ELSEVIER

Seminars in
SPINE
SURGERY

Anterior Posterior Fusion and the Management of Lumbar Instability

Jonathan R. Stieber, MD,* and Thomas J. Errico, MD†

Anterior-posterior surgery is indicated for the treatment of lumbar instability in the presence of simultaneous compromise of both the anterior and the posterior spinal elements or to augment the stability and rigidity of a fusion construct. The addition of an anterior interbody fusion to a posterior instrumented fusion serves to more successfully restore sagittal balance, effect indirect neural decompression, and to decrease pedicle screw strain by reconstituting the load-sharing ability of the anterior column. A variety of posterior fixation and minimally invasive techniques has been demonstrated to increase circumferential construct stiffness and rates of fusion.
Semin Spine Surg 17:277-284 © 2005 Elsevier Inc. All rights reserved.

KEYWORDS anterior, posterior, lumbar, fusion, circumferential, instability

Clinical instability can occur as a result of trauma, degenerative pathology, tumor, iatrogenic surgery, or a combination of the above.[1] The physiologic loads borne by the lumbar spine are considerable and contribute to the potential for pain, deformity, and disability in the context of instability. Traditionally, anterior stabilization by fusion has been an excellent solution to lumbar instability. Today, increasingly, anterior lumbar spinal reconstruction for certain types of degenerative instabilities may consist of motion-preserving technology such as an intervertebral disc replacement. Clinical experience has increased with intervertebral disc replacement and other intervertebral motion-preserving devices, and ultimately, they may be coupled with nonrigid posterior lumbar stabilization that assists or replaces the posterior elements of the lumbar spine. We currently have much more limited clinical experience with such a construct, and it has yet come to fruition. For the purposes of this discussion, anterior-posterior spinal surgery will be limited to that of anterior spinal fusion in conjunction with either posterior spinal fusion or stabilization.

Anterior-posterior surgery, or circumferential fusion, is indicated for the treatment of lumbar instability in two circumstances. The clearest indication for supplementation of an anterior fusion with posterior fusion or instrumentation is that of instability resulting from simultaneous compromise of both the anterior and the posterior spinal elements. An additional indication exists for the augmentation of an anterior construct's stability and rigidity, thus enhancing the rate of fusion. Anterior lumbar fusion may comprise one or more spinal levels treated with anterior lumbar interbody fusion (ALIF) or corpectomy with subsequent reconstruction. While the gold standard for posterior stabilization is pedicle screw fixation, a number of alternate techniques have emerged. Minimally invasive technology has also permitted pedicle screw fixation to be performed with decreased morbidity.

The anterior column of the lumbar spine can be compromised by failure of either the anterior spinal disco-ligamentous structures or the vertebral body. The anterior ligamentous structures consist of the anterior longitudinal ligament (ALL) and the anterior annulus and may be attenuated or destroyed by surgery, chemonucleolysis, infection, tumor, or other diseases affecting the soft tissues. Chronic spondylolisthesis may also lead to plastic deformation of the annulus contributing to progressive instability. Similarly, the vertebral body can become osteopenic secondary to infection, tumor, avascular necrosis, or metabolic bone disease. Fractures with severe wedge compression may increase the propensity for progressive deformity as the center of gravity shifts anteriorly, generating a deforming bending moment, particularly if the ALL has been disrupted.[1] Traumatic slice fractures of the vertebral body, or fractures with excessive comminution, may also result in marked instability.

*Department of Orthopaedic Surgery, Monmouth Medical Center, Long Branch, NJ.

†Department of Orthopaedic Surgery, New York University–Hospital for Joint Diseases, New York, NY.

Address reprint requests to Thomas J. Errico, MD, Chief of Spine Service, Department of Orthopaedic Surgery, New York University–Hospital for Joint Diseases, 530 First Avenue, Suite 8U, New York, NY 10016. E-mail: thomas.errico@med.nyu.edu.

1040-7383/05/$-see front matter © 2005 Elsevier Inc. All rights reserved.
doi:10.1053/j.semss.2005.10.007

Anterior Lumbar Interbody Fusion

Lumbar interbody fusion has certain advantages when compared with posterolateral fusion. Eighty percent of spinal loading is borne by the anterior and middle columns and is transmitted to the disc space. As compressive forces stimulate osteoblastic activity, this, in turn, creates a favorable environment for osseous fusion. Similarly, the vertebral body represents 90% of the intervertebral surface area versus the 10% offered by the posterior elements. The intervertebral space also claims superior vascularity when compared with the blood supply to the posterior elements.[2]

