

Graft Migration or Displacement After Multilevel Cervical Corpectomy and Strut Grafting

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Study Design. A retrospective review of consecutive patients with graft migration or displacement after anterior cervical corpectomy surgery was performed.

Objectives. To examine the associated risk factors and results of treatment among patients who sustained graft displacement or migration after anterior cervical corpectomy surgery.

Summary of Background Data. Graft migration or displacement after anterior cervical corpectomy is a potential complication that may require revision surgery, but because of the low incidence, the factors associated with graft movement and the results of treatment are not well defined.

Methods. All patients who had undergone a cervical corpectomy were examined for graft migration or displacement. None of the patients had a previous cervical laminectomy or prior posterior cervical surgery. All the patients were treated with autogenous strut grafting after decompression.

Results. Over a 25-year period, 249 consecutive patients underwent one- to five-level anterior cervical corpectomies and strut grafting. All the patients were fused using autogenous bone grafts (iliac crest or fibula). During the postoperative period, 16 of the patients (10 women and 6 men; average age, 61.4 years) experienced migration of their grafts. The average follow-up period was 4.7 years (range, 2–12 years). The graft migration rates increased with more levels of fusion (odds ratio of 1.65 for having a displaced graft with each additional level): 4 of 95 single-level grafts, 4 of 76 two-level grafts, 7 of 71 three-level grafts, and 1 of 6 for four-level grafts. Of the 16 patients with graft migration, 14 had procedures involving a corpectomy of C6 with a fusion inferiorly extending to the C7 vertebral body ($P = 0.001$, statistically significant difference). Of these 16 patients, 5 underwent revision surgeries acutely for displacement and associated fracture of the inferior graft and vertebral body junction. None of the patients sustained a neurologic or respiratory complication as a result of graft migration or displacement. All of the patients went on to successful fusion.

Conclusions. This study demonstrated that a greater

number of vertebral bodies removed and a longer graft are directly related to an increased frequency of graft displacement. Graft displacement may require revision surgery, but no patient in this study experienced a permanent adverse result from this complication. Corpectomies involving a fusion ending at the C7 vertebral body were associated with a higher rate of graft migration. [Key words: cervical, corpectomy, fusion, graft displacement, myelopathy, surgery] **Spine 2003;28:1016–1022**

Cervical corpectomy is commonly performed in the presence of multilevel cervical degenerative osteoarthritis, and typically requires the use of long anterior strut grafts.^{1–3} A complete decompression often involves resection of the central vertebral body, including the posterior cortex, leaving only the lateral sides of the body and the posterior longitudinal ligament remaining.⁴ Although this procedure can lead to a complete neurologic decompression and excellent clinical results, graft complications can occur. The incidence of graft displacement is not well defined, and migration or dislodgement of these long strut grafts may impinge on surrounding vital anatomic structures or result in a pseudarthrosis.^{4–8}

Posterior migration can lead to compression of the spinal cord and result in paralysis or neural injury. The esophagus can become compressed or perforated by an anteriorly dislodged graft, and tracheal impingement may produce airway obstruction.

Because of the low incidence, factors contributing to graft migration are not well known. The purpose of this study was to examine the causes of graft displacement in a large series of multilevel cervical corpectomies and fusions.

■ Methods

A retrospective review included 249 patients who had undergone anterior cervical corpectomy and fusion with autogenous strut grafting at one institution for cervical stenosis with multilevel disc herniations and spondylosis causing neural compression. All of the patients were refractory to conservative management. The surgical treatment consisted of an anterior cervical corpectomy and fusion without plate fixation using autogenous tricortical iliac crest bone graft for the one-level procedures and most of the two-level procedures. Autogenous fibula was used for some two-level procedures and all procedures involving three or more levels.

The corpectomy consisted of complete removal of the central vertebral body including the posterior cortex of the involved levels. The endplates were machined with a high-speed burr to remove the cartilaginous endplates down to bleeding bone. The superior and inferior vertebral bodies targeted to

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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

accept the upper and lower portions of the graft were machined to leave an anterior lip of 1 to 2 mm that would help prevent the graft from sliding anteriorly and help lock the graft into position.

