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Spine

Posterior Cervical Fusion Failure in Three Morbidly Obese Patients Following Circumferential Surgery

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BACKGROUND
The stability of multilevel anterior corpectomy with fusion (ACF) is often enhanced by simultaneous posterior fusion (PF) which provides a "posterior tension band." Three morbidly obese patients undergoing circumferential surgery had posterior fusions performed without autogenous iliac crest graft to avoid donor site morbidity.

METHODS
Three morbidly obese patients (300–350 lbs.), averaging 48 years of age, presented with rapidly progressive moderate/severe myelopathies. Magnetic resonance imaging (MRI) and computed tomography (CT) studies demonstrated severe ventral ossification of the posterior longitudinal ligament. Two to four level plated ACFs were performed utilizing fibula strut allograft and plates. Posterior spinous process wiring/fusion from C2-T1 were completed with braided titanium cables, fibula strut allografts, Inductive Conductive Matrix (a form of demineralized bone matrix), and allograft bone to avoid iliac crest donor site morbidity in such morbidly obese patients. Halo devices were utilized until fusion was documented on postoperative X-ray and 2D-CT studies subsequently obtained 3, 6, and up to 12 months postoperatively. Patients were followed an average of 3 years.

RESULTS
Postoperatively, all 3 patients demonstrated mild residual myelopathy (Nurick Grade 0-I). Nevertheless, all 3 exhibited posterior pseudarthroses accompanied by anterior strut/plate extrusion (1 patient), partial anterior graft pseudarthrosis (1 patient), and a delayed strut fracture (1 patient). The first 2 patients required secondary posterior fusions performed with autogenous iliac crest graft, while the third fused with 6 months of additional bracing.

CONCLUSIONS
Following circumferential cervical procedures, posterior fusions failed in 3 morbidly obese patients where iliac crest autograft was omitted in an attempt to avoid donor site morbidity.

KEY WORDS
Inductive Conductive Matrix, posterior cervical fusion, morbidly obese.

Autogenous bone remains the "gold standard" for posterior cervical arthrodesis [1,4,19,22]. Major and minor donor site morbidity rates of up to 25% are more frequently reported in females, obese patients, and in combination with major comorbidities [3,9,12,16–18]. Donor site reconstruction has had little impact on limiting morbidity, advocating the avoidance of graft harvesting and prompting the utilization of graft extenders and graft substitutes [3,9,12,16–18].

Graft complications were evaluated in 3 morbidly obese patients undergoing simultaneous 2–4 level anterior corpectomy with fusion (ACF) accompanied by posterior wiring and fusion (PWF) for multilevel ossification of the posterior longitudinal ligament performed in patients with rapidly progressive myelopathic deficits. Posterior fusions were performed utilizing fibula strut allograft, braided titanium cable, allograft bone chips, and Inductive Conductive Matrix (ICM-Sofamor Danek, Medtronic, Memphis, TN), a demineralized bone matrix or graft extender [3,9,12,16–18]. No posterior iliac crest autograft was utilized to avoid donor site morbidity. Complications following three failed posterior fusions were analyzed on sequential X-ray and 2D-CT studies.

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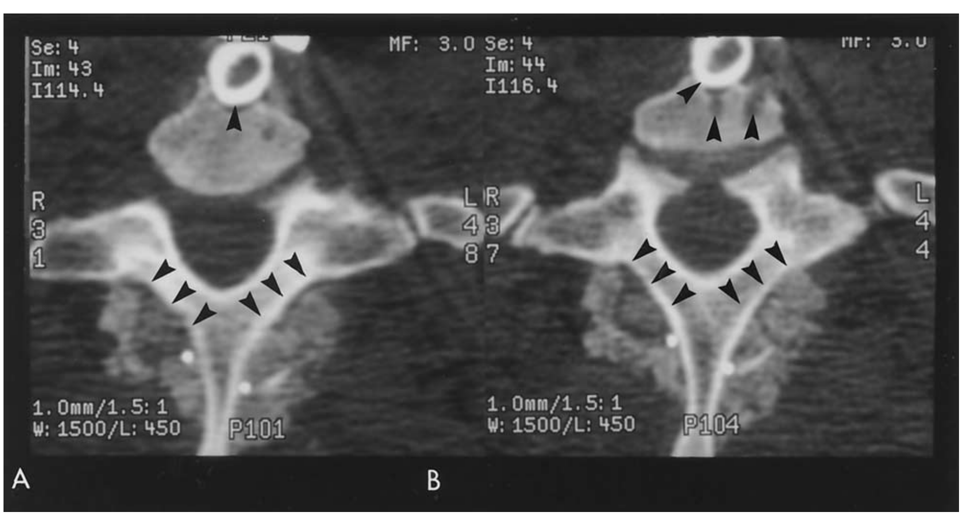
1 Clinical Data for 3 Morbidly Obese Patients Undergoing Circumferential Cervical Surgery

