The Egyptian Journal of Hospital Medicine (January 2025) Vol. 98, Page 676- 681

Management of Sternal Fracture: Single Centre study

Tarek Mohamed Afifi*[1], Mohammad Abdelrahman Hussein[2], Ehab M. F. Ahmed[3], Ahmed Badawy Mohammed Esawy[4]

[1]Department of Cardiothoracic Surgery, Faculty of Medicine, Sohag University, Egypt
[2]Department of Cardiothoracic Surgery, Faculty of Medicine, Cairo University, Egypt
[3]Department of Cardiothoracic Surgery, Faculty of Medicine for Girls, Al-Azhar University, Egypt
[4]Department of Cardiothoracic Surgery, Faculty of Medicine, Beni Suef University, Egypt
***Corresponding author:** Tarek Mohamed Afifi, **Mobile:** (+20) 1098608572, **E-mail:** trk.aff@gmail.com

ABSTRACT

Background: Traumatic sternal fractures are not uncommon injuries primarily caused by blunt chest trauma, such as motor vehicle accidents. Optimal management strategies for these fractures, including conservative management and internal fixation, remain a subject of clinical interest due to limited evidence.

Objective: This study aimed to provide clear overview of our experience in management of sternal fracture and to evaluate the clinical outcomes, complications, and efficacy of internal fixation versus conservative management for sternal fractures at a single-center thoracic surgery unit.

Patients and methods: A retrospective analysis of 28 patients treated for sternal fractures through the period from January 2019 to December 2023. Of the 28 patients, 7 underwent internal fixation using plates and screws, and 21 were managed conservatively. Data collected included demographic characteristics, intervention details, length of hospital and ICU stays, complications, and mortality.

Results: The mean age was 32.8 years, with 89.3% being male. Motor vehicle accidents were the primary trauma mechanism (67.9%). Internal fixation was successful in all 7 cases, with no hardware failures or plate removals. Conservative management was applied to 75% of the patients and resulted in shorter ICU (4.2 days vs. 6.0 days; $p = 0.002$) and hospital stays (8.1 days vs. 14.9 days; $p<0.001$) compared to the surgical group. Complications included one case of wound seroma in the fixation group (14.3%) and one case each of pulmonary infection and deformed healing in the conservative group (4.8%). No mortality was reported.

Conclusion: Both internal fixation and conservative management demonstrated favorable outcomes in the treatment of sternal fractures. Conservative management remains the preferred approach for uncomplicated cases, while internal fixation is effective in selected patients. The absence of mortality highlights the importance of tailored management strategies and careful patient selection. Future research should explore long-term outcomes and standardize treatment guidelines.

Keywords: Sternal fractures, Traumatic chest injury, Internal fixation, Conservative management.

INTRODUCTION

Sternal fractures are not uncommon fractures, usually caused by direct blunt chest trauma, incidence about 3-8% of blunt chest traumas. Most common cause of sternal fracture is direct trauma with motor vehicle accident, with higher incidence after increased use of seatbelt. Other causes include falling from height and spinal flexion injuries [(1-4)].

With sternal fracture, commonly associated chest injuries include vertebral fractures, rib fractures, pulmonary contusion, haemopneumothorax, cardiac and mediastinal injuries, and aortic dissection. However, mortalities and morbidities are more related to associated injuries, with rates ranging from 4% to 45%. Most sternal fractures can be managed with conservative treatment. adequate pain management is very important to avoid respiratory complications. However, surgical fixation may be indicated in case of unstable fractures, fracture displacement, sternal deformity, fracture non-union, respiratory insufficiency, and severe pain. Surgical management can be done using different methods including steel wire fixation or plates with screws [(5)].

Surgical plating gives more stability and better restoration of anterior chest wall function than wiring, and current research shows that plating improves bone healing while decreasing problems and non-union. However, for certain patients with uncomplicated sternal fractures and limited displacement, two treatment strategies might be chosen [(6)]. New Najran General Hospital is a secondary level general hospital, in Najran, KSA, receiving trauma cases of different modes, including motor vehicle accidents, war injuries and others. Consequently, the aim of the study was to provide clear overview of our experience in management modalities and outcomes of traumatic sternal fractures.

PATIENTS AND METHODS

This study retrospectively analyzed data from 28 patients treated for sternal fractures between January 2019 and December 2023 at New Najran General Hospital, a secondary-level facility in Najran, Saudi Arabia.

