

# Postoperative transverse sternal nonunion with a chest wall defect managed by a tibial locking plate and a Gore-Tex dual mesh membrane: a case report.

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## Case report

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# Abstract

**Background:** Transverse sternal nonunion is a rare but disabling complication of the chest trauma or less commonly a transverse sternotomy. Fixation methods, which are mainly used to manage the more common longitudinal sternal nonunion, often fail leaving surgical treatment of transverse nonunion as a challenge.

**Case presentation:** We present a case of a highly disabling postoperative chest wall defect resulting from transverse sternal nonunion after a transverse thoracosternotomy (clamshell incision) and a concomitant rib resection. Following unsuccessful surgical attempts, sternal nonunion was fixed by a tibial locking plate and bone grafted, while the chest defect after the rib resection was reconstructed by a Gore-Tex dual mesh membrane. Adequate chest stability was achieved enabling complete healing of the sternal nonunion and a good outcome in our patient.

**Conclusion:** We believe that in a rare combined postoperative transverse sternal nonunion and the chest wall defect after rib resection, it is important to address both. In our patient a good outcome was achieved after fixing nonunion by a properly sized and shaped locking plate with bone grafting and covering the chest defect by a dual mesh membrane.

## Background

Sternal nonunion is a rare but a potentially disabling complication. It can occur after a sternotomy or even less often as a result of a sternal fracture [1]. The condition is defined by the lack of radiographic signs of sternal bony healing after 3 months and is usually accompanied by a local pain and tenderness. When the patient is symptomatic, sternal nonunion is an indication for a surgical treatment [2–4]. The vast majority of sternal nonunions are longitudinal and result from healing disturbances after a median sternotomy. Transverse sternal nonunions are less common, occurring predominantly after a sternal fracture or after a transverse sternotomy which is rarely performed. Surgical methods that were developed and are being successfully used for managing the more common, symptomatic, longitudinal sternal nonunions are generally not applicable to the transverse ones [1,5].

## Case Presentation

A 50-year-old man was primarily operated for extensive type B aortic dissection with acute bowel ischemia. The portion of the descending aorta starting at the origin of the left subclavian artery and extending to just below the superior mesenteric artery was replaced by a tubular graft through extended posterolateral thoracotomy. The patient recovered well, however, 10 years later, he was diagnosed with an aneurysm of the aortic arch as well as with a dilatation of the thoracoabdominal portion distally to the previous graft. The ascending aorta, aortic arch and descending aorta were replaced in a re-do procedure which was done through transverse thoracosternotomy (clamshell incision). The third and a part of the fourth rib on the left side were resected to gain sufficient access. In the early postoperative period, the

patient developed dehiscence of a transverse sternotomy, which was primarily closed by tension wires. Two attempts of tension re-wiring and even a fixation with one third tubular plate and conventional screws were performed to address the dehiscence, which failed in a few weeks (fig. 1A).

Three years after the last unsuccessful revision surgery, the patient presented to our clinic symptomatic, with pain and an obviously unstable chest, with lung herniating through the chest wall defect. Radiographs and a computed tomography (CT) scan revealed an extensive chest deformation, resulting from a widely displaced sternal nonunion, a bony defect of the sternum resulting from multiple operations and resections of the 3rd and 4th ribs on the left side of the chest (fig. 1B).

The patient was operated again by a team of cardiothoracic and orthopaedic trauma surgeons. An extensive adhesiolysis, a removal of the remaining wires and a debridement of the scar tissue was done. Sternal fragments were refreshed till the healthy bone and approximated, while the remaining defect of 1 cm was filled with a structural iliac crest bone autograft. Then the fragments were compressed by bone reduction clamps. The fixation was done by using a titanium locking compression plate for distal medial tibia (DepuySynthes, West Chester, Pennsylvania). The plate was intraoperatively shaped to match the markedly changed anatomy of the proximal sternum and fixed using 3.5 mm locking screws. The wider shape of the plate, with multiple screw holes, provided a good purchase in a smaller portion of the deformed proximal fragment. All screws were carefully inserted under "finger control", not to protrude at the back of the sternum. In the meantime, a 2 mm thick Gore-Tex dual mesh membrane of size 20x10 cm was attached to the ribs to cover the remaining defect after the rib resection on the left side. The membrane was attached by interrupted trans-costal sutures using heavy polypropylene. More than 60 sutures were placed along the two adjacent ribs above and below the defect to achieve the required strength. Another membrane of 10x5 cm was applied on the remaining soft tissue defect in the second intercostal space on the right side (fig. 1C). The wound was then closed, the thoracic cavity was drained, two drains were also placed subcutaneously to prevent haematoma or a subsequent seroma formation.

