The surgical management of cervical spondylosis has evolved over time. Anterior cervical fusion has been considered by many experts to be the mainstay of treatment since its introduction by Cloward in 1953. Its advantages include providing cervical spine stability and maintaining cervical lordosis. Although the notion of interbody fusion is not new, the choice of fusion material for use in the reconstruction of osseous defects following decompressive anterior cervical surgery remains controversial. The use of autologous iliac crest bone, once considered the graft material of choice, has been questioned because of its harvesting-related morbidities. One alternative to autologous iliac crest bone has been allograft, but in many studies, it has not been demonstrated to yield comparably high fusion rates, although this point remains controversial.

More recently, the placement of anterior cervical cages for reconstruction after discectomies and corpectomies has been described. Cage-assisted reconstruction has been shown to confer biomechanical advantages in the anterior spinal column because of the rigidity provided by the construct. Additionally, by using the autologous bone from the corpectomy, the disadvantages of autograft harvesting, including donor site pain, fracture, and poor bone quality, are avoided. We report our experience with titanium cage– and ACP-assisted reconstruction in 45 patients who underwent decompressive cervical corpectomy for the treatment of various nontraumatic diseases.

**Clinical Material and Methods**

We conducted a retrospective review of cases managed between January 1998 and December 2001. We identified 45 patients (age range 37–77 years [mean 55 years]) who underwent decompressive anterior cervical corpectomy followed by fusion and titanium cage–augmented reconstruction. In general, corpectomies were performed when there was evidence of disease behind the VB. Of the 45 patients, 26 presented with myelopathy, 12 with symptoms of myeloradiculopathy, four with multilevel radiculopathy, one with an intradural extramedullary hemangiopericytoma, and one patient presented with persistent neck pain and radiographic evidence of failed fusion and screw back-out after having undergone a C-6 corpectomy with fibular allograft. Apart from the one patient harboring a tumor, all others suffered from degenerative disease. Patients with traumatic injuries were excluded from the study.

All patients underwent surgery via a right-sided anterior cervical approach. A generous corpectomy at the desired levels was performed. The posterior longitudinal ligament was removed, and dura mater was widely exposed along the entire length of the corpectomy. Titanium cages (Pyramesh; Medtronic Sofamor Danek, Memphis, TN) were packed with bone obtained during the corpectomy and placed into the defect, under fluoroscopic guidance, following manual cervical distraction. In all cases, autologous bone was also obtained from bone fragments col-

**Object.** The authors evaluated the efficacy of titanium cage– and anterior cervical plate (ACP)–augmented fusion for reconstruction following decompressive cervical corpectomy in nontraumatic disease.

**Methods.** Forty-five patients ranging from 37 to 77 years of age underwent anterior cervical corpectomy followed by titanium cage–assisted reconstruction in which the cages were filled with autologous bone obtained from the resected vertebral bodies (VBs). Plates were placed in all patients. Follow-up radiographic evaluation included computerized tomography scanning and plain flexion–extension radiography.

Fusion was demonstrated in all but one patient without reconstruction-related complications. The single complication involved an endplate VB fracture with pistoning of the cage into the VB. The mean follow-up period was 12.9 months.

**Conclusions.** Autologous corpectomy bone–filled titanium cages supplemented with ACPs are an effective means of reconstruction after compressive cervical corpectomy. This technique provides a reasonable alternative to procedures involving long solid strut grafts obtained from the bone bank or from the patient.

**KEY WORDS**

- titanium cage
- cervical spine corpectomy
- reconstruction
- spinal fusion
lected using rongeurs and Kerrison instruments. We did not use bone remnants created during drilling. Leftover bone was packed along the gutters surrounding the cage. In all but one case, we used the patient’s own bone from the corpectomy defect alone to fill the cage. In the one patient with screw backout and failed fibular allograft–assisted fusion following a C-6 corpectomy, autologous iliac crest bone graft was used to fill the cage. Of note, in the failure resulting in reoperation for progressive deformity, we used the autologous corpectomy bone obtained at the additional corpectomy level as well as that where the titanium cage was removed. Additional fusion material, such as demineralized bone matrix, was not used in any patient.

All patients underwent placement of ACPs (Atlantis cervical plates and screws; Medtronic Sofamor Danek). No patient, including the five who underwent three-level corpectomy, were required to wear a postoperative orthosis. Follow-up radiographic evaluation to determine fusion included CT scanning and/or plain flexion–extension radiography. All patients underwent CT scanning within 24 hours of surgery to assess the position of the instrumentation and extent of decompression. At or after 6 months postoperatively, eight patients underwent CT scanning and two patients underwent flexion–extension radiography only to assess the success of fusion. Thirty-five patients underwent both CT scanning and flexion–extension radiography at or after 6 months.

Flexion–extension radiographs and CT scans were analyzed for evidence of progressive deformities, screw or plate backout, and movement or pistoning of the cage construct. Flexion–extension x-ray films were evaluated for signs of abnormal movement; sagittal reconstruction CT scans were analyzed for evidence of lucencies or pseudarthrosis. We believed that with this information we could ensure a solid fusion had been achieved.

