A Novel Technique for Preparing an Allograft Fibula for Use as a Transsacral Graft as Treatment for High-grade Spondylolisthesis

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Abstract

We describe a novel technique for preparing a fibular allograft for use as a transsacral strut with an anterior cruciate ligament (ACL) coring reamer for stabilization of high-grade spondylolisthesis deformities involving the L5–S1 segment in conjunction with instrumented posterolateral fusions. Over 4 years, 6 patients underwent instrumented posterolateral fusions from L3 or L4 to the sacrum or ileum plus posterior implantation of transsacral fibular allografts fashioned with an ACL coring reamer (Arthrex, Naples, Florida). No intraoperative complications were noted. At most recent follow-up (1-6 years), 5 of the patients reported no adverse events; the sixth patient reported prominent hardware, which was removed 5 years after the index surgery. ACL coring reamers seem to facilitate processing of fibular allografts so that they may be used as transsacral dowels for stabilizing high-grade L5–S1 spondylolisthesis deformities.

Most cases of lumbosacral spondylolisthesis respond to conservative measures, such as physical therapy and medications. Indications for operative intervention include documented progression of deformity, neurologic deterioration, and symptoms refractory to conservative treatments. The optimal surgical procedure for managing high-grade spondylolisthesis (Meyerding grade III or IV) or spondyloptosis remains controversial. Successful arthrodesis often is difficult to achieve in these situations because of the altered spine biomechanics, segmental hypermobility, and limited surface area for bone formation. In this patient population, noninstrumented posterolateral fusions with and without reduction of the spondylolisthesis are associated with relatively high risks for pseudarthrosis, progression of deformity, or even cauda equina syndrome.[1,2] Adding instrumentation to these constructs may increase their rigidity, but these cases may be subject to other complications, such as implant failure.[3,4] With circumferential fusion, fusion rates may be higher,[5-7] but this method is associated with increased morbidity, and placement of anterior column support may not even be feasible with severe slips. Several alternative surgical techniques have been described for treating high-grade spondylolisthesis. Unfortunately, one such technique, L5 vertebral body resection with L4–S1 arthrodesis (Gaines procedure),[8] has been shown to lead to an unacceptable incidence of postoperative neurologic deficits.[9]

> "The optimal surgical procedure for managing high-grade spondylolisthesis or spondyloptosis remains controversial."

In 1938, Speed[10] reported on his initial experiences in performing in situ fusion through an anterior transabdominal approach using a tibial autograft as a strut to stabilize an L5–S1 spondylolisthesis. Postoperative care involved bed rest (8 weeks) and prolonged immobilization in a steel brace until bone formation was clearly apparent on follow-up radiographs. In 1982, Bohlman and Cook[11] modified this protocol for patients with spondyloptosis so that 2 autologous fibulas were introduced posteriorly across S1 into the L5 vertebral body in conjunction with a decompressive laminectomy and an uninstrumented L4–S1 posterolateral arthrodesis augmented with iliac crest autograft.

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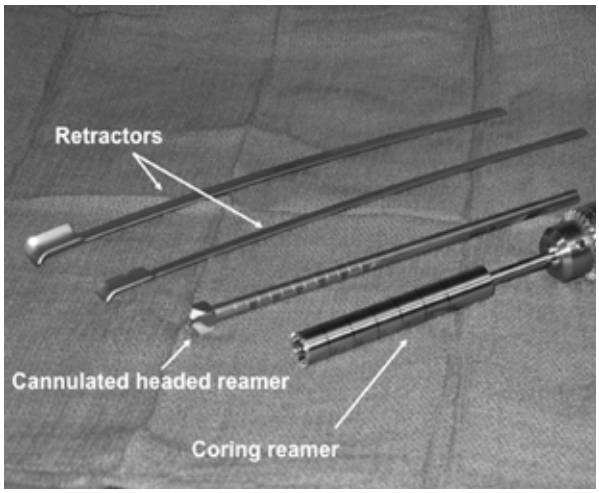

Figure 1. Cannulated headed reamers and coring reamers (Arthrex, Naples, Florida).

