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# Challenges in Complex Oncological Chest Wall Reconstruction with Free Anterolateral Thigh Flap and Titanium Rib Plate

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## Abstract

Extensive chest wall tumor resection and reconstruction possess a formidable challenge and require good collaboration between thoracic and reconstructive surgeons. In this article, we reviewed our experience in six consecutive cases requiring complex chest wall resection and reconstruction with titanium rib plates and free anterolateral thigh fasciocutaneous flap with fascia lata with a minimum 24 months follow-up postoperatively.

Six patients with a mean age of 54 were diagnosed to have locally advanced malignant ($n = 5$) and benign ($n = 1$) tumors. They underwent wide local excision with a mean of six ribs resected, and the average size of the soft tissue defect was 389cm$^2$. The integrity of the thoracic cage was restored by using titanium rib plates. Fascia lata was harvested along with free anterolateral thigh fasciocutaneous flap to achieve near airtight closure of pleural space for soft tissue coverage. Two patients required early flap exploration with successful flap salvage. One flap failure was reported on postoperative day 11 due to a mechanical cause and a redo surgery was required. With an average stay of 3 days in the intensive care unit, no perioperative pulmonary complications were recorded.

Complex oncological chest wall resection and reconstruction with titanium rib plates and free anterolateral thigh fasciocutaneous flap with fascia lata yielded satisfactory aesthetic and physiological functional outcomes.

**Keywords**

- oncological chest wall reconstruction
- anterolateral thigh flap
- titanium rib plate

## Introduction

Complex oncological chest wall resection can cause loss of integrity of the thoracic cage, thus impairing the mechanics of breathing and leaving the mediastinal structures unprotected. The extent of resection to achieve tumor free margin will determine the type of reconstruction needed. Superior oncological and aesthetic outcome can be achieved with multidisciplinary team approach and can prevent these patients to be subjected to merely palliative treatment.

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Common indications for chest wall resection are tumors involving bone and cartilage, soft tissue sarcomas, locally advanced lung cancer, and breast cancer.[1] Resection of these tumors with clear margin leaves a huge composite defect. Reconstruction is aimed to restore skeletal integrity and soft tissue coverage.[2] Skeletal integrity loss can be restored with either an autologous or synthetic materials. Titanium plate has relegated the use of autologous materials in the aspect of convenience, reliability, ease of application, and achieving physiological chest wall reconstruction.

Soft tissue reconstruction in extensive defects often leaves the surgeon with little chance of utilizing locoregional flap such as latissimus dorsi that is considered a workhorse flap.[3] Free anterolateral thigh (ALT) flap provides the versatility of offering a large composite tissue, which allows the surgeon to close the defect in a tension free manner. Microsurgery free tissue transfer has its own difficulties and complications. Overcoming the obstacles in these surgeries is a virtue worth sharing.

Therefore, in this case series we would like to highlight the pitfalls and perioperative complications in complex oncological chest wall reconstruction involving titanium rib plate and free anterolateral thigh flap.

## Patients and Methods

A retrospective case note review of six patients who underwent free ALT flaps with titanium rib plates for chest wall reconstruction in our center between the year 2018 and 2019 was performed.

Detailed information such as sex, age, pathological diagnosis, extent of chest wall defect, number of ribs resected, number of ribs reconstructed with titanium rib plates, flap size, recipient vessels, ischemia time, early and late complications, length of intensive care unit (ICU) stay, and length of hospital stay were collected.

Preoperatively, all the patients were reviewed by a multidisciplinary team that consisted of plastic and reconstructive surgery, thoracic surgery, radiology, oncology, anesthesiology, and pathology to evaluate the nature of the tumor, the extent of the growth, general condition as well as fitness to undergo major and long hours of surgery. Besides that, we will ensure all patients have updated imaging for discussion on the tumor resection margin and potential resultant defect. Dimension of the free ALT flap was designed based on the potential defect size and recipient vessels.

