

Wide Resection of a Giant Sternal Chondrosarcoma and Reconstruction with a Custom-Made 3D Titanium Plate in a Patient with Kartagener Syndrome

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ABSTRACT

Sternal tumors are rare, but the majority of these tumors are chondrosarcomas. Chondrosarcomas are generally resistant to chemotherapy, and the first-line treatment is surgical resection. For malignancies located in the anterior chest wall, wide resection should be performed to prevent recurrence. After a wide resection, the defective area should be reconstructed in a way that preserves chest wall rigidity. This is crucial both to protect intrathoracic organs from trauma and to maintain effective respiratory mechanics. In this report, we aimed to present a case of a patient with Kartagener syndrome and sternal chondrosarcoma, in whom we performed a custom-made three-dimensional (3D) reconstruction.

INTRODUCTION

Sternal tumors are very rare, and sternal chondrosarcomas account for 2% of all chondrosarcomas.^[1] To prevent recurrence in chondrosarcoma resection, a surgical margin of at least 4 cm should be preserved.^[2] To achieve a 4 cm surgical margin, especially in cases of giant chondrosarcomas, it is necessary to perform an en bloc resection of the sternum along with the neighboring ribs. After resection, the large anterior chest wall defect must be reconstructed in a way that preserves chest wall rigidity. In clinical practice, conventional approaches such as titanium bars or meshes and methyl methacrylate have sometimes been found to provide insufficient chest wall rigidity, resulting in paradoxical breathing. This has highlighted the need for methods that allow for more effective reconstruction of anterior chest wall defects. To meet this need, custom made three-dimensional (3D) titanium prostheses have been introduced in recent years. In this article, we present

a case in which we applied a custom-made 3D titanium prosthesis, a reconstruction method recently introduced into thoracic surgery practice.

CASE REPORT

A 68-year-old female patient presented to our outpatient clinic with a swelling and pain in the anterior chest wall. Physical examination reveals a mass measuring approximately 6×10 at the lower end of the sternum. Chest computed tomography (CT) of the patient revealed dextrocardia, bronchiectasis in the right lower lobe, and a 6 cm exophytic mass lesion at the lower end of the sternum. An incisional biopsy performed on the patient was reported as chondrosarcoma. A positron emission tomography/computed tomography (PET-CT) scan performed for staging revealed no distant organ metastases. A preoperative 3D thoracic CT scan was obtained, and a custom-made titanium implant was prepared using a 3D printer. Following a

full-thickness chest wall resection, the patient underwent partial resection of the sternum and the 2nd to 5th ribs, extending 4 cm laterally. A composite mesh was placed between the lung and the titanium plate and secured with prolene sutures. The titanium plate was fixed to the manubrium and the ribs. The plastic surgery team reconstructed the tissue defect by transposing a latissimus dorsi muscle flap (Fig. 1). Intraoperative frozen section work-up confirmed that the tumor surgical margins were negative. The patient was transferred to the intensive care unit postoperatively under mechanical ventilation. The patient had difficulty weaning from mechanical ventilation due to dextrocardia and secretion stasis from bronchiectasis, so a tracheostomy was performed in the intensive care unit. The patient was monitored for a period on home ventilation in the ward and was subsequently discharged in good condition. No recurrence was detected in the patient at the 2-year follow-up.

DISCUSSION

Chondrosarcoma is a chemo-resistant tumor, and wide surgical resection remains the first-line treatment. The large chest wall defect resulting from surgical resection of the sternum and adjacent ribs should be properly reconstructed to protect intrathoracic organs from external

trauma and preserve the chest wall's impact on respiratory mechanics. Therefore, when performing chest wall reconstruction, the use of rigid materials that can substitute for the resected bone tissue is especially critical, particularly after sternum resection. The muscle and skin covering these rigid materials should also be reconstructed using fasciocutaneous muscle flaps, regional flaps, or free muscle flaps.^[3]

Conventionally, rigid reconstruction is performed using materials such as titanium bars or meshes, or methyl methacrylate–prolene mesh. However, the effectiveness of these materials is limited, as they do not provide strong chest wall stabilization and may cause paradoxical respiration, thereby failing to preserve respiratory mechanics.^[4] To address these issues, custom-made 3D titanium prostheses have been introduced in recent years for chest wall resection.

To prepare a 3D titanium prosthesis, the patient's CT data is first imported into the Materialise Interactive Medical Image Control System (MIMICS) Research 20.0 (Materialise, Belgium) to create a digital model. The designed prosthesis model is then transferred to a 3D printer to produce a plastic prototype. This prototype model is used as a guide on a computer numerical control (CNC) machine to produce the final pure titanium prosthesis.