Inclusion criteria: Patients with traumatic sternal fractures.

Exclusion criteria: Patients with significant internal bleeding or multiple severe injuries.

Received: 26/09/2024
Accepted: 28/11/2024

The sample was divided into two groups: 7 patients underwent internal fixation, and 21 patients were managed conservatively.

Data collection: Demographic and clinical information were collected for all patients including age, gender, length of hospital and ICU stays, mechanism of injury, fracture type and location, associated injuries, complications, and outcomes. Imaging studies, including chest X-rays and CT scans with 3D reconstruction, were performed to assess fracture details and associated injuries such as rib fractures, hemothorax, pneumothorax, or lung contusions.

Surgical Management: Patients who were selected for internal fixation met specific criteria, including significant fracture displacement causing severe pain and functional limitations, or flail motion complicating mechanical ventilation weaning. Under general anesthesia, patients were positioned supine with a roll placed under the shoulder for better surgical exposure. A longitudinal midline incision was made over the sternum, guided by the fracture site. After dissection, the fracture was reduced and fixed using titanium plates and cortical screws. Postoperatively, chest X-rays confirmed the absence of complications such as pneumothorax or hemothorax, and the fixation was verified using lateral sternum X-rays. All surgical patients were transferred to either the ICU or surgical ward based on their condition.

Conservative management: Patients without significant fracture displacement were managed conservatively. Treatment involved pain control using analgesics, immobilization with a chest strap or corset, and rest. Adequate pain management was emphasized to prevent pulmonary complications from painful respiration.

Follow-Up: All patients were followed for six months to monitor outcomes. In the surgical group, no hardware failures or plate removals were observed during this period. Similarly, the conservative group showed no major complications, except for one case of pulmonary infection and another of deformed healing, where surgical intervention was declined.

Outcomes monitored: The study assessed ICU and hospital lengths of stay, surgical complications (e.g., wound seroma), and non-surgical complications (e.g., pulmonary infections). Associated injuries, such as rib fractures, lung contusions, and clavicle fractures, were documented. Mortality was also tracked, with no deaths reported in the cohort.

Ethical approval:

The Ethics Committee of the Hospital gave its approval to this investigation. The patient data were kept anonymous. Data were presented by diagnosis rather than by patient name, and patient anonymity was respected. All subjects provided informed permissions, which was documented in Arabic and validated by date and time. Confidentiality was ensured by giving a number to the patients' initials, which only the investigator knew. Throughout its implementation, the study complied with the Helsinki Declaration.

Statistical analysis:

Using IBM SPSS statistics software version 28.0, the gathered data were coded, tabulated, and statistically examined. Mean ± SD and the lowest and maximum of the range are reported together with the qualitative data, and an independent t-test is used for comparison. Qualitative data were expressed as percentages and numbers, and Fisher's Exact test was used to compare them. P-values $\leq$ 0.050 were considered significant, whereas those that were not were considered non-significant.

RESULTS

Among the studied 28 cases, 7 (25.0%) underwent internal fixation and 21 (75.0%) underwent conservative management. Table (1) showed that Mean age was 32.8±11.9 years, cases were mainly males (89.3%). No significant difference according to intervention regarding demographic and clinical characteristics.

Table (1): Demographic and clinical characteristics among the study cases and according to intervention

Characteristics		All cases (Total=28)	Intervention		p-value
			Fixation (Total= 7)	Conservative (Total=21)	
Age (years)		32.8±11.9	28.7±10.1	34.2±12.3	^0.300
Sex	**Male**	25 (89.3%)	7 (100.0%)	18 (85.7%)	§0.551
	Female	3 (10.7%)	0 (0.0%)	3 (14.3%)	
Mode of trauma	**Motor vehicle accident**	19 (67.9%)	5 (71.4%)	14 (66.7%)	§0.999
	Explosions	5 (17.9%)	1 (14.3%)	4 (19.0%)	
	Fall	4 (14.3%)	1 (14.3%)	3 (14.3%)	
Site of trauma in sternum	**Manubrium**	3 (10.7%)	0 (0.0%)	3 (14.3%)	§0.999
	Body	19 (67.9%)	5 (71.4%)	14 (66.7%)	
	Manubriosternal Joint	3 (10.7%)	1 (14.3%)	2 (9.5%)	
	Manubrium and Body	3 (10.7%)	1 (14.3%)	2 (9.5%)	
Associated injuries	**Rib fracture**	18 (64.3%)	6 (85.7%)	12 (57.1%)	§0.364
	Hemothorax or pneumothorax	13 (46.4%)	4 (57.1%)	9 (42.9%)	§0.670
	Lung contusion	9 (32.1%)	3 (42.9%)	6 (28.6%)	§0.646
	Spine fracture	3 (10.7%)	1 (14.3%)	2 (9.5%)	§0.999
	Extremities fracture	5 (17.9%)	2 (28.6%)	3 (14.3%)	§0.574
	Clavicle fracture	4 (14.3%)	2 (28.6%)	2 (9.5%)	§0.253
	Liver injury	2 (7.1%)	1 (14.3%)	1 (4.8%)	§0.444