While the thoracic surgery team was resecting the tumor, the reconstructive surgical team harvested the flap simultaneously. Once tumor resection was completed, the flap pedicle was then divided and transferred to the chest wall defect and microvascular anastomoses were performed. Titanium rib plates (MatrixRIB Fixation System, DePuy Synthes, Switzerland) placed by the thoracic team after successful free flap pedicle anastomosis to reduce plate exposure time and chest drain were inserted. Straight rib plate was contoured and rib thickness was measured to get an appropriate length of screw. Fascia lata of the ALT flap was subsequently anchored to the soft tissue or myofascia of the chest wall defect, creating a near airtight closure. Suction drains were placed at the medial and lateral aspect of the flap prior to skin closure.

## Results

This case series included six consecutive patients who underwent complex oncological chest wall reconstruction with free ALT flap and titanium rib plates. There were two male and four female patients. The mean age of the patients at the time of surgery was 53.8 years (range, 21–67 years). Two patients had underlying diabetes mellitus and one patient had hepatitis C. None of them were smokers (►**Table 1**).

There was a benign and five malignant cases. The tumors were located mainly at the anterolateral chest wall ($n = 3$). The pathological diagnosis for these six cases is stated in ►**Table 1**. The mean number of resected ribs was 5.5 (range, 4–6 ribs). Two cases involved resection of clavicles and one case involved resection of manubrium. The mean soft tissue defect area was 389 $cm^2$ with the dimensions as stated in ►**Table 2**. Two patients had concomitant surgeries, a right upper lobectomy and a thymectomy with left upper lobectomy.

For soft tissue coverage, eight ALT flaps were harvested with the mean skin paddle size of 440$cm^2$. The largest dimension of skin paddle was 31cm × 24cm. Each of the flap was harvested with two to three perforators. The component and details of flap including recipient arteries and veins are summarized in ►**Table 2**. There was only one case whereby an intrathoracic anastomosis was performed (►**Fig. 1**).

**Table 1** Demographic data

| No | Age | Gender | Histological diagnosis | Comorbidity |
|---|---|---|---|---|
| 1 | 61 | M | Chondrosarcoma | Hepatitis C |
| 2 | 62 | F | Leiomyosarcoma | None |
| 3 | 49 | F | Recurrent malignant phyllodes tumor | DM |
| 4 | 57 | F | Recurrent malignant phyllodes tumor | None |
| 5 | 27 | F | Desmoid fibromatosis | None |
| 6 | 67 | M | Thymic squamous cell carcinoma | DM |

Abbreviations: DM, diabetes mellitus; F, female; M, male.

 

**Table 2** Intraoperative resection and reconstructive details

| No | Location | Dimension of soft tissue defect ($cm^2$) | Bony resection | Concomitant surgery | ALT flap skin paddle dimension length(cm) x width (cm) ($cm^2$) | No of perforator | Component of flap | Thoracic chest wall reconstruction | Anastomosis | Recipient artery | Recipient vein |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Antero–lateral thoracoabdominal | 30cmx32cm (660) | Lt: 5th–10th ribs | Partial left hemidiaphragm resection | Rt: 29 × 18 (522) | Rt: 2 | Myocutaneous | 2 TP | ET | Bilateral | VC DIEA |
| | | | | | Lt: 26 × 16 (416) | Lt: 3 | | 3 CM | | DIEA | |
| 2 | Anterolateral | 15cmx20cm (300) | Right clavicle | None | Rt:24 × 20 (480) | Lt: 1 | Fasciocutaneous | 3 TP | ET | Ips IMA | Branch of innominate vein |
| | | | Rt:1st–4th ribs | | Lt (re-do):27 × 18 (486) | Rt: 2 | | | | | |
| 3 | Anterolateral | 26cmx24cm (624) | Lt: 2nd –7th ribs | None | 31 × 24 (744) | 3 | Myocutaneous | 3 TP | ET | Ips Pec Br TAA | VC Pec Br TAA |
| 4 | Anterolateral | 20cmx15cm (300) | Rt: 2nd–5th ribs | Right upper lobectomy | 23 × 19.5 (448.5) | 2 | Fasciocutaneous | 3 TP | ET | Ips Pec Br TAA | VC Pec Br TAA |
| 5 | Posterolateral | 15cmx20cm (300) | Lt: 1st–6th ribs | None | 22 × 10 (220) | 2 | Fasciocutaneous | 3 TP | IT | Ips IMA | VC DIEA |
| 6 | Central | 15cmx10cm (150) | Manubrium | Thymectomy | 17 × 12 (204) | 2 | Myocutaneous | 2 TP | ET | Ips Br CCA | IJV |
| | | | Bilateral clavicle | Left upper lobectomy | | | | | | | |
| | | | Rt: 1st–3rd ribs | | | | | 1 CM | | | |
| | | | Lt: 1st–4th ribs | | | | | | | | |