Data	3 Patients
Mean age (range)	48 (45–49)
Males	1
Females	2
Height and weight of 3 patients	
Case 1	5'2″ 300 lbs.
Case 2	5'4″ 325 lbs.
Case 3	5'10″ 350 lbs.
Preoperative nurick	3.5
Postoperative average nurick grade	0.4
Average anterior corpectomy with fusion levels (range)	2.7 (2–4)
Average posterior wiring with fusion levels	7
Average time to final fusion (range)	6.7 mo (6–8 mo)
Average follow up (range)	3.0 yr. (2.5–4 yr.)
Average plate length (range)	80 mm (65–103 mm)
Average operative time (range)	11.3 hrs (10–14)

Materials and Methods

Clinical Data

Three patients undergoing simultaneous circumferential cervical procedures exhibited neurodiagnostic evidence of multilevel spondylosis, stenosis, and ossification of the posterior longitudinal ligament. They averaged 48 years of age and included 1 male and 2 females (Table 1). Preoperatively, they exhibited rapidly progressing moderate to severe myelopathic deficits (average Nurick Grade 3.5), while postoperatively they improved, showing mild residual radiculopathy or myelopathy (Nurick Grade 0.4). Patients had multilevel anterior cervical corpectomy with fusion (average 2.7 levels) performed utilizing fresh frozen fibula strut allografts along with 2 fixed plates (Atlantis Plate, Sofamor Danek, Memphis, TN) and 1 dynamic ABC plate (Aesculap, Tuttlingen, Germany). Simultaneous posterior spinous process wiring and fusion (PWF) from C2-T1 was performed utilizing split fibula strut allograft and braided titanium cables. Posterior cervical fusion devices employing lateral mass screws and rod or plate systems, although considered by many as part of the "standard of care," were not utilized as they are still not Food and Drug Administration (FDA) approved. Because of the anticipated increased morbidity associated with posterior iliac crest graft harvesting in the presence of morbid obesity (weight range 300–350 lbs.), allograft bone chips and demineralized bone matrix were utilized instead of iliac crest autograft. The demineralized bone matrix utilized in all 3 patients as a "graft extender" was Inductive Conductive Matrix (ICM-Sofamor Danek, Medtronic, Memphis, TN) containing bone morphogenetic protein (BMP), 30% cortical, and 70% cancellous bone (usually four 9 cm strips). Patients were placed in halo devices until



