Telescopic Mating Technique for Bulk Allograft Reconstruction

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Abstract: Bulk allograft reconstruction plays an important role in limb-salvage reconstructive surgery but is complicated by nonunion in up to one-third of cases. Because allograft–host healing is mediated via creeping substitution, intimate bone contact is desirable. Intraoperative assessment and optimization of the allograft–host junction site using a conventional transverse osteotomy is challenging and may result in slight gapping. Speculatively, this may result in longer healing times and may contribute to the high rate of nonunion. Minimizing the nonunion rate and time to union are of value. This article describes the telescopic mating technique, which allows for substantially greater bone contact across the allograft–host junction site.

Primary bone sarcomas, such as osteosarcoma, necessitate wide excision in addition to systemic therapy to realize a cure. Although such excisions were performed historically in a radical manner through disarticulations or amputations, over time it has become clear that these aggressive surgical approaches offer no benefit in overall survival.1 As such, most patients, families, and surgeons prefer a more conservative limb-salvage approach, which permits complete extirpation of the tumor and reconstruction of the defect.

Segmental bone defect reconstruction can be accomplished using a variety of techniques, including endoprostheses, bulk allograft, allograft–prosthetic composites, vascularized or nonvascularized autograft, and bone transport techniques. Allograft reconstruction remains one of the most widely used techniques and is an important tool in an orthopaedic oncologist’s armamentarium. It offers numerous benefits, including the restoration of bone stock, the preservation of the opposing joint surface, and the presence of soft tissue insertion sites.2 Despite its wide use and proven usefulness, bulk allograft reconstruction has a few well-recognized complications, including infection, fracture, and nonunion.1 All 3 complications typically necessitate ≥1 surgical procedures and often interfere substantially with a patient’s quality of life and functional capacity. It is desirable to obviate or minimize these complications to the greatest extent possible.

This article describes a novel surgical technique, termed telescopic mating, that was designed to minimize allograft–host junction nonunion by maximizing bony contact area.

Materials and Methods

Four patients undergoing intercalary or osteoarticular allograft reconstruction following wide excision of either a benign or a malignant tumor in the extremity were reviewed. Cases requiring unicortylar or hemicortical resections and reconstructions were excluded. Resections were performed for osteosarcoma in 2 cases—Ewing’s sarcoma and a locally aggressive giant cell bone tumor. Average follow-up was 15 months from 2009 to 2011.

Two patients underwent adjuvant chemotherapy postoperatively; 1 patient had already completed his chemotherapy regimen at the time of reconstruction, and 1 patient did not require chemotherapy. No intra- or postoperative complications arose. Additional operative time related to graft preparation was not recorded but was estimated as 30 minutes.

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SURGICAL PROCEDURE

Preoperative planning consists of procurement of a size-matched allograft. Familiarity with bone bank procedures and regulatory requirements is helpful in selecting a reliable and trustworthy bone bank and in obtaining a quality and properly screened graft. A graft should be a minimum of 2 cm longer than the expected resection; however, a longer graft is preferable and permits for unexpected intraoperative adjustments.

Following wide surgical excision of the tumor, reconstruction of the defect begins by measuring the resection length. The allograft bone is thawed and prepared in a routine manner. The allograft is cut to a length 5 to 10 mm longer than the resection to permit for bony overlap, or mating. Using a high-speed burr, approximately 50% of the allograft’s outer cortex is circumferentially removed across the length of the added bone (5 to 10 mm) in a uniform manner. The host bone is prepared in a similar fashion, removing approximately 50% of the circumferential inner cortex across the length of added bone (5 to 10 mm) in a uniform manner.

Although a routine round burr can be used for the initial preparation, it is advisable that a matchstick burr tip be used thereafter to obtain a sharp corner rather than a rounded edge at the end of the telescoping surface. This will permit for a more reliable complete mating of the bones (Figure 1). Rotational alignment can be set as needed, and compression across the allograft–host junction site is achieved via internal fixation.

CASE REPORTS

Patient 1

A 12-year-old boy with no significant medical history presented to the pediatric sarcoma clinic with a 1-month history of left leg swelling and pain. Physical examination revealed fullness along the middle of the leg that was tender to palpation. No evidence of trauma, infection, ulceration, erythema, or other concerning features was noted.

Imaging studies consisted of anteroposterior (AP) and lateral radiographs that showed a lytic diaphyseal left tibial lesion in a skeletally immature individual. Periosteal reaction was subtle but visible. A technetium-99 bone scan demonstrated intense uptake of radiotracer in the tibia with no overt evidence of metastatic disease. Computed tomography scan of the chest also failed to identify metastatic disease. Magnetic resonance imaging with and without gadolinium showed a large destructive intraosseous lesion, with areas of heterogeneity suggestive of necrosis. An open biopsy was performed, and histopathology suggested a small, round blue cell tumor. Immunohistochemistry supported the diagnosis of Ewing’s sarcoma, and the patient commenced neoadjuvant treatment.