Anterior lumbar fusion can be performed utilizing a wide range of biologic and mechanical implants. Anterior column support is commonly restored utilizing cages, structural allograft, or a combination of the two. Both threaded and nonthreaded cages have been used in the lumbar spine as intervertebral devices. Threaded cages are inserted horizontally, with most designs incorporating fenestrations to promote intervertebral fusion. While nonthreaded cages are commercially available in a wide range of morphology, these cages are generally oriented vertically and designed with open ends to serve as conduits for intervertebral fusion. Contemporary designs for both threaded and nonthreaded cages may incorporate an element of lordosis to restore lumbar sagittal alignment. For reconstruction following corpectomy, both stackable and expandable cages have been developed in efforts to assist in restoration of anterior column height. Materials used in cages have included titanium alloy, carbon fiber, and polyether ether ketone (PEEK). Anterior fusion may be achieved utilizing autologous bone graft with options including local autograft, iliac crest, fibula, or rib. With the exception of local autograft, all other options necessarily have the drawbacks of increased surgical time, bleeding, and short- and long-term donor-site morbidity. A variety of biologic products have been developed in efforts to avoid the need for autologous graft harvest. Structural spacers constructed from coralline hydroxyapapite in addition to machined allograft bone have been used as osteoconductive matrixes to both provide anterior column support and promote fusion.[3,4] More recently, recombinant bone morphogenic protein has been used successfully as part of an ALIF construct obviating the need for autologous grafting.[5,6]

When compared with posterior lumbar interbody fusion (PLIF), ALIF has the advantage of avoiding entry into the spinal canal with the resultant risks of neurologic injury and epidural scarring. With PLIF, there is also a small, but real, risk of graft migration or extrusion into the spinal canal with potential neurologic sequelae. In contrast to PLIF, ALIF with or without posterior supplementation allows preservation of the posterior elements and the intrinsic stability that they confer on the lumbar motion segment. The ALIF exposure in conjunction with the size and morphology of the available interbody graft may also allow a more substantial reduction of instability as well-improved restoration of coronal and sagittal alignment. The larger graft surface area of the ALIF graft, compared with those grafts inserted posteriorly, provides a more substantial fusion surface. Structural anterior column grafting also places the center of fusion near the center of vertebral motion. Additionally, a characteristic ALIF interbody graft that restores and maintains normal disc height has the potential to effect a more thorough indirect decompression of the neural foramena when compared with grafts inserted during a posterior procedure.

When ALIF is used as a stand-alone procedure or is combined with minimally invasive posterior stabilization, morbidity associated with dissection of the paraspinal musculature, termed "fusion disease," can be avoided. In their evaluation of trunk muscle strength in lumbar spine surgery patients, Mayer and coworkers[7] found that those patient who had undergone standard fusion procedures with the requisite muscle dissection were significantly weaker than those who had undergone discectomy alone with its more limited exposure. Moreover, Rantanen and coworkers[8] found that patients with inferior clinical outcomes following lumbar surgery were more likely to have persistent pathologic changes in their paraspinal musculature. The true long-term clinical effects of "fusion disease," however, need to be better defined and demonstrated in the literature.

Anterior lumbar interbody fusion is contraindicated in patients with advanced osteoporosis predisposing graft subsidence. Relative contraindications to ALIF include neoplasm, active disc space infection, significant peripheral vascular disease, an infrarenal abdominal aortic aneurysm, an anomalous genitourinary system with a singe ureter, and a history of prior retroperitoneal surgery.[9]

Anterior lumbar interbody fusion carries a separate set of surgical risks that must be weighed against alternative methods of treatment. As access to the lumbar disc requires identification and mobilization of the great vessels, the risk of vascular injury is always present. The risk of major vascular injury was found to be 1.9% in a recent, large series of patients undergoing anterior lumbar spinal surgery.[10] Deep vein thrombosis can occur from manipulation of the great vessels and requires treatment with anticoagulation. In men, injury to the superior hypogastric plexus from dissection or the use of electrocautery during the surgical approach can lead to retrograde ejaculation in a reported 0.4 to 5% of cases.[11-13] This is potentially a serious complication for a male of reproductive age, and preoperative sperm donation is often recommended. The transabdominal or retroperitoneal approach can yield a prolonged postoperative ileus, and, as with many abdominal surgeries, the anterior approach carries the risks of denervating the abdominal wall with resulting muscular atony as well as incisional hernia.

Stand-Alone Anterior Lumbar Interbody Fusion

Stand-alone ALIF has been found to be an effective procedure for fusion of the lumbar spine at the L4-5 and the L5-S1 levels. Recently, utilizing dual tapered, threaded cages, Burkus and coworkers reported fusion rates of 89% with iliac