CORR Tumor Board

CORR® Tumor Board: Is There Benefit to Free Over Pedicled Vascularized Grafts in Augmenting Tibial Intercalary Allograft Constructs?

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What are the surgical and research implications of this study?

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The development of effective chemotherapy and improved imaging techniques in the 1970s and 1980s ushered in the current era of limb surgery. Massive bone allografts are now reliable options for reconstruction of bone

defects following sarcoma resection, with improved function in intercalary allografts compared to allograft fusion and osteoarticular allografts [4, 5]. However, because complications, such as infection, nonunion, and fracture, are common in these reconstructions [1], we still need to develop improvements in surgical techniques. Free vascularized fibula transfer has been applied to salvage allograft fracture and nonunion, but more recently it has supplemented the original allograft reconstruction in an effort to decrease these complications at the outset. The added surgical complexity, longer operative time, and risk for donor-site morbidity have led many to reserve free vascularized fibula transfer only as an effort to salvage the original construct after allograft complications; the decrease in nonunion provided is seen as not worth the added negatives.

In their study, Manfrini and colleagues seek to achieve the general benefits of a vascularized fibula, but decrease the surgical risks, using the pedicled transfer technique. By eliminating the need for microvascular

A note from the Editor-in-Chief:

We are pleased to present the next installment of The CORR® Tumor Board column. The CORR® Tumor Board column provides multidisciplinary perspective on the themes raised in selected CORR® tumor papers. In this column, we will discuss the implications of the highlighted article from the varied disciplines of the Tumor Board members: Orthopaedic surgery, pathology, and radiology. This month's column features the study "Is There Benefit to Free Over Pedicled Vascularized Grafts in Augmenting Tibial Intercalary Allograft Constructs?" by Manfrini and colleagues available at: DOI: [10.1007/s11999-016-5196-2](https://doi.org/10.1007/s11999-016-5196-2).

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This CORR Tumor Board column refers to the article available at DOI: [10.1007/s11999-016-5196-2](https://doi.org/10.1007/s11999-016-5196-2).

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anastomosis and surgery on the contralateral leg, the pedicled transfer may be more broadly applicable and carry less risk.

Manfrini and colleagues found that an experienced team could perform pedicled transfers with similar risks of complications and shorter surgical times compared to free vascularized fibular transfers. In order to assess whether pedicled fibula transfer is truly superior to free transfer and allograft without transfer, longer followup with surveillance for later-term complications, especially infection and fracture, and greater numbers and types of patients are warranted. If a pedicled fibula transfer decreased risk of non-union, fracture, and infection in the short- and long-term compared to allograft without transfer, and had acceptable perioperative and donor site risks, shorter surgical time, and was simpler to learn than free vascularized fibula transfer, then it would certainly behoove surgical teams to teach and train this technique.

What issues does this study raise in terms of musculoskeletal imaging?

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Imaging of a patient with a tibial sarcoma can be divided into three

phases, each with its own important considerations. Preoperative imaging constitutes the first phase where the radiologist must identify for the surgeon the full extent of the tumor and whether there is tumor involvement of important structures such as the joint space or neurovascular bundle. With accurate information, the surgeon can size the allograft appropriately and determine the type of treatment to best restore function. MRI should be performed to best assess full tumor extent.

The next phase is imaging during the immediate postoperative period. In this phase, one must assess for correct positioning of hardware and allograft and determine that the entire tumor has been resected. It is imperative for the radiologist to be familiar with the surgery that has been performed by reading the operative note or contacting the surgeon directly.

The third and final imaging phase is delayed postoperative imaging. During this phase, one needs to assess for incorporation of the allograft with the native tibia, any hardware/allograft complications, and tumor recurrence. This phase can last indefinitely and the radiologist must recognize the imaging appearance of these potential complications. An important pitfall in this phase is overcalling delayed or non-union of the fibular allograft with the host tibia. For fractures in a healthy patient, healing with mature bridging

bone is typically seen in 6 weeks to 12 weeks. However, in a patient with a tibial sarcoma, incorporation of the fibula allograft with the tibia can take much longer depending on perfusion to the region and whether adjuvant chemotherapy or radiation has been performed.

In this study, the authors use imaging in all three phases and found that imaging was especially crucial in identifying complications in the third, delayed postoperative, phase. Of the 17 patients with complications, 12 had diagnoses that were predominantly or solely based on imaging. Macrofracture of the massive bone allograft-vascularized fibula construct was the most common complication overall, occurring in eight patients, and is a diagnosis that can only be made on imaging. It is also important to note that many of these complications will be first identified on imaging, as opposed to clinical findings; thus, is it important to perform serial imaging exams following the surgery as the authors have done here.

What more does the surgeon need to know about musculoskeletal pathology in order to get the most out of this study?

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When allograft reconstruction follows resection of a malignant bone tumor, the subsequent recurrent tumor evaluations may allow for close clinical and radiologic followup of graft healing. The pathologist, however, rarely examines uncomplicated engraftment microscopically. With interposition of a healthy living fragment of bone, one expects that healing stages recapitulate those observed histologically in fracture resolution, including hematoma, inflammation, variable amounts of granulation tissue and callus formation, and remodeling. Still, the precise histologic correlations to the three vascularized fibular graft-healing patterns described in CT studies are not well known [2, 3]. Along with the histologic changes involved in fracture repair, there are many signaling pathways involving cell types, ranging from hematopoietic stem cells to all manner of inflammatory cells, vascular cells, stromal cells, and the traditionally recognized “bone” cells (osteoblasts/osteocytes and osteoclasts).

A pathologist is more likely to examine a tumor recurrence, infection, nonunion, or fracture, than a healthy engraftment. Histologic evaluation for tumor at the site of an allograft may be straightforward, but could become challenging if superimposed fibrosis, exuberant callus, or chemotherapy and radiation-induced changes occur.

Infection at an allograft site is typically bacterial and may appear histologically different from the classic hematogenously seeded osteomyelitis. The latter often is associated with infarction (remodeled into “sequestrum”) due to swelling in a confined space; the former may lack infarction and is more likely to be contiguous with a soft tissue abscess or cellulitis. Nonunion resembles a late-stage callus with proliferation of cartilage and fibrovascular tissue, but it lacks substantial ossification. Histologic examination of an allograft fracture may show, in addition to the fracture, underlying bony changes reflecting a predisposition to fracture such as osteopenia, healing microfractures, or ischemic changes. Presumably, the same cell signaling pathways active in allograft engraftment are also operative in the bone repair processes that accompany the various allograft complications.

Despite all that is known about the histologic features of bone engraftment and its complications, and all that is known about the burgeoning field of cellular and molecular regulation in bone repair, one thing is notable: It is studies like this one, based on mechanical intervention and clinical outcome, rather than cellular pathophysiology and molecular biology, that can demonstrate the clinical feasibility of novel approaches for the treatment

of fracture and related processes involving bony repair.

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