Data are presented as Mean±SD or number (%). ^Independent t-test. §Fisher's Exact test.

Table (2) showed that: Mean±SD of Lag between admission and fixation (days) and Operation duration (minutes) was 5.3±1.8 and 86.9±11.7 respectively. None of cases that underwent internal fixation had failure of internal fixation nor needed removal of plates.

Table (2): Internal fixation characteristics in cases underwent internal fixation

Characteristics	Mean±SD	Range
Lag between admission and fixation (days)	5.3±1.8	3.0–8.0
Operation duration (minutes)	86.9±11.7	70.0–100.0
	n	**%**
Failure of internal fixation	0	0.0%
Removal of plates	0	0.0%
Total= 7.		

Table (3) showed that length of ICU stay and hospital stay were significantly longer in cases underwent internal fixation. Side effects were wound seroma (14.3%) in internal fixation intervention as well as deformed healing and pulmonary infection (4.8% for both) in conservative management.

Table (3): Clinical outcomes among the study cases and according to intervention

Characteristics		All cases (Total=28)	Intervention		p-value
			Fixation (Total= 7)	Conservative (Total=21)	
ICU length of stay (days)		4.6±1.4	6.0±1.2	4.2±1.2	**^0.002***
Hospitably length of stay (days)		9.8±4.1	14.9±1.8	8.1±3.1	**^<0.001***
Side effects	**Wound seroma**	1 (3.6%)	1 (14.3%)	0 (0.0%)	§0.250
	Deformed healing	1 (3.6%)	0 (0.0%)	1 (4.8%)	§0.999
	Pulmonary infection	1 (3.6%)	0 (0.0%)	1 (4.8%)	§0.999
Mortality		0 (0.0%)	0 (0.0%)	0 (0.0%)	NA

Data are presented as Mean±SD or number (%). NA: Not applicable. ^Independent t-test. §Fisher's Exact test. *Significant.

The following figures (1 and 2) showed CT images for a displaced sternal body fracture and intraoperative view for the same patient after internal fixation using plates and screws.

Figure (1): patient with displaced sternal body fracture.

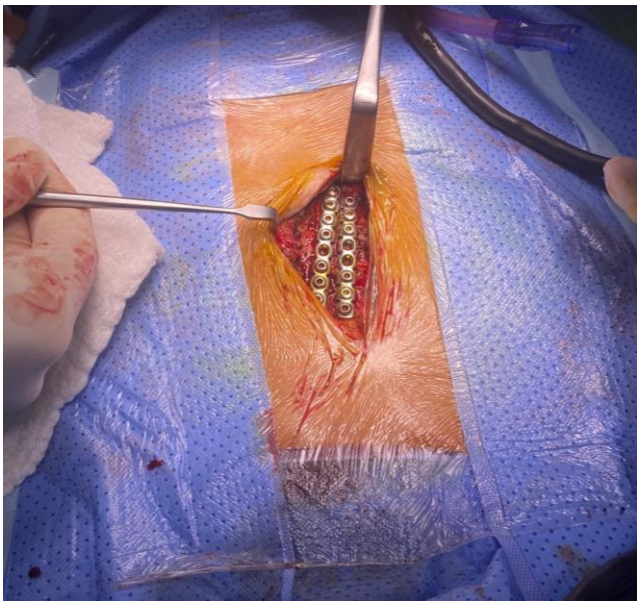

Figure (2): Intraoperative; internal fixation of sternal fracture.

DISCUSSION

Sternal fractures from blunt trauma are accounting for about 3% to 8% of all occurrences [(7)]. Injuries to the anterior chest are most commonly caused by direct blunt force from automobile accidents, followed by falls [(8)].