Abbreviations: ALT, anterolateral thigh; Br, branch; CCA, common carotid artery; CM, composite mesh; DIEA, deep inferior epigastric artery; ET, extrathoracic; IJV, internal jugular vein; IMA, internal mammary artery; Ips, ipsilateral; IT, intrathoracic; Lt, left; Pec Br TAA, pectoral branch of thoracoacromial artery; Rt, right; TM, titanium mesh; TP, titanium rib plate; VC, venae comitans.

**Table 3** Perioperative modality

| No | ICU LOS | Complications | Additional surgery | Donor site morbidity | Hospital LOS (days) | Follow-up (months) |
|---|---|---|---|---|---|---|
| 1 | 3 | Day 7—wound dehiscence with exposed composite meshMonth 20—exposed titanium rib plate | Wound debridement, NPWT and SSGRemoval of rib plate | None | 105 | 26 |
| 2 | 2 | Day 11—flap failure secondary to dislodged clavicular plate | Flap exploration and re-do ALT | None | 42 | 30 |
| 3 | 4 | Day 1—flap congestion secondary to folded pedicel between the titanium plate | Flap exploration and released of pedicle | Skin graft loss 30% | 33 | 12 (deceased) |
| 4 | 5 | Day 3—flap congestion secondary to trapped and kinked pedicle under the edge of 3rd cut rib | Flap exploration, reposition of pedicle, shortening of 3rd rib | None | 22 | 8 (deceased) |
| 5 | 1 | Day 21—wound dehiscence | Wound debridement and secondary suturing | Seroma post primary closure | 15 | 25 (continuous follow-up in other center) |
| 6 | 4 | Day 16—intrathoracic collection | Ultrasound-guided drainage resolved | Skin graft loss 40% | 39 | 18 |

Abbreviations: ALT, anterolateral thigh; ICU, intensive care unit; LOS, length of stay; NPWT, negative pressure wound therapy; SSG, split thickness skin graft.

Of the six patients, two underwent emergency early flap exploration on postoperative day 1 and 3, respectively, due to venous congestion, indicated by the change in skin paddle color and reduced venous Doppler signals. Both the flaps were noted to be bloated due to nonfunctioning active drains. The change was noted immediately after the nonfunctioning drains were revacuumed. Intraoperative finding in the first case revealed one of the pedicles was folded between the titanium rib plate (►**Fig. 2**), whereas in the second case, the pedicle of the flap was trapped beneath the cut edge of third rib. However, there was no vascular thrombosis and both flaps were salvaged. There was also a delayed flap failure on day 11 of surgery due to compression of pedicle by dislodged titanium plate from clavicle (►**Fig. 3).**

The patient with large thoracoabdominal chondrosarcoma developed necrosis of the native skin edges at the suprapubic region after surgery, exposing the composite mesh cover. He needed split thickness skin graft to cover the defect. He also experienced scar contraction and thinning of chest wall skin leading to exposure of the titanium plates, which were explanted by the thoracic team at 20 months after surgery (►**Fig. 4**). For donor site morbidities, there were two patients with skin graft loss of 30 to 40% but was managed conservatively. Otherwise, there were no functional morbidities reported over the ALT donor site.