After surgery, all the patients were treated with the same protocol, which consisted of immobilization with a two-poster brace for 6 to 8 weeks. The halo vest was used for one three-level and all four- and five-level surgeries. Radiographs were taken 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 radiographs and clinical examinations were obtained by the surgeon, and the medical records were reviewed by an independent observer. Solid arthrodesis 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 junction of the graft and vertebrae. A pseudarthrosis was defined radiographically by the absence of bridging trabecular bone from the vertebral bodies to the graft, motion on dynamic radiographs, and the presence of a lucent line at the junction of the graft and vertebral body during a minimum 1-year follow-up period or until the patient had revision surgery. Clinical symptoms and neurologic findings were documented at follow-up assessment, and further cervical surgery was documented. 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 the final follow-up assessment, use of pain medications, work status, and subjective rating of the pain level. These were graded according to Odom's criteria, as listed in Table 1.⁹

■ Results

Over a 25-year period from 1972 to 1997, 249 patients underwent a one- to five-level anterior cervical corpectomy and fusion: 95 single-level, 76 two-level, 71 three-level, and 6 four-level corpectomies, as well as 1 five-level corpectomy. Autogenous iliac or fibular bone graft without plate fixation was used. Of the 249 patients, 16 (10 women and 6 men) experienced grafts that migrated or displaced during the postoperative period. The type of graft used did not correlate with graft migration or displacement. The average age of the patients was 61.4 years (range, 34 to 80 years). The average follow-up period was 4.7 years (range, 2 to 12 years).

Graft migration occurred in 4 of the 95 single-level, 4 of the 76 two-level, 7 of the 71 three-level, and 1 of the 6 four-level corpectomies. The graft did not migrate in the one patient who had a five-level procedure. These results are shown in Table 2.

Table 2. Graft Migration

Corpectomy Levels	Total Patients With Surgery	Patients With Displaced Grafts	Incidence of Graft Displacement
One level	95	4	4.2%
Two levels	76	4	5.3%
Three levels	71	7	9.9%
Four levels	6	1	16.7%
Five levels	1	0	0%

Although the migration rates increased with the greater number of levels decompressed, the statistical relation to level based on a logistic regression analysis is not statistically significant ($P = 0.112$). This results from the fact that the sample size was small for the high levels. Even for the three-level corpectomies, 7 of the 71 patients sustaining graft migration (9%) had a 95% confidence interval of 4.1% to 19.3%. However, the estimated odds ratio still is 1.65 for an increased risk of having a displaced graft with each additional level.

Of the 16 patients who had graft migration, 14 involved a corpectomy that included the sixth cervical vertebral body with a fusion ending at the C7 vertebrae. The remaining two patients with graft migration had single-level corpectomies ending at the C6 vertebrae. There was no graft migration with the two-, three-, four-, and five-level corpectomies if the fusion did not end at C7. According to logistic regression analysis, ending the fusion at C7 is statistically associated with graft migration or displacement ($P = 0.001$; odds ratio, 10.7; 95% confidence interval, 2.4–48.4).

Of the 16 patients with graft migrations, 5 had complete dislodgements anteriorly, with an associated fracture of the inferior seventh cervical vertebrae. All five patients required revision surgery, which involved a corpectomy of the fractured inferior vertebral segment and placement of graft to the seventh cervical or first thoracic vertebra. In four of the five patients, a subsequent posterior cervical fusion with autogenous iliac crest bone grafting was performed with spinal instrumentation consisting of either interspinous wiring or lateral mass plating.

All five patients with complete dislodgement of their grafts and fracture of the inferior vertebral body presented with acute neck pain and subjective feelings that something had moved in their neck. Three of the patients had prior episodes of nausea with emesis thought to have resulted in the graft migration. None of the patients with complete dislodgement or simple migration of their graft had any neurologic or respiratory compromise either acutely or after revision surgery. Two of the patients had transient difficulty swallowing immediately after displacement. Two patients had graft migration identified within 4 days during the hospital stay. Each of these patients had an episode of emesis thought to predispose to increased stress on the graft. The other 14 patients

were discovered to have migration 2 to 6 weeks after surgery during their first or second postoperative visits, when radiographs were taken.

