

## Multidisciplinary Collaboration in Chest Wall Surgery: Excellent Outcomes with a First of Its Kind Combined Orthopaedic and Thoracic Team

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**Significance & Hypothesis/Techniques:** Complex chest wall pathology is technically demanding, requiring oncologic resection, structural stability, protection of intrathoracic structures, and preservation of function. These challenges often exceed the scope of a single specialty. We established the first dedicated combined orthopaedic and thoracic surgery team for chest wall reconstruction and hypothesized that this model would achieve durable reconstruction, low failure rates, and favorable functional outcomes.

**Innovation:** This study presents a first-of-its-kind orthopaedic-thoracic collaborative model for chest wall reconstruction, with clinical innovation in multidisciplinary operative planning, conceptual innovation in applying limb reconstruction principles to chest wall pathology, and technical innovation through methods such as IlluminOss-assisted sternal fixation and femoral allograft sternal replacement.

**Approach (Materials & Methods):** We performed a retrospective case series of 12 patients treated between 2019 and 2025 at a high-volume tertiary academic center. Mean age was 56.4 years (range, 27–80) (**Table 1**). Indications included osteoporotic or traumatic sternal nonunion (n=5), sternal chondrosarcoma requiring excision and reconstruction (n=4), and other chest wall sarcomas requiring resection with or without reconstruction (n=3). Reconstruction techniques included: 1) Illuminoss-assisted sternal reconstruction with plating (n=5) by creating an intramedullary cavity, introducing balloon nails, and inflating/curing them under light activation to achieve stable medial-lateral fixation and canal fill in addition to plating (**Figure 1**), 2) femoral allograft replacement of the sternum (n=2) using a distal femur allograft step-cut fixed inferiorly to residual sternum with FiberWire, secured proximally to clavicles and reinforced by a bifurcated vascular graft and cables, with Prolene mesh spanning rib gaps (**Figure 2**), 3) bone cement with cancellous screw reconstruction of the sternum (n=2), 4) titanium mesh chest wall reconstruction (n=1), and 5) primary layered chest wall closure without reconstruction (n=2). Patients were followed for a mean of 29 months (range 2–75 months). Radiographic follow-up with X-rays and CT scans was performed.

**Results:** All reconstructions achieved immediate stability, with no recurrences observed during follow-up with X-rays and CTs. Complications included deep venous thrombosis (n=2), neuropathic pain requiring medical management (n=3), and one sub-pectoral seroma that resolved spontaneously. One fracture occurred in one case of sternal allograft reconstruction, where postoperative clavicular fixation was required due to fracture about the right clavicular screw (**Table 1**). One patient in the IlluminOss group underwent elective sternal plate removal because of discomfort. Functional outcomes were favorable across all patients, with stable constructs, preserved mobility, and resolution of pain in the majority apart from 3 patients who experienced neuropathic pain that improved with Lyrica prescription (2 Illuminoss construct with sternal plate for sternal non-union and 1 multiphase reconstruction using titanium mesh for chest wall sarcoma).