The mean length of ICU and hospital admission were 3 days (1–4 days) and 42.6 days (15–105 days), respectively. There was no reported respiratory complication in this series. For long-term follow-up (►**Table 3**), three patients (50%) achieved disease-free stage after 24 months post-surgery and still under follow-up. One patient with residual tumor still undergoes radiotherapy. Two patients with recurrent malignant phyllodes tumor deceased due to progression of disease at 8 and 12 months after surgery.

## Discussion

In our case series, all the patients presented with locally advanced disease. With the refinement in reconstruction methods and multidisciplinary team approach, we aim to achieve tumor free margin to ensure good outcome of surgery. Preoperative assessment is important to outline a comprehensive management for each of our patients including postsurgical oncological treatment. Our resection is aimed at removal of ulcerative mass, pain control as well as improving quality of life for the patient. Free tissue transfer for soft tissue reconstruction allows thoracic surgeons to have the freedom to obtain a clear surgical margin.

The objectives of chest wall reconstruction are restoration of chest wall rigidity, prevention of lung herniation, avoiding contraction of chest wall, prevention of trapping of scapula, particularly when it involves the resection of fifth and sixth ribs, protection of mediastinal organ after sternal resection, and a good cosmetic outcome.[2] In this case series, we present six consecutive cases in which reconstruction involved the usage of titanium plates for skeletal support and free ALT flap for soft tissue reconstruction.

Generally, the skeletal reconstruction is indicated when defect is larger than 5 cm where four or more ribs are

 