The postoperative recovery of the patient was uneventful. The chest X-ray and the CT scan, one year after the operation, showed complete bony healing of the sternum and good membranes positions (fig 2). After three years, the chest remained stable, there was no pain or lung herniation. There were also no implant related problems and therefore no indications for plate removal.

## **Discussion And Conclusions**

Transverse sternal nonunion is a rare but a disabling complication, occurring mainly after traumatic sternal fractures or after a rarely performed transverse sternotomy [1]. The rate of nonunion is less than 1% after sternal fractures, while the condition becomes more common and is considered an important chronic complication after a transverse sternotomy, with the rate of 6.8% [4,6]. A transverse thoracosternotomy (known as a Clamshell incision) is typically used in double-lung transplantations, offering an excellent exposure to the heart, lungs and the great vessels [6,7]. Due to multidirectional movements with tension and compression forces acting in all planes, fixation of the transverse

sternotomy, sternal fracture or transverse nonunion remains a challenge [1,5]. There is very limited data published on transverse sternal nonunion, especially after a sternotomy, mostly being case reports or small case series [1,8,9]. Different fixation materials and techniques were described to fix transverse fractures, osteotomies or nonunions, with tension wiring and plating being the most commonly performed [4,5,8]. Tension wires, which are still typically used to close a median sternotomy, often fail when used for a transverse sternotomy closure, which also occurred in our patient in the early postoperative period. When using cerclage wires, the crossed wiring closure technique reduced the incidence of sternal dehiscence compared to the uncrossed technique [10]. In their comparative study Qin-Yun Ma with co-workers showed a significantly higher sternal healing rate in the plated group compared to the tension-wired group after a transverse sternotomy [11]. Biomechanical advantages of sternal plating were previously shown in a cadaveric study [12]. Other authors also reported good functional outcome of sternal plating, with a high rate of union mainly after the usage of the one or two parallel locking plates [3,5–7,9,13,14]. Locking implants, with screws that are angular stable locked in the plate, in contrast to conventional plating better resist continuous multidirectional forces that act on the construct during breathing. Additionally, monocortical locking screws could be used as a safer option to prevent an iatrogenic injury to the retrosternal vital structures. But on the other hand, they provide less purchase than bicortical locking screws, especially in a weaker bone [3,9]. A review of the published literature done by Schulz et al. in 2015 showed good results for the most locking plate systems that were used, and a review from Klei et al. from 2018 confirmed that plating was the most common type of fixation after sternal fractures (83%), with a good consolidation rate and low complications [8,15]. In our case, the patient had a symptomatic postoperative chest wall defect because of transverse sternal nonunion in combination with a rib resection. Nonunion was previously unsuccessfully treated by tension wiring and one-third tubular plate fixed with conventional, non-locking screws. In accordance with available published data, we fixed the nonunion with a locking plate. Due to the anatomical conditions, we did not use one or two regular longitudinal 3.5 mm locking plates. We decided to use a single stronger locking plate that is normally used to fix distal tibial fractures, which we shaped to the bone. As the patient was tall and obese, the plate appeared to be well sized. The broad ending of the plate with multiple locking screws that were applied in different directions provided a really strong purchase in a deformed proximal fragment. The sternal defect was also bone grafted with a tricortical iliac crest autograft. Bone grafting was also advocated for and performed in some other published cases of transverse sternal nonunion with a bone defect [1,5,16,17]. Important late complications of the sternal plating are pain and irritation, caused by the prominent material, requiring removal of the plate in 15.4% and in 27% of the patients, respectively [2,9]. In our case there were no implant-related problems and therefore, there were no indications for plate removal.

A Gore-Tex Dual mesh membrane was additionally used in our patient, to cover the chest wall defect after rib resection. Gore-Tex dual mesh membranes were shown to be a good option for reconstruction of chest wall defects, especially after wide surgical resections [18–20]. By using the membranes, we successfully closed the remaining defects and treated the lung herniation. Besides that, we believe that

membranes also diminished loads applied on the plate during continuous chest movements and possibly contributed to prevention of an early plate failure.

We reviewed the literature for similar cases and could only find a few small series and case reports describing a successful combination of titanium plates with Gore-Tex dual mesh membranes to achieve a stable chest that allows the complete range of respiratory movements, most of them being used after wide surgical resection of the thorax [19,21]. However, we could not find any reports of a similar treatment in such an extensive postoperatively deformed chest, resulting from widely displaced sternal nonunion and rib resection. To our knowledge this is also the first time that a specific tibial plate being successfully used to fix transverse sternal nonunion is reported.