Patients in whom posterior fusion or instrumentation procedures were planned or those with fewer than 6 months of follow-up data were excluded from the study.

Results

In 44 (97.8%) of 45 patients a solid arthrodesis was achieved without complications related to the cage and plate reconstruction, based on cervical CT scans or flexion–extension x-ray films. Twenty-three patients underwent a one-level, 17 a two-level, and five a three-level corpectomy. The follow-up period ranged from 6 to 33 months (mean 12.9 months). Cervical fusion rate was determined by means of cervical CT scanning and/or flexion–extension radiography.

Four patients underwent two-level corpectomies and discectomies at adjacent levels. Fibular allograft bone was used to fuse the discectomy sites, and this required extension of the ACP implant. Patients in whom placement of posterior instrumentation was planned were excluded from the study.

Of note, one patient underwent a one-level posterior hemilaminectomy at the time of surgery. He was a 64-year-old man who presented with progressive myelopathy. Preoperative magnetic resonance imaging revealed severe multilevel spondylosis, abnormal signal intensity within the spinal cord at C5–6 and significant anterior and posteroir compression. Because of the extent of his disease, he underwent C-5 and C-6 corpectomies followed by titanium mesh cage– and ACP-assisted fusion; additionally, we performed posterior decompression via a unilateral approach involving C5–6 hemilaminectomies with bilateral decompression and removal of the ligamentum flavum.

Representative images obtained in one case, a 55-year-old woman with severe cervical stenosis, are presented in Fig. 1. The patient underwent C-5 and C-6 corpectomies and titanium mesh cage–augmented fusion in which the cages were packed with autologous corpectomy bone. The immediate postoperative radiographs are shown in Fig. 1A and B. Postoperative Day 1 axial CT scans (Fig. 2 upper) can be compared with those acquired 1 year following surgery (Fig. 2 lower) which reveal extensive bone growth and fusion surrounding the titanium mesh cage, thereby creating a solid osseous construct, a pattern observed in almost all these patients.

Apart from the one radiographically documented failure (see the next section), there was no evidence of significant subsidence or postoperative deformity during the radiographic follow-up period in this patient population.

Radiographic Failure

The one case in which radiographic fusion was not achieved occurred in a 69-year-old Caucasian man who presented with progressive myelopathy. He underwent a C-4 corpectomy followed by cervical cage-augmented fusion in which the cage was packed with autologous bone, as well as placement of C3–5 anterior cervical instrumentation. Intraoperatively, the right VA was ligated. Of note, postoperative cerebral arteriography verified complete occlusion of this blood vessel with good collateral flow from the contralateral VA. Although immediate postoperative radiographs demonstrated adequate findings, serial postoperative radiographs obtained at 8, 12, and 14 weeks (Fig. 3) revealed a fracture of the inferior endplate of C-5. In addition, the inferior portion of the ACP was displaced anteriorly and the titanium cage had pistoned inferiorly into the C-5 VB resulting in a significant kyphotic deformity. Eight weeks after surgery, the patient remained asymptomatic and we believed there was rea-
sonable chance that solid arthrodesis would develop without surgical intervention. By 12 weeks, the patient had developed a significant kyphotic deformity and surgery was recommended. Wanting to consider his options, the patient declined surgery at that time but returned 2 weeks later agreeing to proceed with the revision. The last set of x-ray films, obtained 14 weeks postoperatively, were acquired the day before surgery. We decided that unilateral right-sided posterior instrumentation with lateral mass plates would be best to avoid injuring the remaining VA.

The patient was returned to surgery. The ACP and cage were removed. We performed a C-5 corpectomy and placement of a titanium cage implant between C-3 and C-6, insertion of ACPs, and C3–6 posterior unilateral lateral mass plate fusion (Fig. 4). He has had no further complications. Radiography has demonstrated evidence of stability and fusion.

**Procedure-Related Complications**

No patient in our series developed a hematoma or wound infection postoperatively. The aforementioned patient with radiographically documented instrumentation failure suffered an intraoperative VA injury. In two other patients postoperative anterior cervical pseudomeningoceles were discovered, and one of these patients developed meningitis.

The first of these two patients, a 66-year-old man, presented with progressive myelopathy. Preoperative magnetic resonance imaging and myelography demonstrated severe ossification of the posterior longitudinal ligament. He underwent C-3 and C-4 corpectomies followed by pyromesh cage– and ACP-assisted fusion. Surgery was complicated by an intraoperative dural tear repaired using a donor fascia lata graft. Reintubation was required a few hours postoperatively when severe strider and respiratory compromise developed. His postoperative course was compli-
cated by nosocomial pneumonia and adult respiratory distress syndrome. An anterior cervical pseudomeningocele was also noted on postoperative Day 3. This was treated with a 5-day course of lumbar drainage, and the lesion subsequently resolved completely. The patient could not be weaned from the ventilator and a tracheostomy was placed 2 weeks after surgery. He eventually recovered and underwent rehabilitation. Since then the patient has progressed quite well with significant improvement in his myelopathy. Flexion–extension radiography and CT scanning performed 15 months postoperatively demonstrated evidence of a solid arthrodesis.