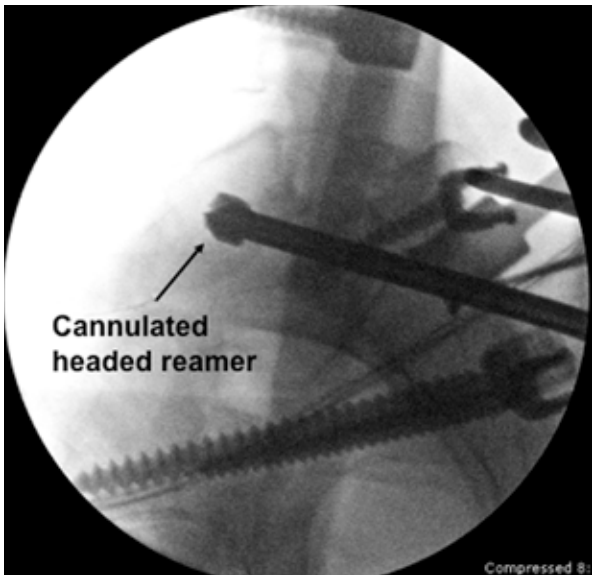

Figure 2. Headed reamer is advanced over guide pin under fluoroscopic guidance.

The primary advantages of this strategy are that it avoids the hazards of an anterior lumbar exposure and allows for fixation of all 3 columns of the spine through a single incision. Besides using transpedicular fixation to enhance the stability of these constructs, in recent years many surgeons also have elected to use allograft fibulas for these types of procedures in order to avoid the considerable morbidity inherent to harvesting structural autografts.[12-14]

Roca and colleagues[12] reported the outcomes of 14 uninstrumented posterolateral fusions supplemented with trans-sacral fibular allografts. The arthrodesis was solid in 13 of these cases. However, in 1 of the 13 cases, the fibular graft was found fractured at 7 months (this graft healed uneventfully), and in another case, a pseudarthrosis developed with worsening deformity and back pain secondary to graft resorption (the patient refused further operative intervention). In

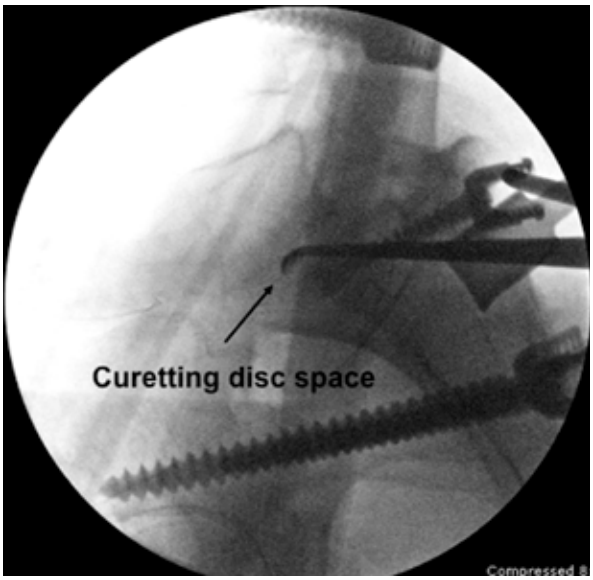

Figure 3. Curved curette is used to remove loose fragments from disk space.

a similar investigation involving 9 consecutive Speed procedures, Smith and colleagues[13] found cracks in the fibular strut grafts in 2 cases in which adjunctive instrumentation was not used. These results were corroborated by Hanson and colleagues[14] in a 17-patient series that included 5 patients with a history of at least 1 previous surgery for high-grade spondylolisthesis. Sixteen of the 17 patients were found to have a successful fusion, and only 1 of the revision patients had a complication—a broken allograft fibula evident on postoperative radiographs.

