A 54-year old male presented with an 8 × 8 cm painful right para-sternal mass. Computed tomography (CT) scan showed involvement of both pectoral muscles, the sternal body and the third and fourth bilateral ribs (Fig. 1A) with no other local or distant metastasis. All of these findings suggested primary sternal chondrosarcoma, so resection was approved by a multidisciplinary committee.

Post-resectional reconstruction was planned by means of a 3D-CTPP. CT high-resolution DICOM data were uploaded via proprietary ordering software to Anatomics Pt Ltd (St Kilda, Australia) to create a 3D surface render of the chest wall and tumour on which resection was approved by a multidisciplinary committee. Oxygen therapy was discontinued on the third postoperative day in the absence of respiratory failure. Morbidity was reduced to a latissimus dorsi myocutaneous pedicled flap. The patient was extubated immediately after surgery and transferred to the recovery room where chest physiotherapy was initiated.

Abstract

A broad range of materials have been described for sternal reconstruction in order to guarantee not only the best preservation of respiratory mechanics, but also adequate mediastinal protection and acceptable cosmetic results. Today, titanium implants are preferred by many surgeons because of their optimal features. As a step forward, tridimensional (3D) laser sintering printing techniques allow us to virtually reproduce even more complex bony structures. Here, we present a case of sternocostal reconstruction by means of a 3D titanium-printed custom-made prosthesis after extensive resection of a chest wall sarcoma. The use of an intraoperative template to precisely set resection margins, the novel prosthetic design as well as a new and safer rib fixation system may offer some advantages over other custom-made reconstructive techniques.

Keywords: Sternal tumour • Chest wall resection • Chest wall reconstruction • Titanium prosthesis • Custom-made prosthesis

INTRODUCTION

After wide excision for local control of primary malignant sternal tumours, reconstruction by means of mouldable titanium plates, bars and meshes as a strong, flexible and easy-to-use material is the usual option [1].

In search of the best functional and cosmetic results, tridimensional (3D) custom-made titanium-printed prosthesis (3D-CTPP) has emerged as a valid option. We present a case of sternocostal reconstruction by means of a newly designed 3D-CTPP powered with a safer rib fixation system plus a custom-made template for a more precise intraoperative setting of resection margins.

CASE REPORT

Tridimensional titanium-printed custom-made prosthesis for sternocostal reconstruction

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CASE REPORT

A 54-year old male presented with an 8 × 8 cm painful right para-sternal mass. Computed tomography (CT) scan showed involvement of both pectoral muscles, the sternal body and the third and fourth bilateral ribs (Fig. 1A) with no other local or distant metastasis. All of these findings suggested primary sternal chondrosarcoma, so resection was approved by a multidisciplinary committee.

Post-resectional reconstruction was planned by means of a 3D-CTPP. CT high-resolution DICOM data were uploaded via proprietary ordering software to Anatomics Pt Ltd (St Kilda, Australia) to create a 3D surface render of the chest wall and tumour on which desired resection margins were confirmed and applied to create the defect extents for reconstruction. Thus, the implant was designed as a rigid sternal core with titanium rods as neo-ribs (Fig. 1B) ended in an attachment clamp with a rough inner surface where costal stumps were further locked by a length-customized titanium bolt (Fig. 1C); for sternal anchoring, simple holes for steel wiring were preferred. An Arcam A1 Electron Beam Melting machine (CSIRO, Clayton, Australia) was subsequently used for implant printing from surgical grade titanium alloy. Finally, a resection template to allow precise intraoperative setting of resection margins was designed using 3D software and printed from a biocompatible material.

Surgery consisted in en bloc resection of the skin, pectoral muscles and sternal body plus bilateral costal arches according to template boundaries (Fig. 2A). A Dualmesh® patch was fixed to the rear side of the prosthesis before placing the 3D-CTPP (Fig. 2B), then covered with a latissimus dorsi myocutaneous pedicled flap. The patient was extubated immediately after surgery and transferred to the recovery room where chest physiotherapy was initiated.

Postoperative pain management was conducted according to the current service protocols [2]. Oxygen therapy was discontinued on the third postoperative day in the absence of respiratory failure. Morbidity was reduced to a latissimus donor site seroma, drained until resolution. The patient was discharged home 12 days after surgery and prior chest Rx showed a stable reconstruction, with preservation of thoracic morphology and excellent cosmetic results (Fig. 2C). Histopathology revealed a Grade II sarcoma with dedifferentiated liposarcoma areas.

DISCUSSION

Although titanium implants are usually preferred for sternal reconstruction, interest has been renewed for a more customized
solution that offers better functional and cosmetic results as shown by recent publications [3]. However, hand-made manufacturing of these devices may lead to inaccuracies whereas 3D computer-assisted design eliminates the need to shape, cut or contour the implant in theatre with perfect anatomical fitting and an almost infinite variety of designs.

Recently, Demondion et al. [4] published their experience with a custom-made titanium plate after resection of a breast cancer metastasis while Turina et al. [5] did it with a patient-specific titanium implant after wide anterior chest wall resection. Although both devices were designed via 3D software, the former is in fact a modified titanium plate whereas only the latter should be considered as a 3D-CTPP; however, its plate-like structure puts it at risk for similar complications to those of other plain and rigid implants (e.g. impairment of respiratory mechanics, device migration or inaccuracy in resection margin setting). Our prosthesis incorporates titanium rods as neo-ribs to improve flexibility and rib attachment clamps with a rough inner surface and self-locking safety bolts to minimize the risk for migration or dislocation secondary to rib stump tearing when using bone screws. Finally, the intraoperative use of the rigid custom-made template allowed objective and precise setting of resection margins for a perfect implant fitting.

Although this is a promising tool, we must admit that the use of 3D-CTPP is probably highly restricted to patients in the need for extensive sternal resection where more simple reconstruction techniques have been deemed inadequate. The prosthesis manufacturing process takes about 1 month, maybe time enough for highly aggressive tumours to induce unexpected findings in the operative field that could make difficult device implantation. Last but not least, functional and cosmetic short-term results seem to be excellent but a long-term follow-up is needed to gain reliable experience on its use and potential complications.
To conclude, 3D titanium-printed custom-made prosthesis seems to be a valid option for reconstruction after extensive sternocostal excision, achieving good functional and cosmetic results. Regarding the use of an intraoperative template to precisely set resection margins, the novel prosthetic design as well as a new and safer rib fixation system may offer some advantages over other custom-made reconstructive techniques.

Conflict of interest: none declared.

REFERENCES