The second patient, a 45-year-old man who presented with a progressive hemiparesis underwent a C-4 corpectomy, excision of an intradural extramedullary hemangiopericytoma, and titanium mesh cage– and ACP-assisted fusion. One month after surgery he presented with fever and an anterior cervical pseudomeningocele. The pseudomeningocele was treated with a 5-day course of lumbar drainage, and cerebrospinal fluid cultures were positive for Escherichia coli. The patient was treated with antibiotic therapy and proceeded to recover fully, with improvement in his hemiparesis. Flexion–extension radiography and CT scanning performed 13 months after surgery revealed a solid arthrodesis.

Quantitative clinical outcome data were not consistently available in this group of patients.

**Discussion**

The use of cervical fusion to treat defects following decompressive surgery was introduced to provide better distraction of the disc space or corpectomy defect, and thereby to maintain cervical lordosis and potentially reduce the rate of postoperative spur formation. The refinement of graft material for cervical fusion has continued over the years partly to circumvent the morbidities associated with harvesting of the graft and fusion-related complications.

Controversy has existed regarding the use of autologous iliac crest bone graft for reconstruction of the cervical spine, with the risk of harvesting-induced morbidity providing a rationale for allograft. Schnee, et al., 15 reported that technical factors influenced the success of fusion when using autologous iliac crest bone; they maintained that with careful surgical technique and thorough anatomical knowledge of region, the rate of harvesting-induced morbidity can be considerably reduced. In their study of 184 patients in whom autologous iliac bone crest grafts were placed, donor site–related morbidity was reported in only four patients (2.8%).

The concern about donor site–related complications, however, has led many surgeons to consider using allograft material for cervical fusion. Although the morbidity associated with harvesting donor bone is avoided, fusion rates have not been demonstrated to be comparable with those achieved in patients in whom autologous bone grafts are used. 1-6,11 In a prospective randomized study, 1 the authors reported that pseudarthrosis developed in 46.2% of patients who underwent fusion with allograft–demineralized bone matrix, whereas pseudarthrosis occurred in 26.3% of patients in whom autograft-assisted fusion was performed. A graft collapse of greater than or equal to 3 mm was demonstrated in 19% of the former patients, whereas the rate was 11% in the autograft-treated patients. A metaanalysis of cases involving one- and two-level anterior cervical interbody fusion in 310 patients showed that autografts were associated with a significantly higher fusion rate than allografts.

Most recently, cages approved by the Food and Drug Administration for lumbar fusion have been used for cervical reconstruction, and the preliminary results have been excellent.10,12,14 In our study we found a fusion rate of 97.7%, which was comparable with those reported in association with autologous bone graft material. Das, et
Titanium cage reconstruction after cervical corpectomy

al.,7 reported a 100% fusion rate in 28 patients who underwent discectomies and 10 patients who underwent corpectomies in whom titanium mesh cages and ACPs were placed. Majd, et al.,10 retrospectively reviewed data in 34 corpectomies and 10 patients who underwent discectomies and 10 patients who underwent corpectomies.17 We believe the advantages of the cage lie not only in the structural support they confer, as demonstrated by their use in the lumbar and thoracic spine,3,11 by providing distraction and restoring physiological height, but also in the existence of their central cavity, which allows packing of autologous corpectomy bone.

One of the concerns about titanium cages, particularly in long cervical reconstructions, relates to subsidence over time.4,17,18 With deteriorating bone quality over the years, these solid constructs may be more likely to piston into the inferior or superior VBs. In the patient in our series with radiographic failure of the anterior cervical spine, a titanium cage packed with autologous bone cement was present, and posterior screws were supplemented with methylmethacrylate for additional support. Although he appears to be doing well at 15 months postoperatively—and with no evidence of instability or instrumentation failure—he will need to be followed closely. Despite the fact that this occurred relatively soon after surgery and was likely related to the patient’s osteoporotic bone, it remains a concern and a longer follow-up period is indicated. Additionally, as illustrated in the aforementioned failure, revisions in these patients can be arduous and often require bone removal above and below the construct, necessitating adjacent-level corpectomies.

Conclusions

Evaluation of our data shows that anterior reconstruction involving cage devices filled with autologous corpectomy bone is effective in patients with nontraumatic diseases requiring fusion.

References


Manuscript received November 4, 2002. Accepted in final form March 6, 2003.
Address reprint requests to: Zeena Dorai, M.D., Department of Neurological Surgery, University of Texas at Southwestern Medical Center, 5323 Harry Hines Boulevard, Dallas, Texas 75390-8855. email: zdorai@excite.com.