Treatment of irradiated poststernotomy sternal nonunion with autologous stem cell–impregnated bone matrix and sternal plating

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Sternal wound complications are an infrequent but significant cause of postoperative morbidity for cardiothoracic surgical patients. Sternal nonunion occurs in fewer than 1% of patients after median sternotomy,¹ but it represents a challenging clinical problem because it is often associated with chronic pain of debilitating magnitude. Affected patients are often treated with débridement and sternal rewiring, which requires reexploration of the mediastinum. We describe the case of a patient successfully treated with an autologous stem cell–seeded bone matrix and sternal plating for chronic manubrial nonunion in a postsurgical, irradiated sternum.

CLINICAL SUMMARY

The patient was an obese 42-year-old woman who, in a workup for upper respiratory symptoms, had undergone a computed tomography of the chest in June 2006 revealing a 10-cm substernal mass. The patient underwent mediastinal exploration through median sternotomy at an outside hospital. At that time, she was found to have a large mass that invaded the mediastinal pleura, bilateral phrenic nerves, left main stem bronchus, and the great vessels. The final pathologic report demonstrated large B-cell lymphoma, and the postoperative course was complicated by respiratory insufficiency requiring mechanical ventilation for 5 days as well as steroid treatment. After full recovery, the patient was treated with 12 weeks of the VACOP-B chemotherapeutic regimen (etoposide, doxorubicin, cyclophosphamide, vincristine, prednisone, and bleomycin), and she received 3600 cGy of radiation to the mediastinum in divided fractions. Therapy was completed in January 2007 and was complicated only by upper extremity deep vein thrombosis treated with subcutaneous heparin injections. A follow-up positron emission tomographic scan did not show evidence of residual or recurrent disease.

FIGURE 1. Computed tomographic scan of chest reveals 7-mm sternal nonunion limited to manubrium.

After completion of her treatment, the patient reported debilitating, severe, constant bilateral chest pain localized to the manubrium and adjacent anterior chest wall. No sternal problems had previously been reported, and a computed tomographic scan 8 months after surgery did not show evidence of sternal nonunion. The patient's condition was initially misdiagnosed as fasciitis, and she underwent repeated injections of analgesic agents without relief. Subsequently, computed tomographic scan of the chest was obtained, revealing a 7-mm sternal nonunion limited to the manubrium (Figure 1). On physical examination, the patient had moderate tenderness over the manubrium without evidence of infection. There was no audible or palpable clicking. The patient was advised to undergo sternal stabilization.

Our operative approach was dictated by the patient's exposure to local radiation, high-dose steroids, and generalized immunosuppression, as well as previous mediastinal exploration. The goal was to achieve full and durable stabilization without mediastinal reexploration or further devascularization of the sternum. The procedure was performed with general anesthesia. The upper portion of the patient's previous sternal incision was incised. The subcutaneous tissue and the pectoralis muscle overlying the upper portion of the sternum were then mobilized for clear exposure of the manubrium and the adjoining ribs. The 6- to 7-mm gap between the sternal edges at the level of the manubrium was then débrided with a curet until normal-appearing marrow was visualized. The bottom of the wound was also gently curetted without extending significantly beyond the posterior plate of the sternum. After ensuring that the sternal edges were mobile and could be reapproximated, a Synthes 12-hole locking star plate (Synthes Inc, West Chester, Pa) of appropriate size

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FIGURE 2. Follow-up computed tomography of chest. Overlying plate introduces artifact, but there is evidence of new bone between halves of manubrium.

was bent to accommodate the curvature of the sternum. The bone edges were reapproximated with the Synthes sternal approximator to a final separation of 2 to 3 mm. Next, a small 1- to 2-cm incision was made over the right iliac crest, and a large aspirating needle was gently tapped into the bone marrow, with 5 passes taken to harvest enough bone marrow for subsequent processing. The harvested heparinized bone marrow was processed with the Collect Graft Preparation system (Depuy Spine, Inc, Raynham, Mass) for selective retention of connective tissue progenitor cells. The cellular extract was then mixed with demineralized bone matrix, and the composite was used to fill completely the residual space between the sternal edges. The star plate was then secured with ten 14-mm screws to distribute the tension and firmly approximate both sides of the manubrium. After completion of the procedure, the area was irrigated with vancomycin.

Six months after the surgery, the patient reported only slight intermittent discomfort in the manubrium, and the repair appeared stable on physical examination. Follow-up computed tomography of the chest at 6-month follow-up is shown in Figure 2. Although the overlying plate introduces

some artifact, there is evidence of new bone between the halves of the manubrium. No morbidity from the marrow aspiration site was noted.

DISCUSSION

Sternal plating has been described for treatment of post-coronary artery bypass grafting sternotomy nonunion² and in conjunction with autologous cancellous bone grafting for treatment of failed sternal nonunion repairs.³ We describe a technique of sternal plating reinforced with autologous osteogenic cell-impregnated bone matrix for sternal nonunion in a high-risk patient with history of malignancy, mediastinal irradiation, chemotherapy, and steroid immunosuppression. The yield of osteogenic cells from bone marrow aspirates can be increased by passing the aspirate through selective filters that increase retention of anchorage-dependent cells. Such concentrated aspirates have been associated with higher fusion rates in an animal model of lumbar fusion than seen with bone grafting alone.⁴ Mesenchymal stem cell allografts have also been demonstrated to be efficacious in revision foot and ankle surgery.⁵ To our knowledge, this is the first described case of augmenting sternal stabilization with osteoprogenitor cell-impregnated allogeneic bone matrix. Greater clinical experience and longer follow-up are needed to assess the full efficacy of this approach in high-risk patients with sternal nonunion.

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