Another technique for conferring stability across the L5–S1 segment for high-grade spondylolisthesis deformities involves introducing pedicular transvertebral screws as described by Abdu and colleagues.[15] With this technique, pedicle screws are passed from the S1 pedicles bilaterally through the sacrum, across the L5–S1 disk space, and into the L5 vertebral body. Results from a recent study comparing this procedure with transforaminal lumbar interbody fusion suggest that these operations may have similar outcomes.[16] Nevertheless, insertion of transvertebral screws may make it more challenging to appropriately seat the interbody graft in patients with higher grade slips.

Despite the availability of other options (eg, metal cages), allogeneic fibulas remain the most widely used graft material for stabilizing the L5–S1 segment in this fashion. Regardless of whether the fibular strut is inserted through an anterior or posterior approach, an important consideration during these operations is proper preparation of the graft so that it may be delivered across the sacrum with minimal difficulty.

Our goal in the present study was to characterize a novel technique for contouring allograft fibulas in an attempt to facilitate their placement as part of the Speed procedure.

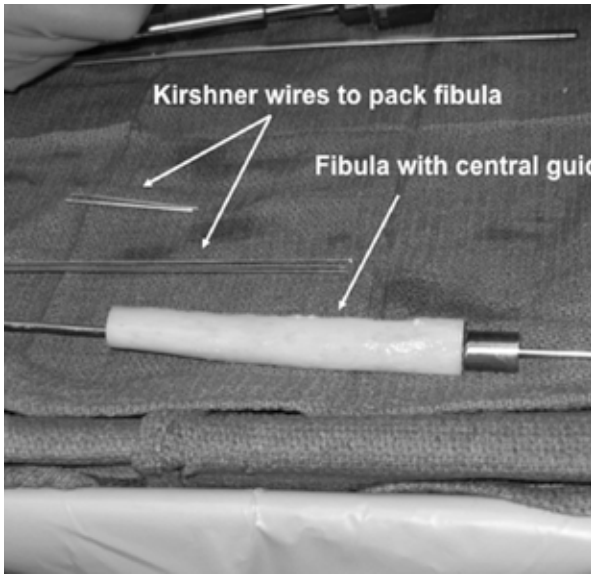

Figure 4. Central core of fibular graft is packed with Kirschner wires to increase stability during reaming.

Methods

At our institution, 6 pediatric and adult patients underwent implantation of a transsacral fibula as treatment for high-grade spondylolisthesis between 2003 and 2008. Indications for surgery were symptoms of severe axial low back pain, with or without lower extremity radiculopathy, that had failed to respond to conservative measures, including bracing, physical therapy, medications, and injections into the pars interarticularis. The medical records of these patients were reviewed with permission from the Internal Review Board/Human Investigation Committee at our institution.

Each operation was performed through a posterior approach with the patient prone on a radiolucent Jackson table (Mizuhosi, Union City, California). Real-time neurophysiologic data were acquired by monitoring somatosensory and transcranial electric motor-evoked potentials and from lower extremity and sphincter electromyography. Once the posterior elements of the lumbosacral spine were adequately exposed, segmental instrumentation was placed so that the fusion construct extended from either L3 or L4 proximally to S1 or the ileum distally. However, no attempt was made to insert pedicle screws into the anteriorly displaced L5 vertebral body in any of these cases. Cancellous bone was harvested from the iliac crest for use as graft material in the posterolateral gutters.