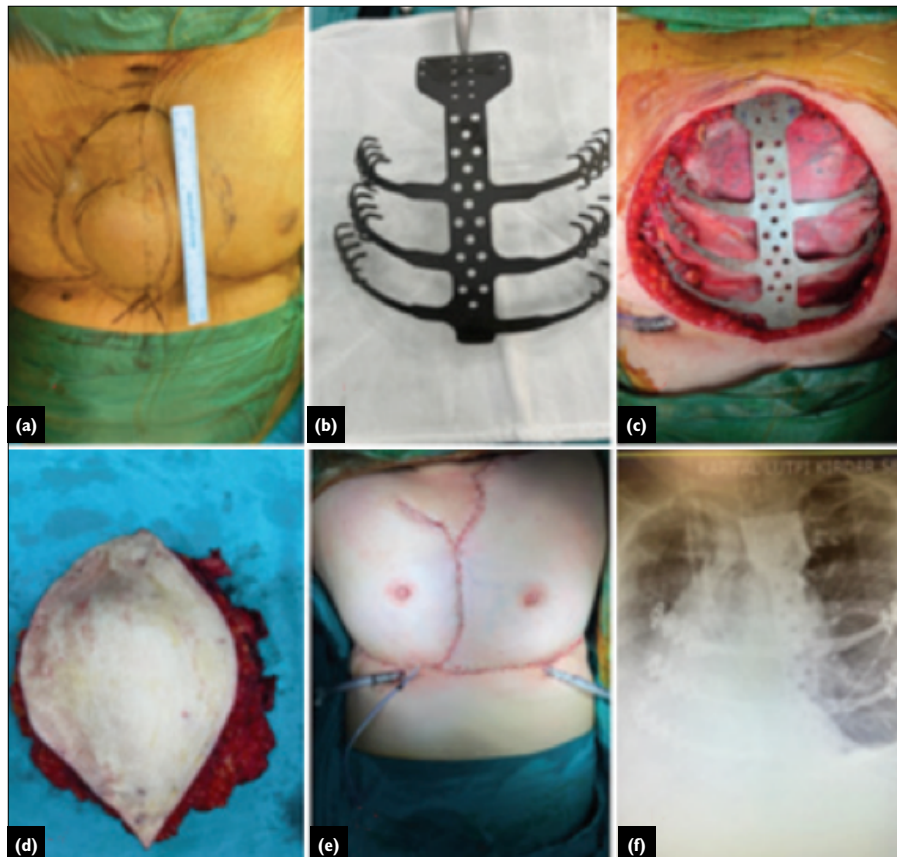


Figure 1. (a) Preoperative appearance of sternum with tumor, (b) Custom-made 3D material, (c) Peroperative view, (d) Resected material, (e) Postoperative view, (f) Postoperative X-ray.

Anterior chest wall reconstructions using 3D titanium prostheses have yielded encouraging results.^[5] Although no studies have yet compared this new technique with conventional methods, it appears to be more robust due to its single-piece implantation. Additionally, it is effective in covering larger defects and helps reduce operative time.

In conclusion, the patient-specific 3D titanium prosthesis method used to reconstruct defects following chest wall resection for sternal tumors preserves chest wall rigidity and respiratory mechanics. By perfectly matching the patient's anatomy, it provides stronger mechanical stabilization as well as a more aesthetic and functional chest wall reconstruction. Moreover, it is effective in facilitating the closure of large defects with at least a 4 cm surgical margin, reducing complications, and shortening operative time.

Informed Consent

Retrospective study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: R.D.; Design: R.D.; Supervision: R.D.; Materials:

R.D., B.Ç.; Data: R.D., B.Ç.; Analysis: R.D., B.Ç.; Literature search: R.Ç.; Writing: B.Ç.; Critical revision: R.D.

Conflict of Interest

None declared.

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Kartagener Sendromu Olan Hastada Dev Sternal Kondrosarkomun Geniş Rezeksiyonu ve 3D Titanyum Plak ile Rekonstrüksiyonu

Sternum tümörleri nadir görülmekle beraber bu tümörlerin büyük çoğunluğunu kondrosarkomlar oluşturur. Kondrosarkomlar kemoterapiye genellikle duyarsızdır ve birinci seçenek tedavi cerrahi rezeksiyondur. Göğüs ön duvarında yerleşmiş malignitelerde nüksü engellemek için geniş rezeksiyon yapılmalıdır. Geniş rezeksiyondan sonra oluşan defektif alanın göğüs duvarı rijiditesini bozmayacak şekilde rekonstrükte edilmesi hem intratorasik organların travmalara duyarlılığını azaltmada hem de solunum mekaniğini devam ettirme açısından önemlidir. Bu raporda sternal kondrosarkomu olan Kartagener sendromlu hastada kişiye özgü 3D rekonstrüksiyonu uyguladığımız olguyu sunmayı amaçladık.

Anahtar Sözcükler: 3D rekonstrüksiyon; göğüs duvarı; kondrosarkom.