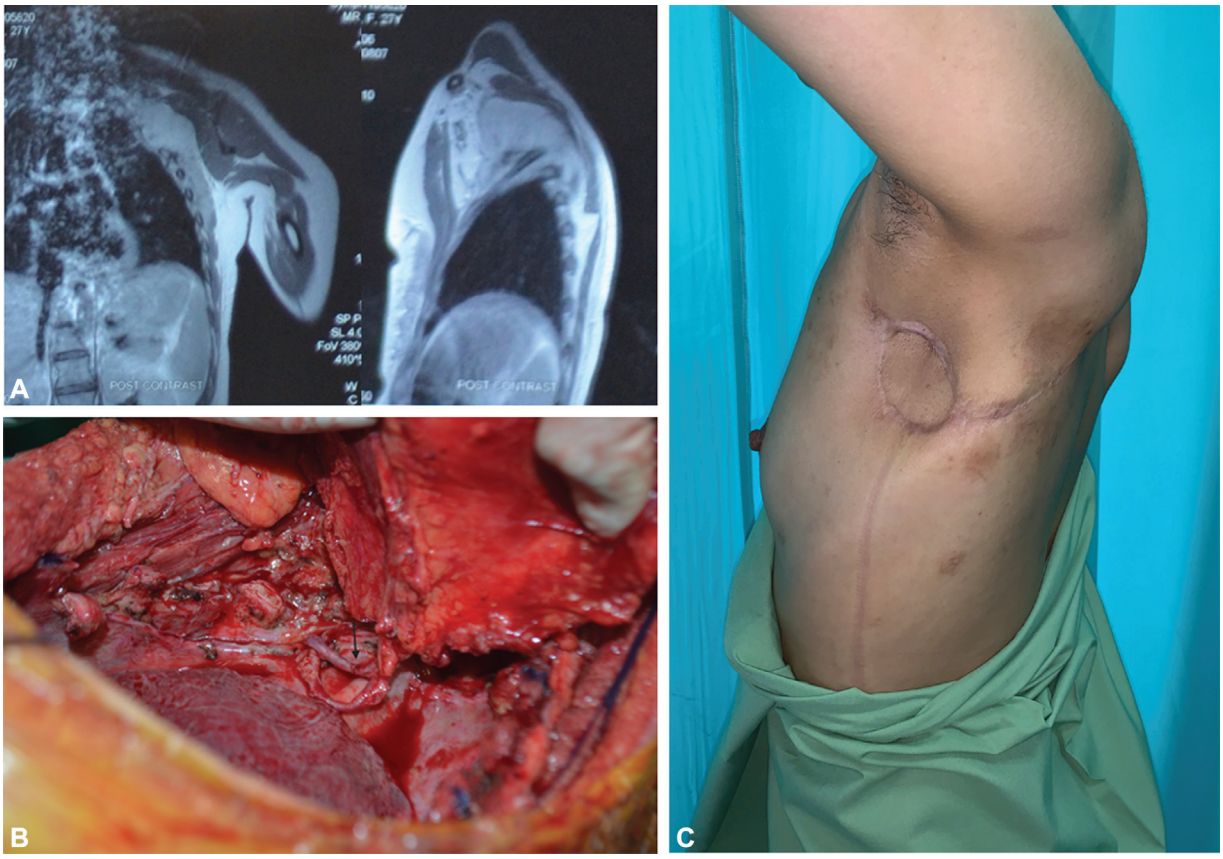


**Fig. 1** (**A**) Magnetic resonance imaging showed tumor located subscapularly with ribs involvement; multidisciplinary team approach—resection started by lifting up the scapula. (**B**) Anterolateral thigh flap was harvested with extended fasciocutaneous, intrathoracic anastomosis was performed (arrow), and chest wall integrity was restored with titanium plate. (**C**) Postoperative 6 months follow-up showed good range of movement of right shoulder.

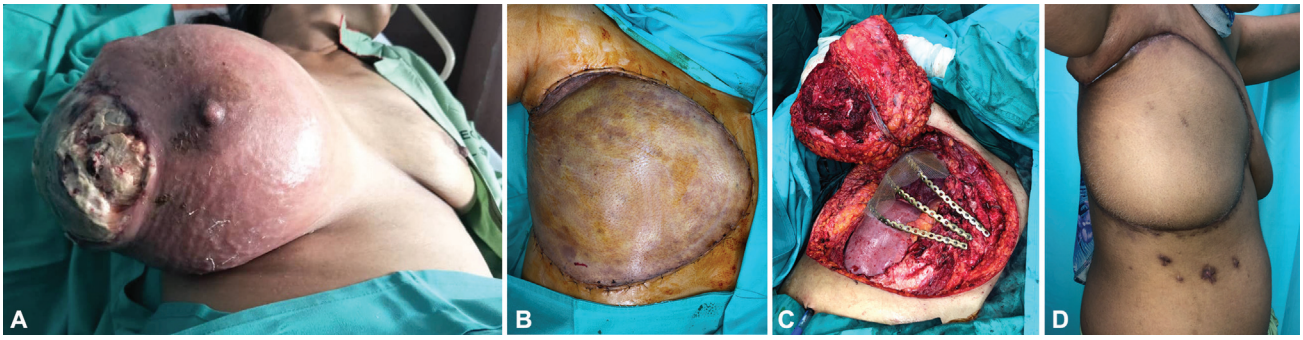


**Fig. 2** (**A**) Right breast recurrent fungating malignant phyllodes tumor (locally advance). (**B**) Postoperative day 3—flap congestion noted. (**C**) During flap exploration, kinked pedicle noted in between the titanium rib plates without vascular thrombosis; additional Prolene mesh was placed along the course of pedicle as a "safety net" to prevent recurrent event. (**D**) Postoperative 4 months follow-up showed good functional and aesthetic chest wall reconstruction.

resected.[3] In our center, rigid reconstruction was the method of choice for anterolateral chest wall defect of more than 10cm in diameter and when more than 3 ribs are resected.[4] Titanium plates were used in all our cases with combination of titanium mesh (central defect) and composite mesh (thoracoabdominal defect). Titanium plates are chosen for its advantage as it allows a more physiologic chest movement, has good tensile strength, and resists infection.[2] Technically, titanium plates are malleable to conform to appropriate shape compared with other materials, for example, bone cement.