Conservative treatment is used to address the majority of cases. However, several circumstances are indications for surgical treatment, including overlapping fractures that cannot be corrected by closed reduction, displacement, severe pain that affects breathing, chronic nonunion, and sternal instability. Open reduction and internal fixation (ORIF) with a plate is the most popular surgical procedure. This technique is the most successful for stabilizing the anterior chest wall, improving bone healing, and avoiding complications [(9)].

Since various surgical approaches for management of sternal fractures represents major conflict and may be associated with complications and mortality. Consequently, this study was conducted and aimed to provide clear overview of our experience in management modalities and outcomes of traumatic sternal fractures and was highlighted as a main point of interest.

The current study provided an insightful analysis of the management modalities and outcomes of traumatic sternal fractures. Conducted retrospectively, the study encompassed clinical data of 28 patients treated for sternal fractures at a thoracic surgery center between January 2019 and December 2023. Patients with significant internal bleeding or multiple severe injuries were excluded to maintain the focus on isolated sternal fractures. The study included 7 patients (25.0%) treated with internal fixation using plates and screws, while 21 patients (75.0%) received conservative management.

Regarding demographic and clinical characteristics, our study showed an average age of 32.8 years, with a male predominance (89.3%). Motor vehicle accidents were identified as the primary cause of trauma, accounting for 67.9% of cases, followed by explosions (17.9%) and falls (14.3%). The distribution of injuries across different parts of the sternum revealed that the body of the sternum was most commonly affected (67.9%). Associated injuries, such as rib fractures (64.3%) and hemothorax or pneumothorax (46.4%), were frequent. Despite these associated injuries, no statistically significant differences were observed in the demographic or clinical variables between the intervention groups, indicating comparable patient profiles across treatments. Similar trends are noted in other studies. For example, **Klei *et al.*** [(10)] conducted a retrospective cohort study at a level-I trauma center from 2007 to 2019, analyzing 262 patients with traumatic sternal fractures to assess treatment outcomes and identify failure risks and reported 71% male population with a mean age of 52 years, while **Kara *et al.*** [(11)] conducted an observational study that analyzed 330 patients treated for sternal fractures to examine associated injuries, clinical features, and outcomes and showed 72.7% males with a median age of 41 years. Despite the age difference, the male predominance and motor vehicle accidents as the main trauma cause are consistent across studies. **Kunhivalappil *et al.*** [(12)] conducted a retrospective review that analyzed 63 patients with sternal fractures, identified via chest CT scans to explore injury mechanisms, management strategies, and outcomes and observed an even higher prevalence of motor vehicle collisions (88.8%) and predominantly male patients (88.8%). These findings suggest that while demographics remain consistent across settings, the age distribution and mechanism prevalence may vary based on geographic and infrastructural factors. **Aamir *et al.*** [(13)] conducted a retrospective review of 249 patients with sternal fractures to identify risk factors for mortality associated with sternal fractures. The mean patient age

was 61 years, with males comprising 72.7% of the cohort. Motor vehicle accidents accounted for nearly half of the cases. Midbody fractures were the most common type.

Regarding internal fixation Outcomes, for the seven patients who underwent internal fixation, the mean lag between admission and surgery was 5.3 days, with an average operation duration of 86.9 minutes. Notably, none of these patients experienced fixation failure or required the removal of plates, indicating the efficacy and durability of the procedure. However, the intensive care unit (ICU) and total hospital stays were significantly longer for this group. The ICU stay averaged 6.0 days, and the total hospital stay was 14.9 days. These extended stays might reflect the complexity of surgical recovery compared to conservative management, or might be affected by the time lag from admission to surgery. Similarly, **Lee *et al.*** [14] conducted a 10-year retrospective cohort study, analyzing 260 patients admitted with sternal fractures and focused on clinical features, treatment approaches, and outcomes and emphasized the stability and effectiveness of surgical interventions, highlighting successful bone union with minimal complications in 98 surgically managed cases. The median hospital stay for surgically treated patients in Lee's study was 27.5 days, which aligns with the longer hospital stays observed in our study (14.9 days). Interestingly, **Klei *et al.*** [10] reported a higher failure rate in surgical treatments (33% vs 0.4% in conservative cases) suggesting that surgical outcomes might vary based on indications and patient selection. our findings align more closely with **Lee *et al.*** [14]**,** where surgical management outcomes were robust with well-defined indications. The relatively low surgical intervention rates in **Klei *et al.*** [10] **(2%)** and **Kunhivalappil *et al.*** [12] **(0%)** contrast with our study's more active use of internal fixation, underscoring variability in surgical thresholds across institutions.