Of the 16 graft migrations, 11 migrated anteriorly and inferiorly, whereas 5 migrated posteriorly at the superior end. The 5 patients that required revision surgery had migration 10 to 16 mm from their initial postoperative position, while the 11 patients without revision surgery had 3 to 8 mm of migration. Patients with more than 8 mm of migration from their initial postoperative position eventually displaced and required revision surgery. Of the 11 patients with graft migration but no fracture or complete dislodgement of their grafts, none required revision surgery, and all were maintained in their two-poster orthosis, although one was placed in a halo vest. All the patients fused successfully without any pseudarthrosis or further displacement of their grafts.

All 16 patients went on to a solid arthrodesis during a mean follow-up period of 24.2 months (range, 12–54 months). Odom's criteria demonstrated that all patients had a good or excellent result after successful fusion. One patient had subsequent surgery at an adjacent level for the development of adjacent-segment degeneration and associated radiculopathy.

■ Discussion

Cervical corpectomy and fusion with strut grafting is a commonly performed procedure for cervical stenosis when there is anterior compression of the neural elements. This procedure is associated with excellent results in terms of neurologic recovery and high fusion rates.^{4,10,11} The length of the strut graft depends on the number of levels that need decompression. The iliac crest is used for one- and two-level corpectomies. Longer fusions require fibula graft.^{12,13}

Graft migration or displacement is among the more significant complications of this procedure, but there is a paucity of literature examining the factors commonly associated with this problem or explaining how to rectify it. The current study examines a large series of patients who had cervical corpectomies performed at a single institution and analyzes the patients that sustained graft migration or displacement.

Although there appear to be differences in the stability of the constructs comparing single-level and multilevel procedures, the postoperative immobilization for this group of patients used either a two-poster rigid orthosis or a halo. This study attempted to identify factors associated with graft migration and dislodgement to determine which procedures may require more stable postoperative immobilization. It also examined the immediate results after these graft complications occurred and noted which proper treatment was instituted.

The incidence of graft migration appears to be associated with the length of the graft and the number of levels involved in the surgery. Single-level corpectomies have the lowest incidence of graft migration, and the incidence increases with each additional level. This is



Figure 1. Lateral preoperative magnetic resonance image demonstrating three-disc-level pathology compressing the neural elements in a patient with cervical myelopathy. Neural impingement is present at C4–C5, C5–C6, and C6–C7, with associated degenerative disc disease at each level.

despite the use of a more rigid and stable postoperative immobilization in halo vests for the four-level procedures, as compared with two-poster braces for one-, two-, and three-level surgeries.

In addition to graft length, the actual level fused appears to have an effect on graft stability. Of the 16 patients with graft migration, 14 involved C6 as the caudal corpectomy, with the fusion extending to the C7 vertebral body. The remaining two patients had single-level corpectomies ending at C6 and a history of emesis in the postoperative period thought to have resulted in movement of the graft. Two-level corpectomies extending to C7 have a higher rate of migration than three-, four-, and five-level corpectomies that did not extend to C7, an example of which is shown in Figures 1 to 5. No long fusion (two levels or more) had a problem with graft migration when it extended only down to C6. The association of a fusion extending down to C7 with graft displacement is most likely related to the cervical lordosis in conjunction with the kyphotic angulation associated with the sagittal inclination at the cervicothoracic junc-