Following induction chemotherapy, the patient underwent wide surgical excision of the primary tumor followed by intercalary reconstruction using a size-matched bulk allograft and internal fixation. Care was taken to maintain his proximal tibial physis. The distal allograft–host junction site was prepared in a conventional nontaesoscopic fashion given the metaphyseal location and its substantially greater contact area. Alignment was adjusted to match the patient’s anatomy, and internal fixation was applied in a compressive manner.

The patient’s postoperative course was uneventful, and he completed adjuvant chemotherapy without complication. Follow-up radiographs suggested bony bridging across the allograft–host junction by 8 weeks (Figure 3) and confirmed complete union by 24 weeks (Figure 4) postoperatively, at which time he was advanced to full weight-bearing status.

Patient 2

A 12-year-old boy with no significant medical history presented to the pediatric sarcoma clinic with a 1-month history of right distal forearm swelling and pain. Physical examination revealed decreased wrist range of motion (ROM) secondary to pain. No evidence of trauma,
infection, ulceration, erythema, or other concerning features were noted.

Imaging studies consisted of AP and lateral radiographs that demonstrated destruction of the radial cortex medially and remodeling of the ulnar cortex laterally (Figure 5). Magnetic resonance imaging with and without gadolinium demonstrated a large destructive intraosseous radial lesion with an extensive soft tissue component (Figure 6). A technetium-99 bone scan demonstrated intense uptake of radioisotopic tracer in the forearm with no overt evidence of metastatic disease. Computed tomography scan of the chest also failed to identify metastatic disease. An open biopsy was performed, and histopathology was consistent with a high-grade sarcoma with telangiectatic features. The patient began neoadjuvant treatment.

Following induction chemotherapy, the patient underwent wide surgical excision of the primary tumor followed by osteoarticular reconstruction using a size-matched allograft. However, catastrophic failure of his hardware secondary to nonunion of his allograft–host junction occurred 5 months postoperatively. The patient underwent revision surgery, at which time (Figure 7) the telescopic mating technique was used.

The patient’s postoperative course after the telescopic mating technique was uneventful. The patient’s wrist was immobilized for the first 4 weeks postoperatively, after which active and passive ROM were encouraged. Follow-up radiographs suggested bridging across the allograft–host junction by 12 weeks and confirmed union by 20 weeks postoperatively (Figure 8). By 24 weeks, radiographs showed complete union.

**DISCUSSION**

Nonunion has been reported to range from 17% to 34% for patients who underwent bulk allograft reconstruction. Even in circumstances where union is ultimately achieved, allograft–host union occurs much more slowly than healing of living bone, usually taking >3 months and frequently requiring 1 year.

Classically, allograft–host junction sites are prepared with osteotomies performed perpendicular to the long bone. It is desirable to create perfect osteotomies, such that the cut bony surfaces of the allograft and host bones are identical, minimizing gaping and maximizing bone contact. This technique is limited by human error inherent in any freehand osteotomy and commonly remains imperfect even after multiple adjustments.

The use of a simple guide has been reported; however, this also requires adjustment in that the application or setting of the guide may be imprecise and the subsequent osteotomies may in turn be slightly angulated. Finally, even when the cuts are optimal, application of compression plates often results in compression across the near cortex and gaping across the far cortex. To accommodate
is slightly more convex than bending technique dictates the Arbeitsgemeinschaft for this discrepant compression, technique using the telescopic mating union 5 months after revision surgery showing full union 5 months after revision surgery using the telescopic mating technique.

Figure 6: (A) T1-weighted coronal magnetic resonance image of the right wrist showing a metaphyseal lesion with cortical destruction and soft tissue extension. Short-time inversion recovery image of the right wrist demonstrating signal heterogeneity and soft tissue extension (B).

Figure 7: Lateral right forearm radiograph showing catastrophic failure of conventional osteoarticular allograft reconstruction.

Figure 8: Anteroposterior (A) and lateral (B) radiographs showing full union 5 months after revision surgery using the telescopic mating technique.

The concept of telescoping a bone inside the other is not novel. Healey et al described a technique whereby the remaining short proximal femur can be telescoped into the metaphyseal flare of an allograft femur. This allows for successful reconstruction using an allograft–prosthetic composite in which the endoprosthesis comprises <40% of the overall reconstruction. Although similar in concept, the technique applies to reconstruction in which intramedullary fixation is used and in areas where a large allograft–host bone size mismatch can be tolerated. The concept of telescoping is also used in rotationplasty surgery; however, rotationplasty uses autogenous bone, not allograft, and healing is expected to be robust.7,9

CONCLUSION
This article describes a modified surgical technique of allograft–host telescopic mating, which was designed to increase bone contact across the junction site and thereby minimize nonunion, delayed union, and time to union. It can be used in a variety of anatomic locations and is not limited by relatively limited soft tissue envelopes. Initial outcomes have been encouraging in this small cohort of patients, and broader experience will be helpful in fully evaluating the technique and its long-term outcomes.

REFERENCES