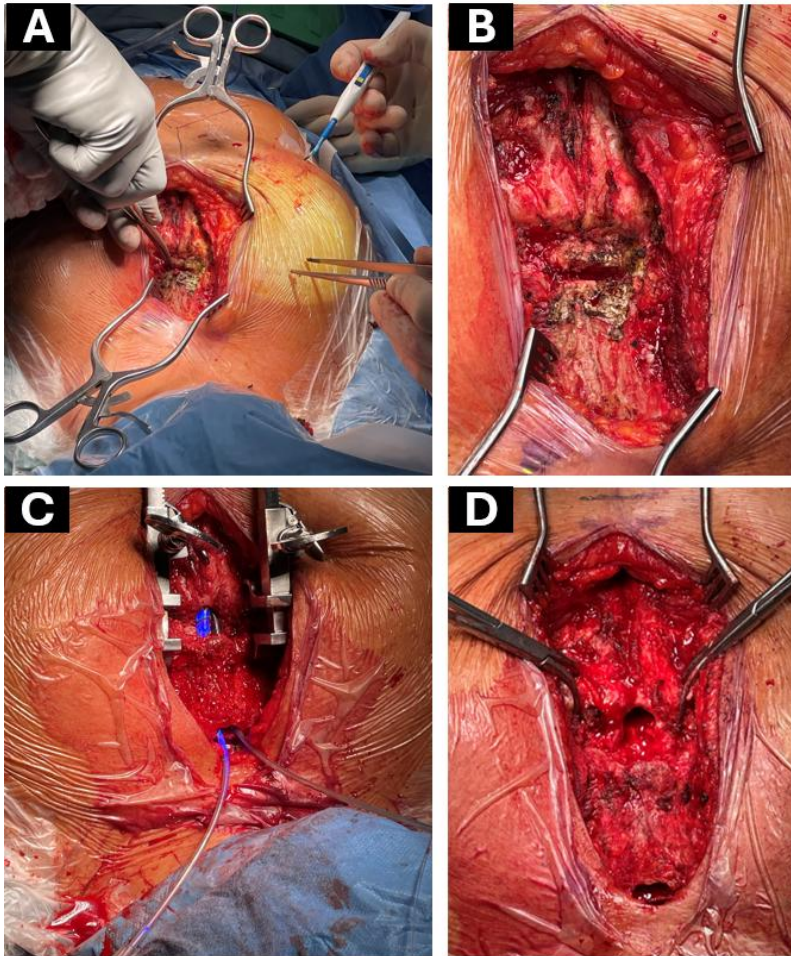
**Discussion & Impact:** This case series demonstrates that a combined orthopaedic-thoracic approach can produce durable and function-preserving solutions for complex chest wall pathology. The partnership expands the reconstructive options available for both oncologic and non-oncologic indications and supports the value of multidisciplinary operative decision-making. By achieving stable reconstructions in this series, this model may help redefine care pathways and establish a new standard for management of complex chest wall defects.