With this advantage, the average ICU stay was 3 days with no perioperative pulmonary complication. However, two patients had implant failure. One patient had a dislodged titanium plate from clavicle on postoperative day 11 after she started ambulation using a walking frame. The dislodged plate was removed and the distal transected clavicle was trimmed further and left afloat. We have not figured an optimal manner to reconstruct the sternoclavicular joint after tumor resection due to huge gap left between the distal clavicle and the sternum. Many available literatures on sternoclavicular joint reconstruction mainly involved joint

 

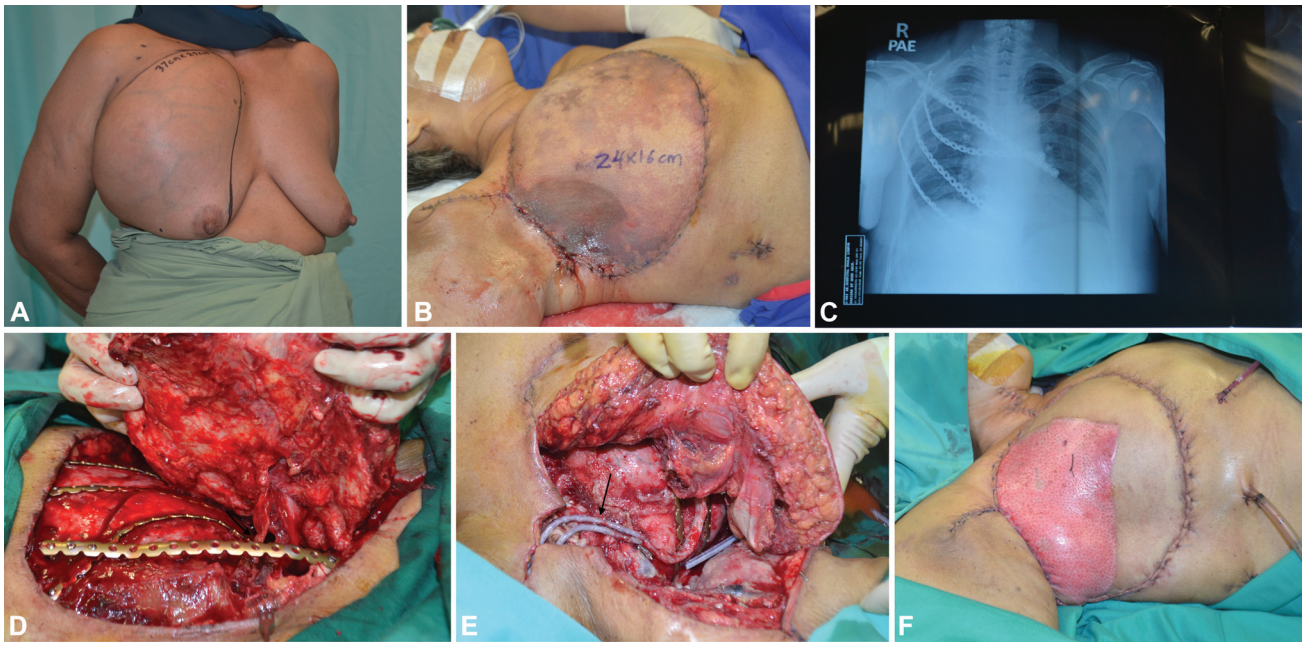


**Fig. 3** (**A**) Right anterolateral chest wall leiomyosarcoma—chest wall reconstruction was performed with four titanium plates and an anterolateral thigh (ALT) fasciocutaneous flap ALT flap with dimension 24 × 20 cm. (**B**) Postoperative day 11—flap congestion and partial flap necrosis noted. (**C**) Anterolateral chest X-ray revealed dislodged clavicular plate and intact titanium rib plates with good rib cage configuration. (**D**) Intraoperatively pedicle of flap was compressed by the dislodged clavicular plate (arrow). (**E**, **F**) Re-do free ALT fasciocutaneous flap with vein graft (arrow).