Regarding conservative management outcomes, the conservative management group, comprised 21 patients, exhibited shorter ICU and hospital stays, averaging 4.2 and 8.1 days, respectively. This shorter hospitalization duration suggests that conservative management may be less resource-intensive and suitable for cases where surgery is not deemed necessary. This may also reflect the nature of more stable sternal fractures in the patients group selected for conservative management. However, conservative management did result in minor complications, including deformed healing and pulmonary infections in 4.8% of cases each. **Kara *et al.*** [11] similarly found that isolated sternal fractures treated conservatively had shorter hospital stays (median of 4 days). **Kunhivalappil *et al.*** [12] also demonstrated that nonoperative management was successful, with patients often discharged directly from the emergency department if cardiac enzyme levels and ECG were normal. **Klei *et al.*** [10] also found conservative management to be highly effective, with a failure rate of just 0.4%. In contrast, **Lee *et al.*** [14] observed longer hospital stays in both surgical and nonsurgical groups, reflecting a cohort with more severe injuries. **Aamir *et al.*** [13] further reinforces conservative management as the standard for most cases, reserving surgery for specific conditions like imminent respiratory failure or nonunion. This consensus aligns with our study's approach.

Regarding complications and mortality, our study revealed that complications were minimal across both groups. In the internal fixation cohort, one patient (14.3%) experienced a wound seroma, while the conservative management group reported a similar frequency of minor complications, such as deformed healing and pulmonary infections. Importantly, no mortality was observed in the study cohort, highlighting the safety of both treatment approaches. **Lee *et al.*** [14] reported no significant differences in pneumonia rates between surgical and nonsurgical groups, although surgery reported minimal surgical complications, including a few cases of wound issues and chest wall instability. **Kara *et al.*** [11] highlighted that complications were more strongly associated with concomitant injuries than with isolated sternal fractures, which aligns with our findings of low complication rates in a carefully selected cohort. The complication rate in **Klei *et al.*** [10] was higher for surgical cases due to infections, but **Aamir *et al.*** [13] identified high troponin and rib fractures as the primary factors associated with complications and mortality, rather than the fracture management method itself.

Mortality in our cohort was 0%, a notable finding given the absence of major complications or failures in either treatment group. By contrast, **Kara *et al.*** [11] and **Kunhivalappil *et al.*** [12] reported mortality rates of 3.2% and 4.8% respectively often due to concomitant injuries. **Aamir *et al.*** [13] highlighted increased age, low GCS, and high troponin as mortality predictors, with an overall mortality of 7.63%, while **Kunhivalappil *et al.*** [12] deaths were linked to severe associated injuries. This disparity in mortality rates likely reflects differences in patient selection, exclusion of polytrauma cases in our study, and better initial triaging.

Clinical implications: The results underscored critical trade-offs between the two management strategies. Internal fixation, while effective and free from long-term mechanical issues, requires longer hospitalization and ICU stays. On the other hand, conservative management appeared to be less demanding in terms of hospitalization but may carry risks of minor complications. The findings suggest that the choice of treatment should consider the patient's clinical profile, the complexity of the injury, and resource availability.

Strengths of the study: One of the key strengths of our study is its focused scope, which examined traumatic sternal fractures within a single-center

setting. This ensured uniformity in treatment protocols and minimized variability caused by differences in institutional practices, enhancing the reliability of the results. Furthermore, the study employs a comparative approach by including both internal fixation and conservative management groups, offering valuable insights into the relative effectiveness and outcomes of these two strategies. Additionally, the study provided detailed data on outcomes, including ICU and hospital stay durations, complications, and demographic characteristics, creating a comprehensive picture of management efficacy. Notably, the study achieved zero mortality, underscoring the safety and effectiveness of the treatment protocols used, particularly for a selected cohort without severe polytrauma. This focus on patient-specific outcomes highlights the importance of individualized treatment approaches.