**Table 1.** Summary table of cases performed by the combined orthopaedic/thoracic surgery team.

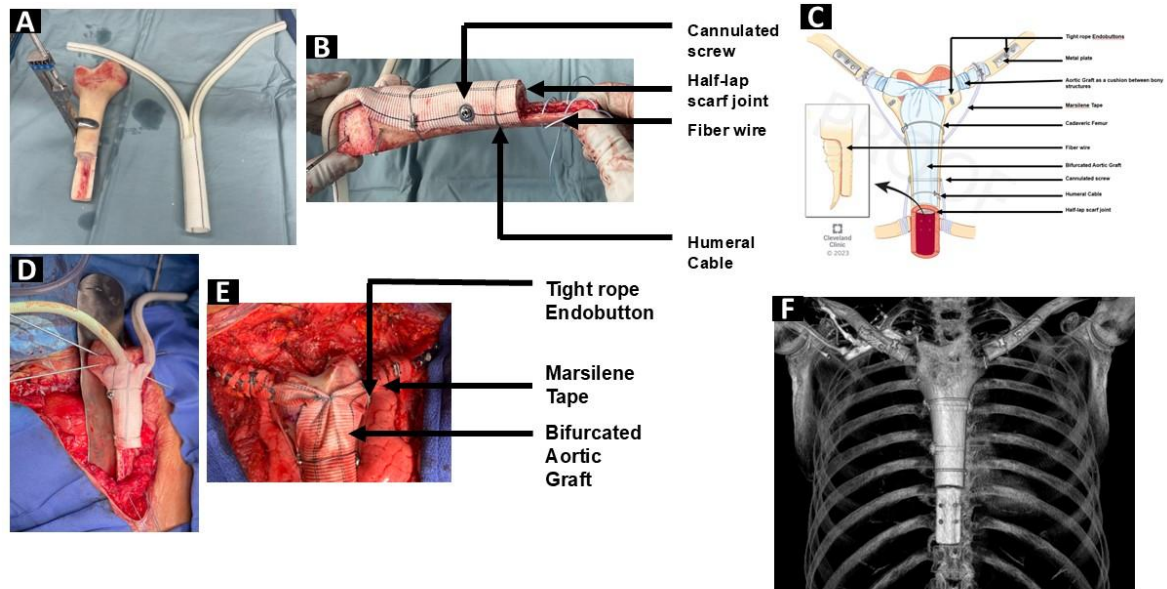
| Case                                                                | Age in Years | Gender | BMI                  | Medical History                              | Chest Wall Pathology                                                       | Surgical Treatment                                                         | Postoperative Complications            | Reoperations | Functional Results and Follow-up                                                                                              | Recurrence/Failure                          | Duration of Follow-Up |
|---------------------------------------------------------------------|--------------|--------|----------------------|----------------------------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------|----------------------------------------|--------------|-------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|-----------------------|
| <b>Sternal Reconstruction Using Illuminoss Device for Fractures</b> |              |        |                      |                                              |                                                                            |                                                                            |                                        |              |                                                                                                                               |                                             |                       |
| <b>Case 1</b>                                                       | 57           | Female | 26 kg/m <sup>2</sup> | Osteoporosis, hypertension                   | Osteoporotic sternal body non-union fracture                               | Illuminoss construct with sternal plate and bilateral pec advancement flap | None                                   | None         | Stable construct with no functional limitations or residual pain                                                              | None                                        | 11 months             |
| <b>Case 2</b>                                                       | 62           | Female | 30 kg/m <sup>2</sup> | Osteoporosis, hypertension, smoking          | Osteoporotic sternal body non-union fracture                               | Illuminoss construct with sternal plate and bilateral pec advancement flap | None                                   | None         | Stable construct with no functional limitations. Patient experienced neuropathic pain which improved with Lyrica prescription | None                                        | 20 months             |
| <b>Case 3</b>                                                       | 37           | Female | 39 kg/m <sup>2</sup> | Hypertension, smoking, diabetes, macromastia | Sternal traumatic non-union fracture with prior two hardware failures      | Illuminoss construct with sternal plate and bilateral pec advancement flap | Right brachial DVT 9 days post-surgery | None         | Stable construct with no functional limitations or residual pain                                                              | Removal of sternal plate due to discomfort. | 58 months             |
| <b>Case 4</b>                                                       | 59           | Male   | 26 kg/m <sup>2</sup> | Hypertension, former smoker                  | Sternal non-union of identified cause (pathological origins were excluded) | Illuminoss construct with sternal plate and bilateral pec advancement flap | None                                   | None         | Stable construct with no functional limitations. Patient experienced neuropathic                                              | None                                        | 12 months             |

|                                                       |    |      |                      |                                                      |                                                                               |                                                                            |                                                                                                         |                                                                                                                                                                           |                                                                  |      |           |
|-------------------------------------------------------|----|------|----------------------|------------------------------------------------------|-------------------------------------------------------------------------------|----------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|------|-----------|
|                                                       |    |      |                      |                                                      |                                                                               |                                                                            |                                                                                                         |                                                                                                                                                                           | c pain which improved with Lyrica prescription                   |      |           |
| Case 5                                                | 47 | Male | 29 kg/m <sup>2</sup> | Hypertension, obstructive sleep apnea                | Sternal traumatic non-union fracture                                          | Illuminoss construct with sternal plate and bilateral pec advancement flap | Sub-pectoral seroma 3 weeks post-surgery that was aspirated then reoccurred but resolved within 4 weeks | None                                                                                                                                                                      | Stable construct with no functional limitations or residual pain | None | 2 months  |
| Sternal Reconstruction/Replacement for Sternal Tumors |    |      |                      |                                                      |                                                                               |                                                                            |                                                                                                         |                                                                                                                                                                           |                                                                  |      |           |
| Case 6                                                | 80 | Male | 26 kg/m <sup>2</sup> | Hypertension, congestive heart failure, dextrocardia | Recurrent sternal chondrosarcoma with prior three failed attempts at excision | Sternal excision with femoral allograft replacement of sternum             | DVT in right calf one month following surgery                                                           | One week after surgery patient developed fracture around right clavicle screw and this was managed with RT clavicle ORIF and LT clavicle prophylactic fixation with plate | Stable construct with no functional limitations or residual pain | None | 13 months |
| Case 7                                                | 58 | Male | 24 kg/m <sup>2</sup> | Hypertension, diabetes, former smoker                | Sternal chondrosarcoma                                                        | Sternal excision with femoral allograft replacement of sternum             | None                                                                                                    | None                                                                                                                                                                      | Stable construct with no functional limitations or residual pain | None | 43 months |

