average follow-up of 19 months, only 13 of the 16 patients (81%) were reported to have a Grade I or II radiographic fusion, although all sixteen patients were reportedly stable at follow-up.

### Bone Graft

With donor site morbidity from autogenous graft harvest being reported as high as 29%,<sup>28,29</sup> it is important to note that in our study no difference in fusion was noted between the 13 patients who had iliac crest bone graft *versus* the 20 patients who underwent local bone grafting; all patients demonstrated a solid osseous fusion. Iliac crest harvest was reserved for patients who smoke or had extension of their fusion secondary to adjacent segment disease. In the literature, there is routine use of iliac crest bone graft for anterior revision procedures and in all of the aforementioned studies on posterior revision procedures except that of Lowery *et al*.<sup>17</sup> Ten of the 17 patients treated with a posterior revision in their study had local bone graft only, but they failed to emphasize or report equal success between the iliac crest bone graft group and the group with local bone graft only.

All 20 patients treated with local bone grafting in our study went on to a solid fusion. Our results suggest that excluding those patients who smoke, have kyphotic deformity, graft dislodgement, or the need for adjacent segment fusion, one could use local bone graft alone and

spare patients the potential complications associated with iliac crest bone graft harvest.

### Complications

In the current study, no significant complications resulted from the approach or the placement of posterior instrumentation. A posterior fusion for cervical pseudarthrosis has a relatively low risk of complications when compared with the potential complications associated with the alternative treatment approach, a revision anterior fusion. Revision anterior procedures can be associated with complications that include injury to the recurrent laryngeal nerve, carotid or vertebral vessels, esophageal or tracheal perforation, as well as postoperative hematoma, dysphagia, or dysphonia.<sup>2,7,20</sup> In a recent study by Edwards *et al*,<sup>30</sup> adverse outcomes after anterior cervical arthrodesis have been underreported by as much as 80%; the prevalence of dysphagia and dysphonia is estimated to be between 40% and 60%. It would logically follow that anterior revision procedures would be associated with an even higher rate of complications given the inherent difficulties of dissecting through scar tissue and disrupted tissue planes.

### Outcome Measures

All 33 patients in the index study reported improvement in symptoms after the posterior revision surgery and 72% were satisfied with the results of the procedure. These results compare favorably with reports in the literature on the treatment with posterior or anterior revision procedures for cervical pseudarthrosis.<sup>15,17–21,27</sup> The previously cited references on anterior and posterior revision procedures all lack analysis using standardized outcome measures; therefore, many would suggest the results can be difficult to interpret as well as very difficult to compare with other treatment options. In our study, we used CSOQ, SF-36, and AIMS2 standardized outcome measures in an attempt to more objectively report results as well as to serve as comparative data for future studies. The most salient of these data seem to be the CSOQ pain scales with the finding that, although 52% of the patients reported mild or no pain, 28% of the patients continued to report moderate to severe pain at follow-up. Surgeons and patients faced with the treatment of cervical pseudarthrosis need to be aware of these data and therefore make more informed decisions on treatment.

The SF-36 physical and mental scores certainly correlated with AIMS2 and CSOQ scores ( $P < 0.001$ ), but the magnitude of this correlation was small. We found the SF-36 score to lack specificity with respect to the cervical spine, and it was more often influenced by other health problems encountered in an aging population. The SF-36 still serves as the best generic health status questionnaire and serves to compare populations and benefits provided by a wide range of treatments. The SF-36 may be a more specific outcome measure of cervical spine treatment in a young population where comorbidities are less common.

AIMS2 outcomes data are highly correlative with CSOQ scores, but to date there is a paucity of previous

studies using this outcome measure to assess degenerative disease of the cervical spine. This remarkable correlation further supports the future study and use of AIMS2 questionnaires as a routine outcome measure to be used in evaluation of all cervical spine conditions.

In a study by BenDebba *et al*,<sup>26</sup> CSOQ data were collected after surgery on patients who underwent anterior cervical fusions. Their published scores matched for the number of levels fused: neck pain,  $55.71 \pm 24.05$ ; shoulder-arm pain,  $55.02 \pm 21.11$ ; physical symptoms,  $58.4 \pm 21.56$ ; and functional disability,  $44.74 \pm 23.34$ . No statistically significant difference was observed between these scores and the CSOQ scores in the index study of posterior revisions. The significantly higher proportion of Workers' Compensation patients in the BenDebba *et al* study<sup>26</sup> may explain the overall trend for the patients in our study to have slightly better CSOQ scores. The similar scores between the two groups may suggest that, once a successful fusion is achieved in those patients with anterior cervical pseudarthrosis, their clinical outcome approaches that of the initial post-ACDF population. The index study serves as a very important step in our understanding of patient outcomes after posterior fusion for treatment of cervical pseudarthrosis and may serve as a more objective measure for future comparisons in treatment options.

### Conclusion

Posterior revision procedures offer patients with pseudarthrosis after anterior cervical discectomy and fusion an exceedingly high rate of fusion while potentially sparing the patient the donor site morbidity associated with iliac crest bone graft. Posterior revision with selective foraminotomies demonstrates reliable improvement in preoperative symptoms and an acceptable rate of postoperative patient satisfaction, but the surgeon as well as the patient need to be aware that a relatively high percentage of patients will continue to experience moderate to severe cervical pain after this revision procedure.

### Key Points

- Retrospective review of 33 patients who underwent posterior fusion with selective nerve root decompression for the treatment of symptomatic pseudarthrosis after anterior cervical discectomy and fusion.
- All 33 patients demonstrated a solid osseous fusion.
- Outcome measures including AIMS2, CSOQ, and SF-36 were used to more accurately assess clinical outcome and to serve as data for future comparisons of treatment options for patients with symptomatic pseudarthrosis after anterior cervical discectomy and fusion.
- A total of 72% of the patients were satisfied with the result of their posterior revision surgery, but 28% of patients continued to report moderate to severe pain after revision surgery.

- Local bone graft alone achieves successful fusion when using a posterior fusion procedure for pseudarthrosis after anterior cervical discectomy and fusion, sparing patients the morbidity associated with iliac crest bone graft harvest.

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