In conclusion, we present a rare case of a patient with a symptomatic postoperative chest wall defect resulting from transverse sternal nonunion after a transverse thoracosternotomy (clamshell incision) and concomitant rib resection. We believe that addressing both, the transverse sternal nonunion by a properly sized and shaped locking plate with bone grafting and the chest wall defect after rib resection by a dual mesh membrane, was important for a good outcome in our patient.

## List Of Abbreviations

CT; Computed tomography

## Declarations

### Ethics approval and consent to participate

Not applicable

### Consent for publication

Consent for publication has been obtained from the patient presented in the case report.

### Availability of data and materials

The authors declare that the data supporting the findings of this study are available within the article.

### Competing interests

The authors declare that they have no competing interests.

### Funding

The authors received no funding for this study.

### Authors' contributions

TM and BP wrote the manuscript. TM, TS, JMK were involved in the treatment of the patients. All authors read and approved the final written manuscript.

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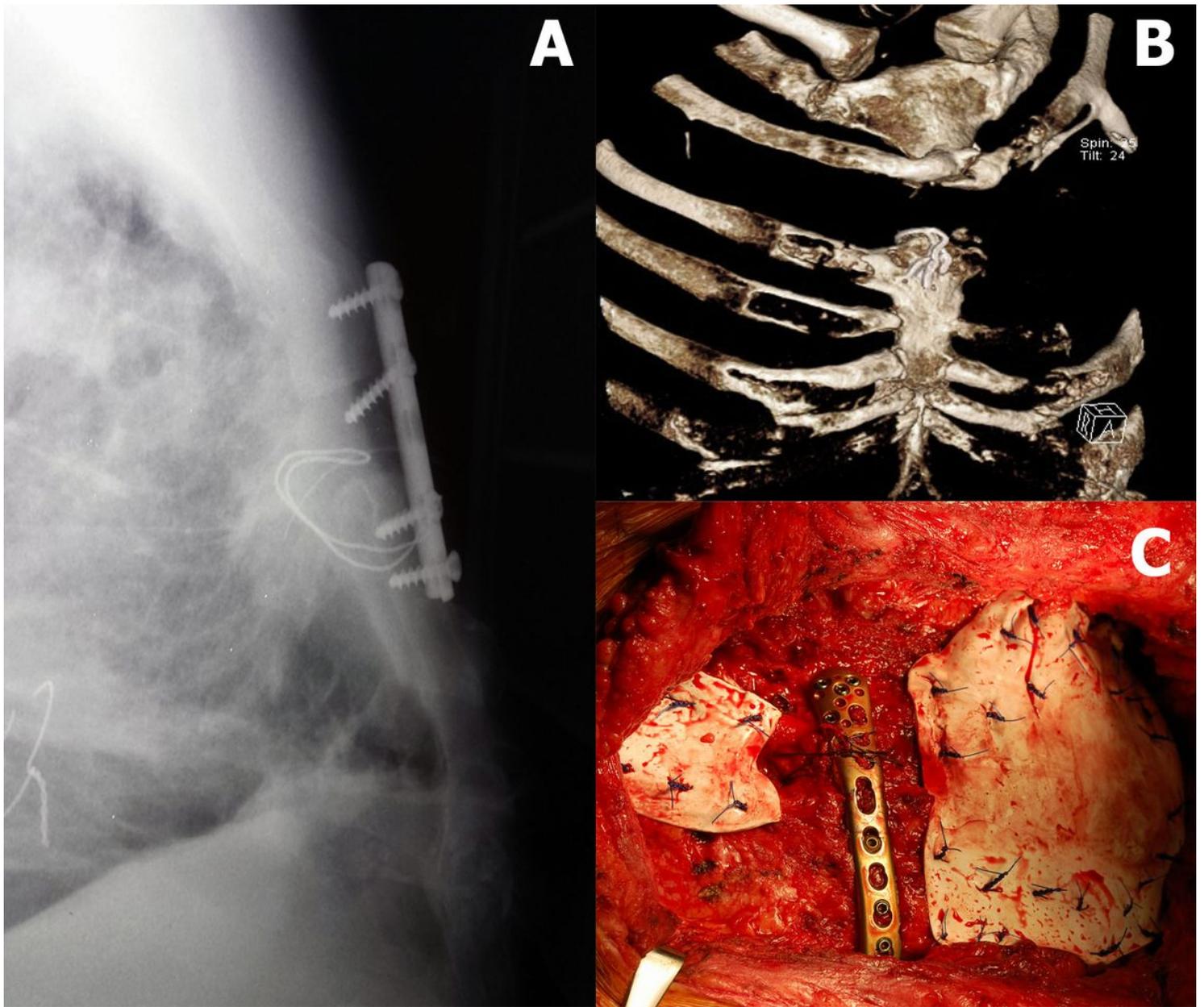
Not applicable.

