

Attachment Issues: A Case Report of a Promising Sternal Implantation with 3D-printed Polyethylene

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Summary: Sternal reconstruction is beneficial for chest wall stability, respiratory function, and cosmetics, with no superior prosthesis or method thus far identified. We present a case of sternal reconstruction in a patient 6 years post sternal removal using a 3D-printed, patient-specific, polyethylene prosthesis with reasonable short-term outcomes. We believe a polyethylene prosthesis shows advantages over other materials and is worth further investigation, providing a technique for attaching said prosthesis to the native tissues is established. (*Plast Reconstr Surg Glob Open* 2021;9:e3985; doi: [10.1097/GOX.0000000000003985](https://doi.org/10.1097/GOX.0000000000003985); Published online 14 December 2021.)

Many techniques and materials have been used in the repair of sternal and chest wall defects following resections of mediastinitis and cancers, with none so far proving to be superior and rates of complications appearing similar.^{1,2} The innovative use of 3D printing of patient specific prostheses combined with development of new materials shows promising results in stabilizing the chest wall, improving respiratory function,³ reducing prosthetic infection, and improving cosmetic appearance.⁴ We present a case of sternal reconstruction using a 3D-printed porous polyethylene sternal implant, trialing multiple attachment techniques.

CASE REPORT

Our patient is a 58-year-old man with a physically demanding job who underwent uncomplicated coronary artery bypass grafting in 2011. Two years later, his sternum dehisced, requiring revision. Rewiring in 2014 failed and the patient developed osteomyelitis, at which point the sternum was excised and the defect covered with a rectus muscle flap. Following two further presentations with graft stenosis and PCI, and repeat coronary artery bypass grafting via thoracotomy, a sternal prosthesis was discussed between cardiothoracic surgery, plastic surgery, and the patient, for chest wall stability. Six months post redo coronary artery bypass grafting, the patient was fit for sternal reconstruction. There were no signs of active infection at the time of operation. A 3D StarPore prosthesis was designed in advance by Anatomics,⁵ using computed topography (CT), according to the patient's

specifications. In a joint operation with plastic surgery, a midline sternotomy extending to an inverted T incision was made and the previous subcutaneous flaps were raised. The pectoralis major muscle was mobilized and raised to expose the ribs on each side. The ribs were mobilized and the prosthesis was positioned and secured to the costal cartilages with Ethibond tape sutures. Six universal gold plates (MatrixRIB) were placed between the prosthesis and the costal cartilages (Fig. 1) to provide additional support. The pectoral flaps were reapproximated in the midline with two subpectoral drains left in situ, and the wound was closed.

The patient was discharged on day four, with the two drains still in situ. He was readmitted 17 days later with anemia and high hemorheous drain output, and a superficial hematoma inferomedial to the origin of the pectoralis muscle was identified on CT. The prosthesis appeared stable and well seated (Fig. 2). He was transfused two units of packed red blood cells and discharged after three days with an ultrasound-guided drain into the hematoma, replacing the two previous drains.

Six months postoperatively, the patient was experiencing left anterior chest pain. A chest x-ray found that several of the screws securing the prosthesis had loosened and migrated (Fig. 3), causing the rib plates, specifically at the lateral costal cartilage ends, to lift and create pain on movement.

He was brought forward for exploration, with the aim of excising the prosthesis should it not be implanted properly. In theater, the prosthesis was found to be firmly incorporated in the tissues. As expected, the lateral aspects of the rib plates were loose, but there were no signs of infection or concerns with the prosthesis itself. The plates were firmly attached medially to the sternal prosthesis, and the prosthesis in turn well adhered to the tissues. The idea of removing the prosthesis was abandoned in favor of refixing the plates to the costal cartilages. Ten loose screws were removed from the plates and surrounding tissue.

