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IDEAS AND INNOVATIONS

Reconstructive

Novel Approach to Difficult Spinal Reconstruction: Bilateral Simultaneous Rib and Iliac Crest Vascularized Bone Graft Spinoplastic Surgery

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Summary: Pseudoarthrosis is a severe complication of spinal fusion surgery with occurrence rates as high as 35%–40%. Current options of revision surgery to correct pseudoarthrosis frequently carry high failure rates and risk of developing junctional kyphosis. Pedicled vascularized bone grafts (VBGs) are an innovative approach to boost spinal fusion rates via improving structural integrity and increasing the delivery of blood to the donor site. This versatile technique can be performed at different spinal levels without additional skin incisions and with minimal added operative time. Here we present the first bilateral rib and iliac crest VBG spinoplastic surgery performed to augment spinal fusion in a 68-year-old woman with distal junctional kyphosis and severe positive sagittal balance with low back and neck pain and significant difficulty standing upright. The patient had history of multiple spinal operations with preoperative CT imaging demonstrating loosening and pull out of L3 and fracture of L2 screws. She underwent two-stage surgical treatment involving anterior lumbar interbody fusion L3-S1 followed by removal of hardware, T4 to pelvis fusion with L2-3 prone lateral interbody fusion, and T11-S1 posterior column osteotomies. The surgery was augmented by bilateral rib and iliac crest VBGs performed by plastic surgery. At three-month follow-up the patient demonstrated functional improvement, being able to maintain upright posture and walk; was satisfied with the result of the surgery; and demonstrated no graft-related complications. In conclusion, utilization of pedicled VBGs is a novel, promising approach to augment spinal surgery in high risk patients. *(Plast Reconstr Surg Glob Open 2024; 12:e5656; doi: 10.1097/GOX.0000000000005656; Published online 8 April 2024.)*

OVERVIEW

Pseudoarthrosis is a severe complication of spinal fusion and the leading cause of pain with occurrence rates as high as 35%–40%.[1–2] Risk factors for pseudarthrosis after spinal arthrodesis include obesity, diabetes, osteoporosis, malnutrition, chronic steroid use, chronic illnesses, age, smoking, previous surgery, and irradiated field.[1] Autografts are considered the gold standard in spinal fusion grafting.[3] For some patients, nonvascularized bone grafts (N-VBGs) are an appropriate option; however, in complicated cases, N-VBGs alone are not sufficient because they carry high failure rates due to intrinsic demand for healthy, vascularized tissue to promote creeping substitution and autogenous bone development.[4]

Vascularized bone flaps deliver blood to the donor site, improving fusion rates and decreasing infection risk and healing time, and are indicated in cases of postoperative complications or complex comorbidities.[4] Historically, free bone transfer has been used; however, free flaps are

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associated with substantial complications and donor-site morbidity, and require a microsurgical approach with significant added operative time.[5] A new rung to the reconstructive ladder has been developed with the use of pedicled vascularized bone grafts (VBGs) that receive blood supply from periosteal feeding vessels running in Sharpey's fibers, with rib-VBG (R-VBG) being implemented first.[6] Pedicled VBGs offer an innovative approach to boost spinal fusion rates by providing structural integrity and increasing delivery of blood to the donor site, augmenting primary bone healing, while avoiding additional skin incisions and decreasing morbidity and blood loss with minimal added operative time. The approach using pedicled VBGs continues to evolve with recent development of techniques involving occipital, clavicular, scapular, spinous process, iliac crest, and posterior element VBGs.[4] Here, we demonstrate versatility and potential of pedicled VBGs, presenting the first bilateral R-VBG and iliac crest-VBG (IC-VBG) spinoplastic surgery performed to augment spinal fusion in a high-risk older patient with history of multiple unsuccessful spinal operations.

TECHNIQUE AND CASE PRESENTATION

A 68-year-old woman presented with distal junctional kyphosis and severe positive sagittal balance with back and neck pain and significant difficulty standing upright. Due to kyphosis, she spent most of the time looking at the ground, could not lay flat, and had difficulty with oral intake resulting in severe malnutrition. The patient had history of multiple spinal operations to correct kyphosis and scoliosis with most recent being revision extension of fusion from T9-10 to L2-3, extension of C2-T10 fusion to L3, and posterolateral T10-L3 fusion performed 2.5 years ago. Preoperative imaging demonstrated loosening and pull out of L3 and fracture of L2 screws (Fig. 1).