**Fig. 4** (**A**) Thoracoabdominal grade 2 chondrosarcoma. (**B**) Post-tumor resection defect with exposure of bowels and lung. (**C**) Post-rib plate installation and composite meshes placement. The pleural cavity was separated with abdominal cavity by anchoring one of the composite mesh along the remaining diaphragm and rib plate (arrows). (**D**) Postoperative 23 months follow-up showed thoracoabdominal reconstruction with titanium rib plate, composite mesh, and double free ALT. (**E**) Scar over donor sites post-split thickness skin graft were supple with no functional morbidity.

instability due to trauma or arthritis rather than tumor.[5] Another patient presented at the 20th month post-operation, with extrusion of the rib titanium plate most likely due to pressure of the titanium plate on the thin chest wall skin and scar contraction. Our implant failure rate is 33% compared with 44% as mentioned in literature.[6] However, to date none of our patients presented with infected implant.

Chest wall soft tissue reconstruction was first described by Tansini using pedicle latissimus dorsi myocutaneous flap for coverage of anterior chest wall after radical mastectomy.[7] Locoregional flaps were often the choice of reconstruction and free flap will be an option for larger defects that affects the vascularity of the local flaps. Free ALT flap is our main choice in chest wall reconstruction as it provides a large skin

 

paddle, long pedicle, and reliable vascularity based on one to three perforators as mentioned by Song et al.[8] Long pedicle broadens the choice of recipient vessel whether its intrathoracic or extrathoracic.[9,10] Availability of large skin paddle allows the closure of soft tissue defect without tension to avoid wound dehiscence. It also allows us to have two teams approach that helps to reduce the total operative time. Besides that there were no significant functional donor site morbidity noted. In our practice, fascia lata will be harvested together as one component with the ALT free flap. During the closure of the thoracic defect, we anchor the fascia lata to the fascia of the chest wall cut muscle edge to create a near airtight thoracic cavity.

To date there is no literature that focuses on usage of free tissue transfer for large complex chest wall reconstruction. Here, we would like to highlight the technical difficulties and unprecedented complications. Microvascular anastomosis can be challenging especially in the usage of intrathoracic recipient vessels. The movement of the mediastinum will cause the instability of surgeons' hand as well as inability to maintain the focus via microscope on the anastomosis. This is even more challenging for the less experienced junior surgeon. Collaboration with the anesthetist team to reduce the breathing rate and tidal volume is vital in overcoming this hurdle. Placement of the pedicles should be performed in a meticulous manner to avoid pedicle kinking, migration, and compression. The length of the pedicle is also important and needs to be tailored accordingly to prevent excessive movements and dangling.

In addition, postoperative chest tube should be inserted for drainage of effusion and prevention of pneumothorax as pneumothorax will cause the floating of the flap as well as the pedicle, and sudden revacuuming of the drain can cause a negative pressure in the thoracic cavity, which can result in migration or kinking of the pedicle. To prevent this complication, active drain must be ensured functional all the time. Besides that, placing polypropylene mesh along the course of the pedicle as a safety net can prevent entrapment of pedicle between the titanium plate or the resected rib ends.

Lastly, close monitoring of the flap should be continued especially when patient starts ambulating. Dislodgement or migration of the plate can happen and subsequently cause flap failure as seen in one of our cases.

## Conclusion

The use of microsurgery free flaps and titanium plates provides nearly limitless possibility for complex oncological chest wall reconstruction. Multidisciplinary collaboration is crucial perioperatively to minimize the possibility of complications and to achieve good oncological outcome.

Conflict of Interest
None declared.

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