Limitations of the study: Despite its strengths, the study had some limitations. The relatively small sample size of 28 patients limits the generalizability of the findings to larger and more diverse populations. Additionally, the exclusion of patients with significant internal bleeding or severe injuries, while methodologically sound, restricted the study's applicability to more complex cases often encountered in high-trauma settings. The single-center design, while beneficial for consistency, also limits the external validity of the conclusions, as practices and resources may vary across institutions. Moreover, the retrospective nature of the study could introduce biases related to data collection and analysis. Certain variables, such as long-term functional outcomes and patient-reported quality of life, were not explored, which might have provided a more holistic view of the treatment impacts**.**

CONCLUSION

The current study demonstrated that both internal fixation and conservative management are effective and safe options for managing sternal fractures. Internal fixation was shown to be successful without failures or hardware-related complications, making it a reliable option for specific cases. Conservative management, applied to the majority of patients, was also effective, with shorter ICU and hospital stays compared to surgical interventions. The absence of mortality in the cohort is a testament to the success of the treatment approaches employed. Future studies should aim to address the limitations identified by expanding the sample size and including multi-center collaborations to enhance the generalizability of the findings. Incorporating patients with more complex injuries could provide insights into management strategies for high-risk cases. Additionally, prospective studies that evaluate long-term outcomes, including functional recovery and quality of life, are recommended to better understand the broader impact of different management modalities.

Conflict of interest: None.
Financial disclosures: None.

REFERENCES

1. **Kim D, Yoon S, Lee G *et al.* (2022):** Nuss procedure for surgical stabilization of anterior flail chest with mechanical ventilation weaning failure: a case report. J Chest Surg., 55:183–7.
2. **Krinner S, Grupp S, Oppel P *et al.* (2017):** Do low profile implants provide reliable stability in fixing the sternal fractures as a ‘fourth vertebral column’ in sternovertebral injuries? J Thorac Dis., 9:1054–1064.
3. **Athanassiadi K, Gerazounis M, Moustardas M *et al.* (2002):** Sternal fractures: retrospective analysis of 100 cases. World J Surg., 26:1243–1246.
4. **Harston A, Roberts C (2011):** Fixation of sternal fractures: a systematic review. J Trauma Inj Infect Crit Care, 71:1875–1879.
5. **Edwards J, Clarke P, Pieracci F *et al.* (2020):** Taxonomy of multiple rib fractures: results of the chest wall injury society international consensus survey. J Trauma Acute Care Surg., 88: 40–45.
6. **Klei D, de Jong M, Oner F *et al.* (2018):** Current treatment and outcomes of traumatic sternal fractures: a systematic review. Int Orthop., 43: 1455–64.
7. **Schulz-Drost S, Oppel P, Grupp S *et al.* (2016):** The oblique fracture of the manubrium sterni caused by a seatbelt: a rare injury? Treatment options based on the experiences gained in a level I trauma centre. Int Orthop., 40:791–8.
8. **Doyle J, Diaz-Gutierrez I (2021):** Traumatic sternal fractures: a narrative review. Mediastinum, 5:34. doi: 10.21037/med-21-27.
9. **Zhao Y, Yang Y, Gao Z *et al.* (2017):** Treatment of traumatic sternal fractures with titanium plate internal fixation: a retrospective study. J Cardiothorac Surg., 12: 22. doi: 10.1186/s13019-017-0580-x.
10. **Klei D, Schutte H, Öner F *et al.* (2021):** Traumatic sternal fractures can be safely treated conservatively-A 13-year retrospective cohort study. Journal of Surgery and Research, 4(4): 572-87.
11. **Kara H, Bayir A, Degirmenci S *et al.* (2022):** Sternal fractures in blunt chest trauma: retrospective analysis of 330 cases. J Coll Physicians Surg Pak., 32(6):799-803.
12. **Kunhivalappil F, Almansoori T, AbdulRahman M *et al.* (2023):** Management of Blunt Sternal Fractures in a Community- Based Hospital. Surgery Research and Practice, 23(1): 8896989. doi: 10.1155/2023/8896989.
13. **Aamir J, Alade B, Caldwell R *et al.* (2023):** Sternal fractures and thoracic injury: an analysis of 288 sternal fractures attending a major trauma centre. European Journal of Orthopaedic Surgery & Traumatology, 33(6): 2619-2624.
14. **Lee N, Kim S, Kim J *et al.* (2023):** A decade of treating traumatic sternal fractures in a single-center experience in Korea: a retrospective cohort study. Journal of Trauma and Injury, 36(4): 362-368.