|               |    |        |                      |                                        |                                                                                                                                      |                                                                                            |      |      |                                                                                                                             |      |           |
|---------------|----|--------|----------------------|----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|------|------|-----------------------------------------------------------------------------------------------------------------------------|------|-----------|
| Case 8        | 50 | Male   | 24 kg/m <sup>2</sup> | Smoking                                | Sternal chondrosarcoma                                                                                                               | Sternal excision with reconstruction using bone cement and cancellous screws               | None | None | Stable construct with no functional limitations or residual pain                                                            | None | 26 months |
| Case 9        | 27 | Male   | 21 kg/m <sup>2</sup> | Smoking                                | Sternal chondrosarcoma                                                                                                               | Sternal excision with reconstruction using bone cement and cancellous screws               | None | None | Stable construct with no functional limitations or residual pain                                                            | None | 39 months |
| Miscellaneous |    |        |                      |                                        |                                                                                                                                      |                                                                                            |      |      |                                                                                                                             |      |           |
| Case 10       | 69 | Female | 21 kg/m <sup>2</sup> | Hypertension, former smoker, COPD, CKD | Left chest wall undifferentiated pleomorphic sarcoma 4 <sup>th</sup> to 7 <sup>th</sup> rib secondary to radiation for breast cancer | Excision and multiphasic reconstruction using titanium mesh, followed by myocutaneous flap | None | None | Stable construct with no functional limitations. Patient experience neuropathic pain that improved with Lyrica prescription | None | 75 months |
| Case 11       | 58 | Female | 31 kg/m <sup>2</sup> | Hypertension, breast cancer            | Recurrent right chest wall phyllodes breast sarcoma                                                                                  | Excision with primary layered closure without need for reconstruction                      | None | None | No functional limitations or residual pain                                                                                  | None | 12 months |
| Case 12       | 70 | Male   | 22 kg/m <sup>2</sup> | Hypertension, CAD                      | Right posterior shoulder/scapula girdle high-grade soft                                                                              | Excision with primary layered closure without need for                                     | None | None | No functional limitations or residual pain                                                                                  | None | 31 months |



**Figure 1.** Full exposure of the non-union sternal fracture with scarring from previous failed fixation surgeries (A, B). An intramedullary cavity was created under fluoroscopic guidance, followed by passage of a ball-tipped guide wire to facilitate flexible reaming up to 5.5 mm, and fracture reduction was achieved with a Bailey rib approximator and the Illuminus device within the reamed cavity (C). Post-inflation of the Illuminus device achieving sternal stability (D).



**Figure 2.** The distal femoral allograft was thawed, trimmed flat, reinforced with vancomycin-PMMA in the canal, and given a distal step cut to fit behind the residual sternum/xiphoid (A). The bifurcated Hemashield vascular graft was wrapped around the femoral allograft and secured with cannulated screws, cables, and Mersilene tape for added reinforcement (B). Illustration of the construct showing the distal femur allograft step-cut fixed inferiorly to residual sternum with FiberWire, secured proximally to clavicles using TightRopes, screws, plates, and Mersilene tape, reinforced by a bifurcated Hemashield vascular graft and cables, with Prolene mesh spanning rib gaps (C). The femoral allograft was positioned with its distal step cut anchored to the residual sternum and its proximal flare secured to both clavicles using Arthrex TightRopes, screws, and plates (D, E). Postoperative 3D reconstructed CT image demonstrating sternal reconstruction with a femoral allograft construct. The resected sternum has been replaced with a structural femoral allograft, which has been contoured and fixed to the manubrium superiorly and the native sternum inferiorly (F).