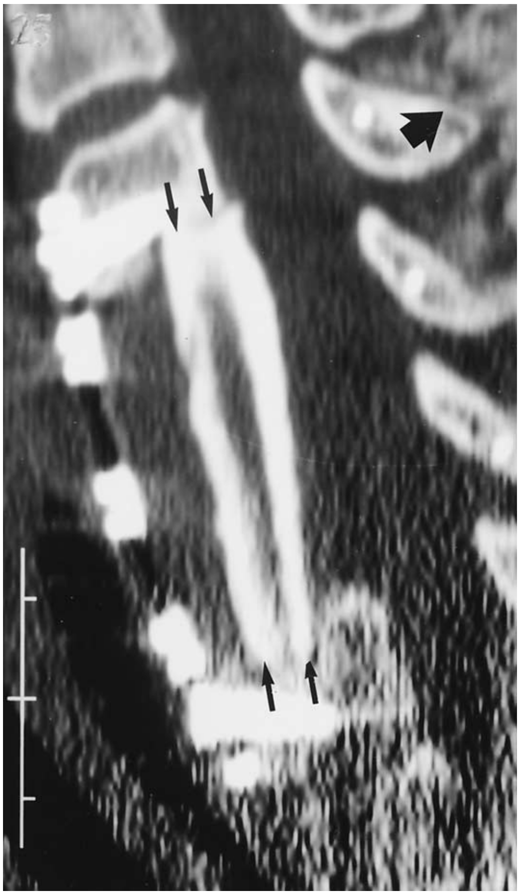
1 (**A**,**B**) (Case 1) A 48-year-old female had a fixed-plated C2-C7 ACF with fibula strut allograft and a C2-T1 PWF performed with braided titanium cables, fibula strut allograft, ICM, and allograft bone chips. No autogenous iliac crest graft was utilized. One month postoperatively, the transaxial bone window CT at the C6-C7 disc space level (**A**) and mid C7 vertebral body level (**B**) revealed inferior plate and fibula strut graft extrusion (single arrow). In **B**, the tracts from the extruded screws are evident (double arrows). Posteriorly, an abundant "cloud" of ICM and allograft bone chips is observed (triple arrows). The anterior plate and graft were immediately replaced. Of note, 4 months later when the plate/graft again extruded, the CT also demonstrated complete resorption of the posterior "cloud" confirming pseudarthrosis.

2 (Case 2) Coronal 2D-CT scan obtained 6 months postoperatively in this morbidly obese 44-year-old female demonstrates anterior fibula strut fusion from C4-C7. Observe the bony trabeculation, lack of bony lucency, extension of bony ingrowth into the central canal at the cephalad graft/vertebral body interface indicating solid fusion (double arrows).

fusion was documented on sequential postoperative X-ray and 2D-CT studies obtained at 3, 6, and 12 months postoperatively. Dynamic X-rays confirmed fusion when no translation, less than 22 degrees of angulation, and less than 1 mm of motion was demonstrated between the tips of adjacent spinous processes. 2D-CT criteria for fusion included the lack of bony lucency, presence of bony trabeculation, and ingrowth of bone into the center of the anterior fibula strut. Posteriorly the bone fragments had to appear continuous with the posterior elements. Patients were followed an average of 3 years (range 2.5–4.0 years).

Results

All 3 morbidly obese patients (weight >300 lbs.) undergoing posterior fusion without autograft bone developed postoperative complications partially attributed to posterior pseudarthroses. A 48-year-old female (5′2″, 300 lbs.) undergoing a fixed-plated C2-C7 ACF/C2-T1 PWF developed an inferior anterior strut graft and plate extrusion 1 month postoperatively (Figure 1). The second surgery included anterior strut graft and fixed plate replacement. Four months later, the anterior plate/graft again extruded and a posterior pseudarthorsis was documented. At the third surgery, the anterior strut was replaced and a 103 mm dynamic ABC plate was applied. Posteriorly, following takedown of the failed posterior fusion, a repeat posterior wiring and fusion was performed now utilizing autogenous bone graft. She subsequently fused both anteriorly and posteriorly 8 months later. A 45-year-old second female patient (5′4″, 325 lbs.), undergoing a fixed-plated C4-C7 ACF/C2-T1 PWF, developed infec-



3 (Case 2) A 6-month postoperative midline sagittal 2D-CT demonstrates both cephalad and caudad fusion of the fibula strut graft anteriorly (double arrows). The patient had an infection of the posterior wound within a month following the surgery. Note that the posterior fusion fragments had largely resorbed (large single arrow).

4 (Case 2) Following a 2000 mile auto ride 18 months after the original surgery, this patient developed a fracture of the fibula strut. This coronal 2D-CT study demonstrates the fracture just below the cephalad vertebral body/graft fusion site (double arrows).

tion in the posterior wound one month postoperatively requiring debridement. A 2D-CT demonstrated fusion of the anterior corpectomy strut 6 months following the original surgery; while posteriorly, pseudarthrosis was demonstrated as the posterior graft had resorbed (Figures 2 and 3). One year later, following a 2,000 mile auto ride, she developed a fibula strut fracture below the superior vertebral body/graft fusion site (Figures 4 and 5). She fused following an additional 6 months of immobilization in a CTO orthosis. A third patient, a 49-year-old male (5′10″, 300 lbs.) 6 months following a C3-C6 ACF/PWF, developed an evolving pseudarthrosis of the superior fibula strut anteriorly with posterior pseudarthrosis. Following a secondary PWF with autogenous bone graft, he fused within 6 postoperative months.