In addition to posterior decompression of the neural elements being completed as necessary, the S2 lamina was removed to permit direct visualization of the S1–S2 disk. The starting point for the guide pin usually was located between the S1 and S2 segments and accessed from either side of the thecal sac. Because the dural tube progressively tapers more distally in the sacrum and is less bulbous at this level, a Love retractor or squared posterior lumbar interbody fusion retractor was used to retract the neural elements during insertion of the guide

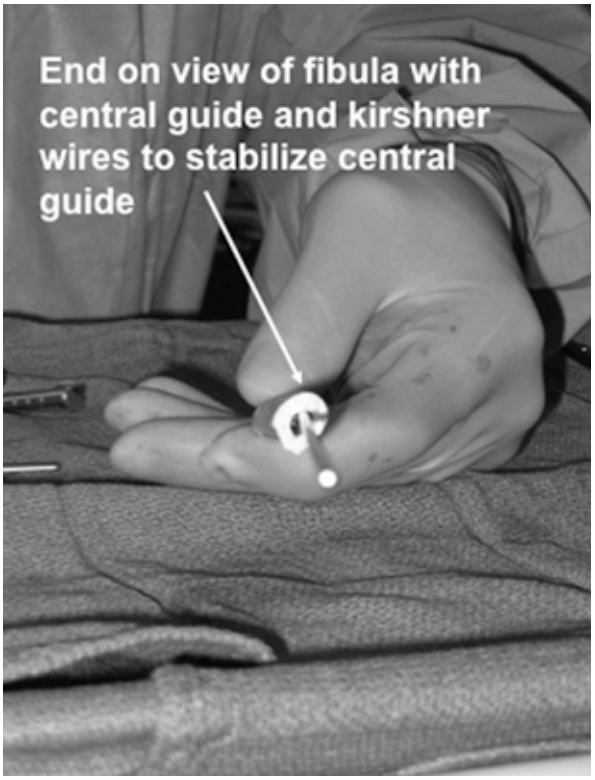

Figure 5. End-on view of fibular graft filled with Kirschner wires.

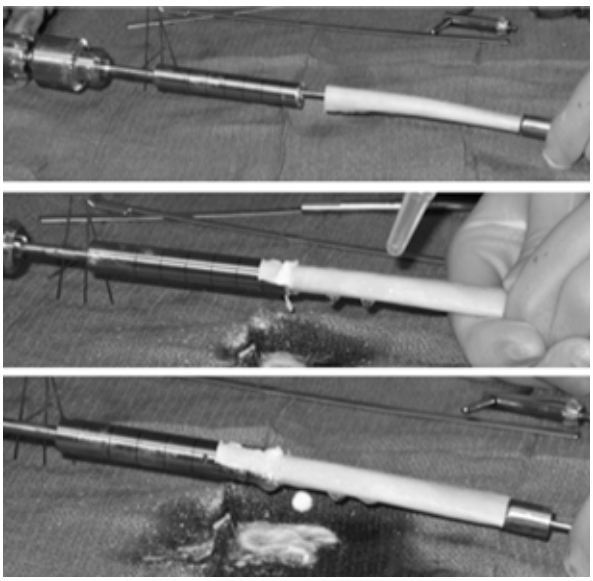

Figure 6. Cannulated coring reamer is passed over fibular graft.

pin, reaming of the channel, and introduction of the graft. From this entry site, a guide pin was passed across the L5–S1 disk space toward the anterior-superior corner of the L5 vertebra. After pin location was confirmed with both anteroposterior and lateral views on intraoperative fluoroscopy, the tunnel for the fibula was created with an 11- to 13-mm cannulated headed reamer (Arthrex, Naples, Florida) (Figure 1). During this pro-

Figure 7. Final anteroposterior fluoroscopic image after placement of fibular graft and transpedicular instrumentation.

cess, fluoroscopic shots were obtained intermittently to ensure that the guide pin was not being advanced inadvertently through the anterior cortex of the L5 vertebral body (Figure 2). At this point, the reamer was withdrawn, and curved curettes were introduced into the newly formed tract to facilitate removal of any loose bony or soft-tissue fragments from within the L5–S1 disk space (Figure 3).