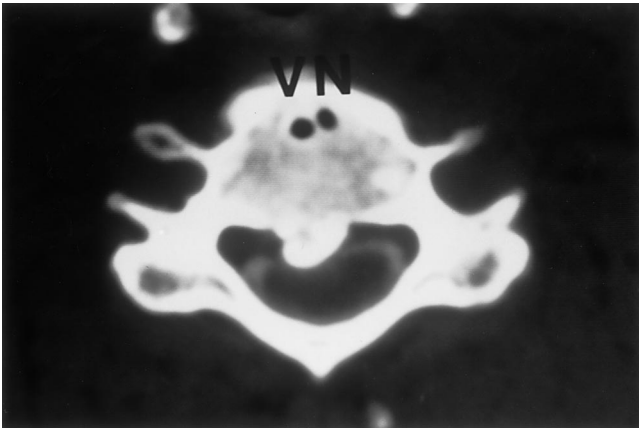


Figure 2. Axial computed tomography myelogram of same patient as in Figure 1 demonstrating compressive osteophytes contributing to the spinal cord compression.

tion. This sharp angular change is most likely associated with increased stress at the graft endplate interface, resulting in a higher probability of graft extrusion.

Fusions that extend down to C7 should be performed carefully to ensure that the graft is seated. Care should be



Figure 3. Lateral postoperative radiograph after two-level corpectomy of C5–C6 with a single strut graft extending from C4 to C7.



Figure 4. Lateral radiograph demonstrating anterior dislodgement of the strut graft after surgery.

taken to preserve as much of the anterior cortex of the lower vertebral body as possible to resist fracture and allow for a strong inferior anchor. Other factors also could be considered for those fusions that end at C7 to help prevent graft migration. A cervical buttress plate may be used, although this is not a guarantee against extrusion. In addition, more rigid postoperative immobilization such as a halo vest or cervicothoracic orthosis and the addition of posterior cervical fusion could be considered for these patients.

This study documents the incidence of graft migration associated with the number of levels involved. Of the 16 graft migrations, 11 were not associated with complete dislodgement or fracture, and were successfully managed with careful observation and continued immobilization. One of the 16 patients was placed in a halo vest for more rigid immobilization. The patients in this group all healed completely without any long-term adverse effects or neural damage from the graft movement. These patients all had migrations no greater than 8 mm. The patients that presented with postoperative graft movement but not complete dislodgement and without signs of neural or respiratory compromise or dysphagia did not re-

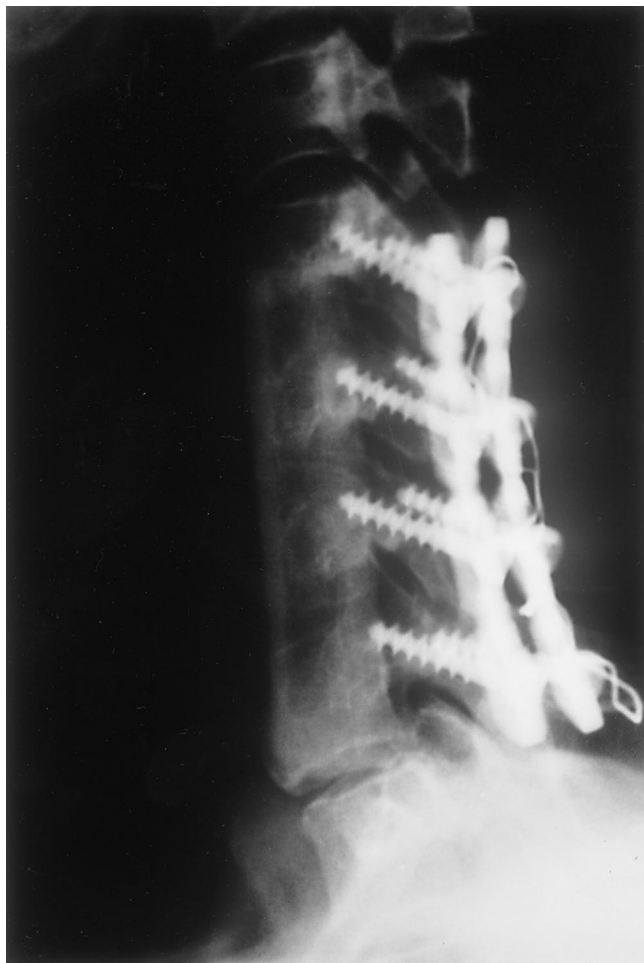


Figure 5. Lateral radiograph after revision of anterior graft and subsequent posterior spinal fusion with lateral mass plates.