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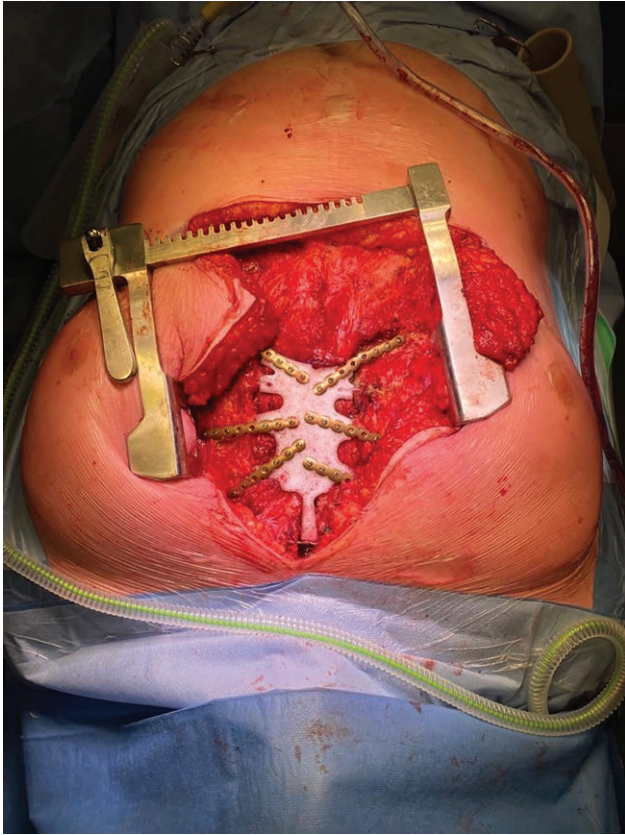


Fig. 1. Intraoperative view of StarPore polyethylene sternal prosthesis, sutured in place with Ethibond sutures and further stabilized with universal plates.

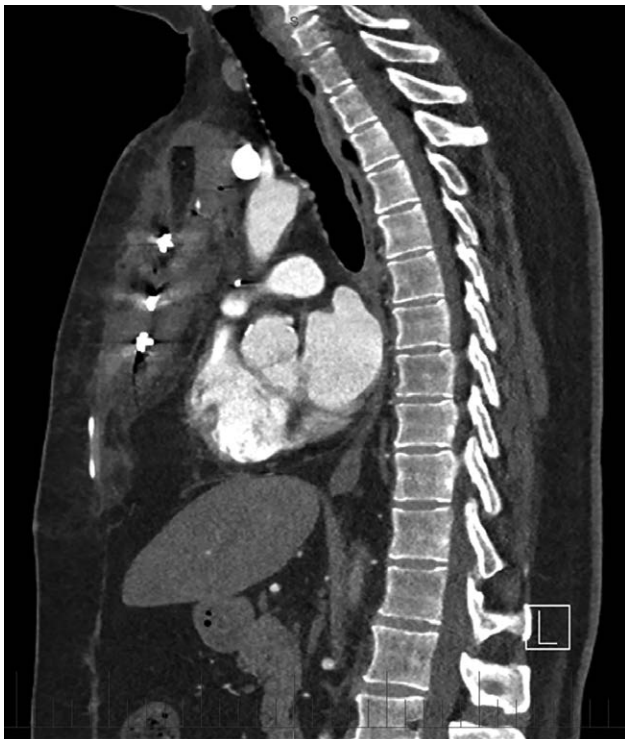


Fig. 2. A 17-day postoperative CT scan (sagittal view) showing stable and well-seated appearances of the radiolucent prosthesis.

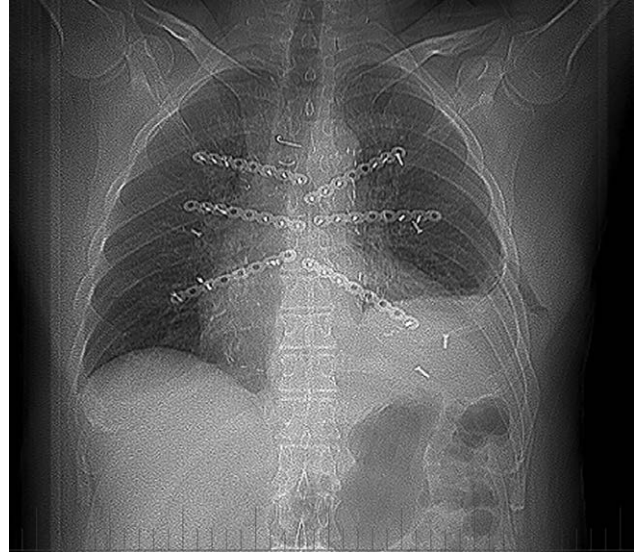


Fig. 3. CT scout view of migrated screws 1 year after the initial operation.