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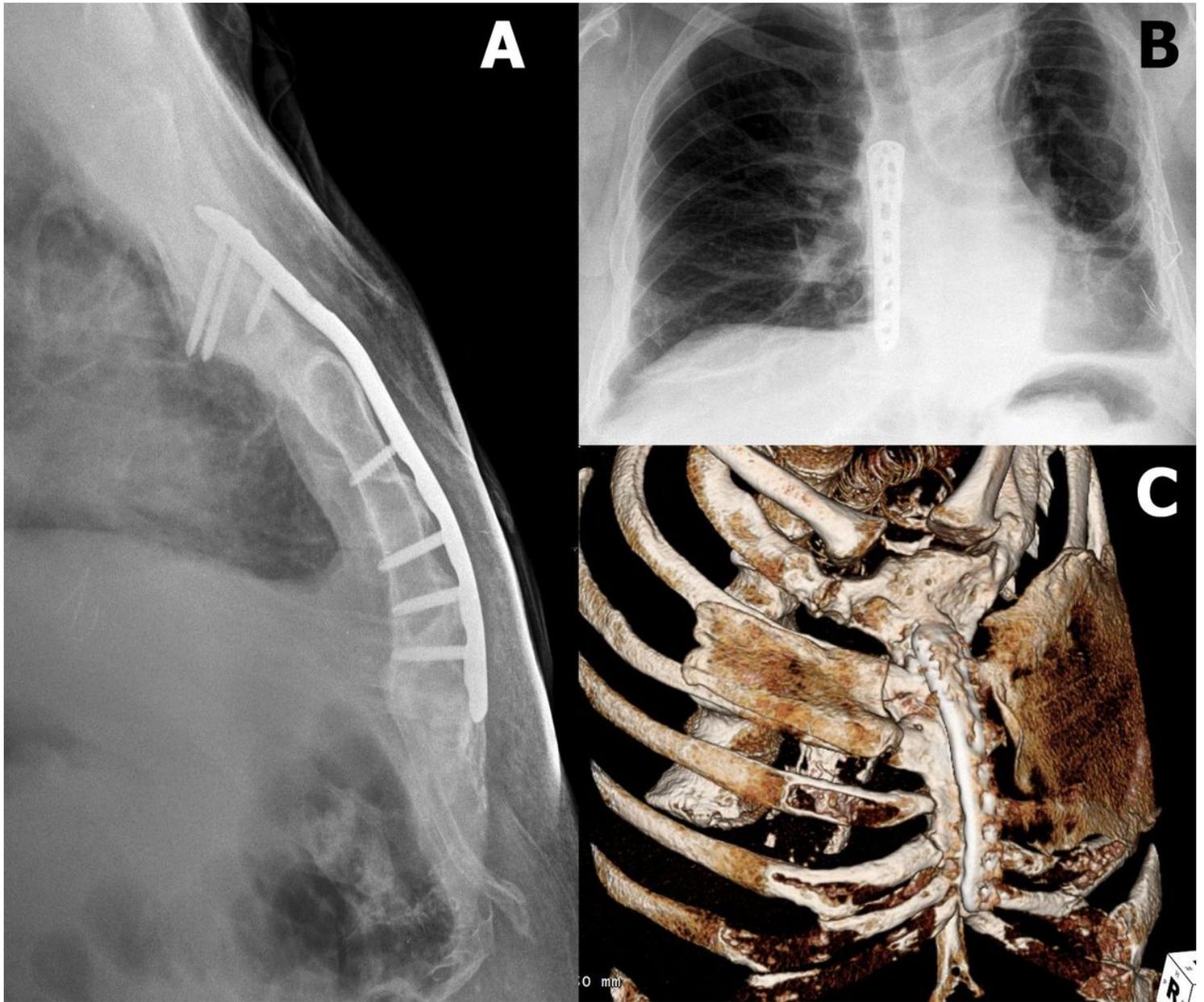
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## Figures



**Figure 1**

a, A failed fixation of the transverse sternal nonunion with 1/3 tubular plate and tension wiring. b, 3D reconstruction of the CT showing a big chest wall defect resulting from sternal nonunion and rib resection. c, Intraoperative view of the sternal fixation with a locking tibial plate and closure of the remaining chest wall defects with two Gore-Tex dual mesh membranes.



**Figure 2**

Chest X-ray. a, lateral; b, AP view. c, 3D reconstruction of the CT one year postoperatively showing healing of the sternum and good Gore-Tex dual mesh membranes position.

## Supplementary Files

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