Figure 6. Lateral radiograph of a tolerably migrated graft treated with halo vest immobilization without surgical revision.

quire revision surgery and healed without long-term problems. If the patient has less than 8 mm of migration without complete displacement or fracture, more rigid postoperative immobilization by the placement of a halo vest should be considered until there is evidence of osseous healing.

Five patients with more than 8 mm of graft migration at initial presentation eventually had further displacement and required revision surgery. These patients presented with increased pain, but no breathing problems or signs of neurologic compromise. Such patients can be managed successfully with revision of the lower vertebral endplate or extension of the corpectomy beyond the fractured segment to the next lowest level with additional grafting. Subsequent posterior cervical stabilization with interspinous process wiring or lateral mass plating and posterior cervical fusion also should be performed. Managed in this fashion, the patients in this study sustained no long-term adverse neurologic problems or other problems such as difficulties with swallowing or breathing.

For long corpectomies of three or more levels that end caudally at C7, some type of supplementary stabilization should be considered. Graft migration may occur in one

fourth of the patients in this situation even with the use of halo vest immobilization. In these situations, the authors now consider the addition of a posterior cervical fusion to add stability, or they consider performing a

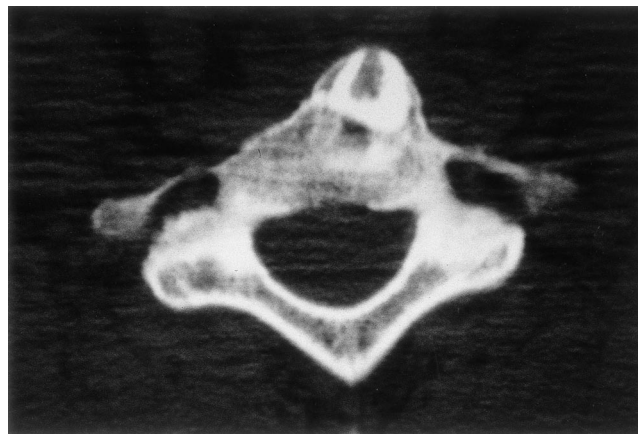


Figure 7. Computed tomography scan of a tolerably migrated graft that demonstrated healing of the inferior edge of the graft to the C7 vertebral body. The patient did not require revision surgery.

posterior decompressive procedure as long as there is cervical lordosis instead of an anterior decompression.

Cervical corpectomy and fusion with autogenous strut grafting has an increasing migration–displacement rate with the increasing number of segments removed and the increasing length of the graft. Decompression involving the C6 vertebral body with fusion ending at C7 is associated with a higher rate of graft migration and displacement. Fusions extending to C7 should be performed with careful attention to surgical technique, and additional stabilization or postoperative immobilization should be considered to protect against graft migration. Patients in whom graft migration or complete dislodgement develops can be treated successfully without permanent long-term adverse consequences. Figures 6 and 7.

■ Key Points

- The risk of graft migration or displacement increases with the number of levels decompressed and the length of the strut graft.
- Corpectomies that involve a fusion that ends at C7 appear to have an increased probability of migration or displacement.
- The results of treatment for this complication appear to be favorable.

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■ Point of View

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This important article from an unequivocally acknowledged leader in spine surgery demands reflection on what some might consider refinements in cervical corpectomy surgery, namely, instrumentation. One question from Wang's data asks whether spine surgeons, while lacking first-class evidence of safety and efficacy, have bought too avidly into the role of anterior cervical instrumentation for the otherwise stable cervical spine.

In this era of spinal hardware, perhaps no procedure has spawned endorsement for plates and screws more than cervical corpectomy. Such instrumentation is based on the intuitive logic of “internal orthosis” as a means for avoiding the consistently reported graft morbidity of cervical corpectomy for degenerative disease. The fact that in the experienced hands of these authors (249 cases without hardware) only 2% of the patients required reoperation challenges the risk and expense of routine hardware use. My own experience with similar case numbers is not quite so laudable, but nevertheless has left me a lonely hardware skeptic. My bias is that with prac-

tice the carefully crafted multilevel graft probably is as secure as it can be, hardware and orthoses notwithstanding. The failures can and should be dealt with according to the precise nature of the individual problem, the arguable exception being the very long strut that can be further secured by concomitant posterior stabilization, as the authors suggest.