One FibreTape from Arthrex⁶ was tightened around both costal cartilage and plate for five of the six ribs. The sixth plate was already attached firmly to the rib rather than to the costal cartilage and did not need further reinforcement. A subcutaneous drain was left in situ. The patient was discharged on day one following repeat chest x-ray (Fig. 4). The drain was removed on day nine, and the patient will be followed up virtually with a repeat chest x-ray.

DISCUSSION

Prosthetic sternal implants are becoming more common; however, a paucity of convincing evidence for the choice of material means a dominant method is not yet established. The main reasons for reconstruction of sternal defects focus on maintaining chest wall stability, adequate respiratory function, and cosmetic effect.²

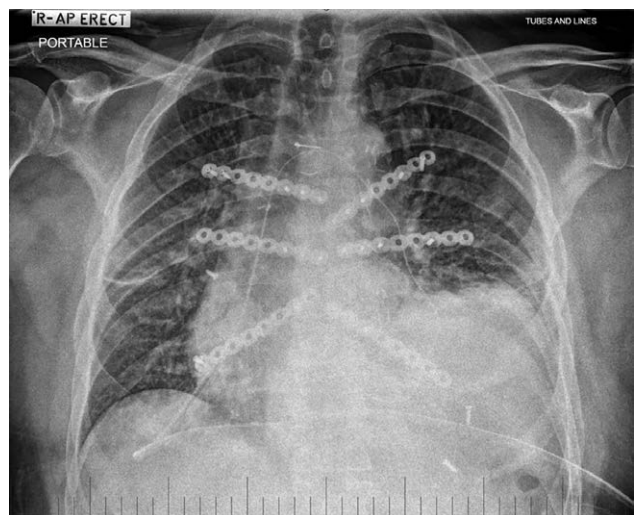


Fig. 4. Postexploration chest x-ray showing improved appearances of rib plates.

Prosthetic implants seem to have favorable outcomes over muscle flaps or other methods of reconstruction in terms of longevity and fewer complications,² but there is no clear evidence yet for choosing one material over another.^{1,2} The most significant risks of sternal prostheses common to all methods are stability, respiratory, and infection based, with complications being reported in an estimated one third to almost half of cases.²⁻⁴

One challenging aspect of sternal reconstruction is the development of a suitable implant material that is ergonomic and reduces complications but also designed according to patient specifications. Hence, we enter the realm of 3D printing which has several advantages, including more accurate shaping,⁷ reduced handling, and possibly a positive effect on respiratory function.^{3,8,9} Titanium and polyethylene are thus far the most investigated materials with favorable results.^{4,7}

The material used in this case, StarPore, is a 3D-printed porous polyethylene scaffold that enables tissue integration, helping with stability and infection resistance.⁵ It allows for intraoperative modification, is strong and rigid yet somewhat flexible, and highly porous.⁵ It is nonreactive, nonabsorbable, and reduces growth of organisms, making it an ideal next generation material.^{4,5}

The difficulty we faced was finding an appropriate way to secure the prosthesis to the ribcage. Intraoperatively we were hesitant about the strength provided by the Ethibond sutures alone, so elected to reinforce using the rib plates as used by other centers using a StarPore prosthesis.^{8,10} One used full-sized rib plates to secure the prosthesis, and the other, a titanium structure coated with StarPore with titanium arms to slot over the ribs.⁸

Our rib plates loosened as most of the screws were in the costal cartilages rather than the ribs due to the size of the universal rib plates. This issue could only have been avoided by making a larger incision and using the full size rib plates that would reach from the sternum to the ribs proper.

The second operation used FibreTape, which is also marketed as a sternal closure method and is designed to have adequate strength to maintain stability without damaging bone.⁶ At the time of operation, the plates appeared to be effectively held in place to the costal cartilages.

We are constrained by our single case experience with a limited follow up time. The short-term results suggest StarPore is a promising material but success will depend on further research to establish a technique for securing the prosthesis to the native tissues until tissue integration has occurred.

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