In the past, we typically used a burr to contour the fibula. As fashioning a strut that readily traversed the cavity proved to be challenging with this method, we developed a technique in which a coring reamer was passed over the fibula to form a uniform cylinder with dimensions precisely matching the diameter of the anterior cruciate ligament (ACL) headed reamer that had been used to generate the channel (Figure 1). The fibula was placed over the guide for the coring reamer, and a more secure fit was achieved by packing the medullary canal with several Kirschner wires to minimize any "chatter" as the coring reamer was conveyed over the graft (Figures 4, 5). After its profile was properly shaped in this manner, the fibula was cut to the appropriate length, and the burr was used to remove any remaining sharp edges from its ends (Figure 6).

The strut was dipped in iohexol (Omnipaque; GE Healthcare, Little Chalfont, England) to enhance its visibility on C-arm images and was then manually impacted across the sacrum into the L5 vertebral body under fluoroscopic guidance. Rods spanning the entire fusion construct were fixed within the heads of the pedicle screws on each side, and the posterior elements of the levels of interest were decorticated to promote bone formation. The entire wound was copiously irrigated, and the incision layers were closed over a drain. On fluoroscopic anteroposterior image and postoperative lateral radiograph (Figures 7, 8), the final position of the fibular graft was clear.

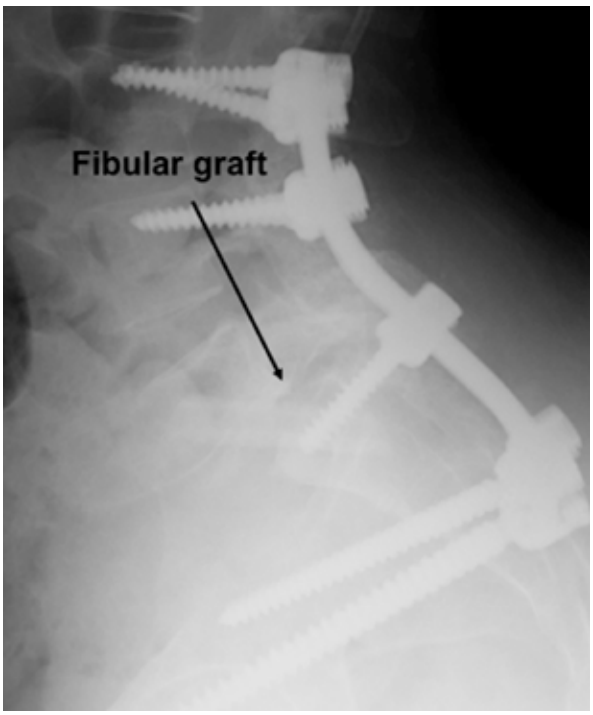

Figure 8. Postoperative lateral radiograph shows final construct.

Results

These cases had no intraoperative complications, and the patients' perioperative courses were uneventful. Follow-up ranged from 1 to 5 years. Five of the 6 patients reported excellent clinical outcomes; the sixth reported prominent hardware, which necessitated removal of instrumentation 5 years after the index procedure.

Discussion

We have presented a case series of 6 patients with high-grade slips whose deformities were stabilized with transsacral fibular allografts prepared with ACL coring reamers corresponding to the cannulated headed reamers used to drill the tunnel across the L5–S1 segment. Without a reliable template, it may be challenging to obtain a suitable dowel for this purpose. An undersized strut that is grossly mobile within the channel may not confer sufficient rigidity to the spondylolisthesis and is less likely to yield a solid fusion, whereas a strut that is too large may require excessive force for insertion, which increases the risk for implant fracture or iatrogenic neurologic injury. As we were able to produce a perfectly cylindrical graft of the correct dimensions with a single pass of the coring reamer, this technique may preclude the need for repeated modifications of the fibula and therefore reduce total operative time.

Our study suggests that use of cannulated headed and coring reamers during the Speed procedure represents an elegant method for preparing fibular allografts

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so that they slide easily into osseous channels spanning the lumbosacral junction. Given these results, we believe that use of this integrated ACL reamer system will increase the safety and efficacy of this operation as a treatment for high-grade spondylolisthesis.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

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This paper will be judged for the Resident Writer's Award.