Two forms of graft morbidity are described by the authors: complete displacement and incomplete displacement. Only the former is said to require surgical revision. Complete displacement, in my experience, occurs during the immediate postoperative period, is an elementary radiographic diagnosis, and, as pointed out, is ordinarily without predictable symptoms. The authors found that incomplete displacement was the most frequent graft problem, and I would have to agree. Although they define graft position change short of complete displacement only in millimeters of “migration,” in my experience, this is associated with subsidence or angulation. Short of the potential for painful pseudarthro-

sis, which was not encountered in this series, there does not appear to be any clinical consequence, no matter how disappointing the radiographs! Indeed, they found no incidence of nonunion in this group, but it should be noted that all their struts were autograft bone. Furthermore, there also was no consequential morbidity associated with surgical revision of the complete displacements. In effect, beyond the “embarrassment” of needing to revise or admit to a less than perfect radiographic picture, there was no morbidity in their experience with graft “migration displacement.” This, also, has been my experience.

It is implied that the authors’ graft success is not so much a reflection of their skill from experience as the authority of their four posters and halo vests: “for three or more levels that end caudally at C7, some type of supplementary stabilization should be considered.” Admittedly, my graft success has not been so good as theirs. My acute revision rate is 6%. If one accepts the differential between their 2% displacement and my 6% as reflecting the impact of the less authoritative Philadelphia Collar used in my series, the additional 8% of allowed motion with the latter orthotic¹ must be viewed as a critical compromise. I find this unlikely because most of my displacements resulted from technical errors that I argue could not have been prevented by orthosis or anterior hardware. Actually, there are no conclusive studies to support the use of any particular orthotic after anterior cervical spine surgery for degenerative disease.

The concept of “internal orthosis” with hardware also is tenuous. The unique spondylotic challenge of the myopathic dystonic should be considered. In my experience, it usually is naïve in such cases to attempt graft protection with either implanted hardware or orthotics.

The factor of inherent morbidity associated with mortising to C7 is an important observation emphasized in this article. I am not certain that this reflects anything more significant than the fact that long grafts usually must involve C7. Admittedly, in our series of 31 long grafts,² the small numbers are inconclusive, but of the 3

displacements, 2 were categorically because of technique and selection. One fractured out of a terribly osteoporotic 75-year-old C7, and the other out of C2 because of an overly long strut placed with excessive distraction. In any event, my sense is that the inherent hazard at C7 is not as compelling as the authors’ 25% seems. Therefore, the routing concomitant posterior fusion with the grafting of C7 is overkill.

In a further focus on C7, there is the technical admonition that C7 should not be overly weakened (“preserve as much of the anterior cortex . . . to resist fracture and allow for a strong inferior anchor”). This is important advice not only for C7, but also for caudal mortising in general. Actually, in my view, no anterior cortex need be or should be taken because the dorsal-to-ventral angle of the caudal interspace is cephalad–caudad. The caudal mortise site is perfectly suited for complete preservation of the anterior endplate cortex as it joins the cortex of the anterior body. In effect, the seat for the graft can be confined entirely to the bony endplate. Apropos to the instrumentation debate, it is doubtful that a caudal buttress plate with a screw-hole violation of the anterior cortex could be more robust than a deep mortise in the bony endplate completely sparing the anterior cortical “corner.”

In the final analysis, the Wang group has shown elegantly that with experience, bone grafting in cervical corpectomy can be achieved successfully in the vast majority of cases without implanted anterior hardware. The reader must be impressed by the fact that in the cases wherein radiographic perfection was wanting, and even in those requiring surgical revision, there was no consequential morbidity. I am not confident that the same can be said for the occasional problems seen with the use of anterior plates and screws.

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