Discussion

Graft extenders and graft substitutes have been developed to avoid autogenous bone harvesting and its attendant major (25%) and minor (24%) morbidities [1,3,4,9,12,16–19,22]. Bioengineered gels contain differing osteogenic growth factors that promote and enhance fusion or fill bony defects [11,13]. The gel form of demineralized bone matrix (DBM) combined with autograft produces a more vigorous fusion response [11]. Recombinant human bone morphogenetic protein rhBMP-2 effectively supplements autogenous intertransverse process fusion in a canine model evaluating spinal arthrodesis [10]. Osteoconductive matrix also promotes

5 (Case 2) A midline sagittal CT study obtained 18 months postoperatively demonstrates a cephalad strut fracture just below the cephalad vertebral body/graft fusion site (double arrows). Also note, all of the posterior fusion fragments have now resorbed (triple arrows).

fusion but only when supplemented with autologous bone [21]. More extensive fusion occurs where fusion masses were supplemented with transfected marrow cells encoded with cDNA osteoinductive protein [5]. When Boden et al performed one level posterolateral fusions in rabbits, the use of hydroxyapatite (HA) with bone marrow resulted in no solid fusions. HA with autogenous bone produced a 50% fusion rate, while alternatively, HA supplemented with osteoinductive growth factor extract promoted 100% fusion [6]. Bone morphogenetic protein also served as an effective extender and enhancer of posterolateral intertransverse fusion in a rabbit model [14]. Recombinant human osteogenic protein-1 applied to a bone collagen carrier rhOP-1 promoted more rapid fusion than autogenous bone alone [8].

When employed in clinical fusions, bioengineered gels act best as graft extenders when utilized in combination with autogenous bone graft. Their success as graft substitutes to reconstruct or fill defects in craniosynostosis surgery is reportedly linked to the greater osteogenic capacity of the pericranium of infants and young children [15,20]. Following 1-2 level anterior diskectomy and fusion, demineralized bone matrix (DBM) and allograft resulted in a 46.2% pseudarthrosis rate compared with a 26.3% rate for autograft alone [1]. Autograft supplemented with DBM utilized during posterolateral lumbar fusions resulted in grade I solid fusion 80% of the time, while allograft constructs alone exhibited reduced fusion rates [2]. Boden et al performed 14 posterior lumbar interbody fusions utilizing cylindrical cages filled with autologous bone alone (3 patients) versus rhBMP-2 collagen (11 patients); X-ray and computed tomography (CT) studies documented fusion in only 2 of 3 control patients while those employing rhBMP-2 fused faster with superior outcomes documented on SF-36 and Oswestry questionnaires [7]. In this study, all 3 posterior cervical fusions performed without autogenous bone to avoid donor site morbidity failed, the resultant pseudarthroses significantly contributing to increased postoperative morbidity and the need for additional surgery.

Conclusions

Successful posterior wiring and fusion still relies on the use of iliac crest autograft, which may be enhanced by the addition of bioengineered gels. In this author's series, 3 morbidly obese individuals having initial posterior fusions performed using ICM and allograft alone, without autograft, failed to fuse.

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COMMENTARY

The paper deals frankly with the difficulties encountered trying to stabilize and fuse the cervical spine after multilevel corpectomies in myelopathic, obese patients. It is worthwhile because it is a problem that is underreported. The author suggests that the use of autografts and bioengineered gels are likely to increase the fusion rate posteriorly in such patients. It is possible, though, that the patients' cervical myelopathy and obesity have altered the structural integrity of the cervical spine in such a way that those measures will be insufficient. Giving equal importance to the integrity of the spine and to the obese patient's myelopathy may be necessary. Staging the procedures by performing a posterior fusion first and then waiting to assure that a satisfactory fusion has occured before decompressing the ventral spinal cord and fusing the anterior cervical spine may be appropriate in patients whose myelopathy is not worsening rapidly and whose cervical spine is not kyphotic.

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