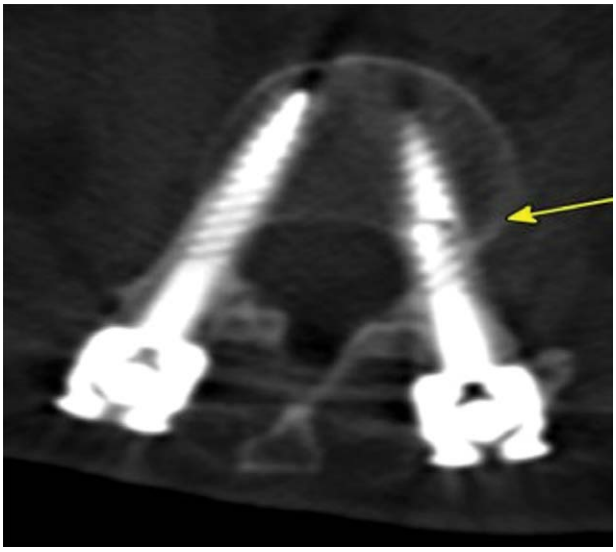

Fig. 1. Preoperative imaging: computed tomography image demonstrating close view of the L2 screw fracture. Arrow points to fractured L2 screw. Four months before surgery.

Takeaways

Question: How to augment spinal fusion without additional skin incisions and with minimal added operative time in high-risk patients with pseudoarthrosis?

Findings: Bilateral simultaneous rib and iliac crest vascularized bone graft spinoplastic surgery was performed in a high-risk patient with significant risk factors for pseudoarthrosis. The technique required no additional skin incisions and added only 2 hours of operative time. The patient experienced no graft-related complications, demonstrated functional improvement, and was satisfied with the result of the surgery.

Meaning: Pedicled vascularized bone grafts are a novel, promising approach that can be successfully utilized at different spinal levels to augment spinal fusion in high-risk patients.

She underwent two-stage surgical treatment involving anterior lumbar interbody fusion L3-S1 followed by next-day removal of hardware, T4 to pelvis fusion with L2-3 prone lateral interbody fusion, and T11-S1 posterior column osteotomies. The surgery was augmented by bilateral R-VBGs and IC-VBGs performed by plastic surgery.

After exposure of the spine and replacement of hardware, the eighth ribs were sized and dissected bilaterally, along with the intercostal arteries. Following harvest, the R-VBGs were tunneled underneath the paraspinal muscles and placed bilaterally at the T7-T8 junction. The ribs demonstrated appropriate bleeding, indicating preserved vascularization. Bone graft was packed underneath. Open reduction/internal fixation (ORIF) was performed bilaterally with 2-0 cranial maxillofacial plates. [**See Video 1 (online),** which demonstrates the R-VBG technique, intraoperative record.]

The IC-VBGs were harvested bilaterally from the posterior iliac crest on quadratus lumborum pedicles. Dissection of each graft was initiated from midline, working laterally over the posterior iliac crest. Care must be taken to avoid damage to the retroperitoneal structures, which was accomplished through blunt dissection. After exposure, harvest of the IC-VBGs was completed, and the grafts were tunneled underneath the lumbar paraspinal muscles and rotated over the lateral aspects of L5-S1. The IC-VBGs demonstrated bleeding vessels under operative microscope, and, after packing bone graft underneath, ORIF was completed bilaterally [**See Video 2 (online)**, which demonstrates the IC-VBG technique, intraoperative record.] (**See figure, Supplemental Digital Content 1**, which demonstrates an intraoperative photograph of left R-VBG and right IC-VBG after ORIF. **http://links.lww.com/PRSGO/D97**.). Performing all four VBGs added just two hours of operative time. There were no intraoperative complications.

At the 3-month follow-up, the patient demonstrated functional improvement, being able to maintain upright posture and walk more than 150 feet, and was satisfied with the result of the surgery. Postoperative imaging

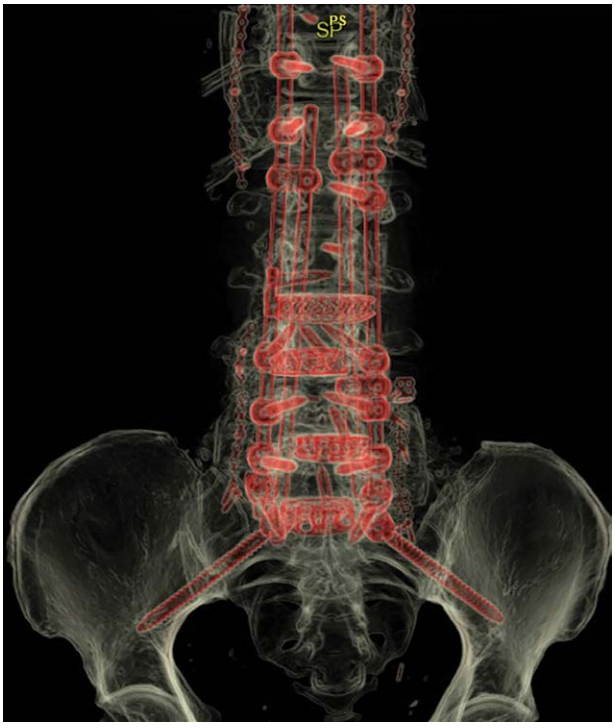

Fig. 2. Three months postoperative computed tomography demonstrating appropriate placement of bilateral R-VBGs and bilateral IC-VBGs and osseous integration of the grafts.

demonstrated appropriate VBG positioning and osseous integration of the grafts (Fig. 2). Standing x-ray demonstrated significant improvement in global sagittal balance (Figs. 3 and 4). To date (8 months postoperatively), the patient has experienced no graft-related complications and continues to demonstrate functional improvement.

DISCUSSION

Many current options for revision surgery to correct spine pseudoarthrosis carry high failure rates and risk of developing junctional kyphosis.[7] Pedicled VBGs possess robust blood supply and reduce morbidity and operative time associated with free tissue transfer and avoid additional skin incisions.[4] Although there are no absolute contraindications specific to pedicled VBGs compared with free bone flaps, relative common contraindications include chronic infections, diabetes, immunosuppression, substance abuse, previous surgery or irradiation at the harvest site, and inadequate soft-tissue coverage.[8,9] However, because most of the relative contraindications are also the risk factors for pseudoarthrosis, the use of pedicled VBGs can be justified and necessary in high-risk patients when step-up approach is needed.

In the thoracic spine, R-VBG has demonstrated low morbidity and low risk compared with vascularized fibula flap. Pedicled R-VBG provides the advantages of a vascularized bone flap in complicated spinal fusion cases, without the morbidity associated with free tissue transfer.[2]

Fig. 3. X-ray demonstrating severe kyphosis centered around T7-T8 with severe positive sagittal balance 4 months before surgery.

In the lumbar spine, the current gold standard in the management of pseudoarthrosis is the autologous non-vascularized iliac crest bone graft. Improvement can be achieved using pedicled VBGs. The use of IC-VBGs in the augmentation of lumbar fusion was evaluated in 14 cases requiring salvage after pseudoarthrosis. Decreased operative time and bleeding compared with a free flap procedure was demonstrated, as well as no graft-related complications.[10]

Fig. 4. Three months postoperative x-ray demonstrating significant improvement in kyphosis and global sagittal balance.

Another advantage of the pedicled VBGs compared with the free bone flaps is that pedicled VBGs require a less technically complex approach, without the need of microvascular anastomoses, and, therefore, are easier to learn than free tissue transfer, constituting an important tool in the arsenal of spine surgeons.

The presented patient had several risk factors for pseudoarthrosis, including previous spine surgery, hardware failure, and severe malnutrition. Utilization of VBGs to augment spinal fusion allowed for improved patient care with little additional operative time or surgical morbidity.

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DISCLOSURE

The authors declare no conflicts of interest.

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