

Rib Healing and Heterotopic Ossification After Surgical Stabilization of Rib Fractures

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Introduction

- ❖ Bone healing is a highly coordinated, complex physiological process. It encompasses multiple overlapping stages, including an inflammatory phase, a reparative phase characterized by new bone formation, and a remodeling phase that restores the bone to its original shape and strength. These stages are influenced by factors such as biomechanical stability at the fracture site, adequate blood supply, and the local cellular environment.
- ❖ When bones are properly aligned and stabilized as they are with surgical fixation the healing process will proceed in a predictable and efficient manner. When the healing environment is suboptimal complications such as non-union can arise.
- ❖ Non-union is the failure of a fracture to heal within the expected timeframe, and it can lead to prolonged pain, decreased respiratory function, and diminished quality of life.
- ❖ Another possible complication following trauma or surgical intervention is heterotopic ossification (HO). HO is the aberrant formation of bone tissue in locations where bone is not typically found, such as within muscles or connective tissues of the chest wall. This abnormal bone growth often results from an exaggerated healing response and may be precipitated by trauma, surgery, or prolonged inflammation.
- ❖ In patients with rib fractures, especially those treated with SSRFs, HO can result in localized pain, stiffness, and in some cases, functional impairment of the chest wall. Data on the incidence of both non-union and HO, particularly in patients who have undergone the surgical stabilization of rib fractures (SSRF) is limited.

Aims

The aim of this investigation is to determine the rate of fracture healing following SSRFs as well as to characterize the occurrence of HO after chest trauma.

As SSRFs have become more commonplace, alternative rib plating systems have been developed with plates that vary in thickness, flexibility, absorbability, and fixation technique. There has been a growing interest in the performance and outcomes of different rib plating systems. Recent studies comparing efficacy of non-absorbable and absorbable plates note a significant difference in outcomes, highlighting a need to expand this investigation to a multi-center study comparing rib healing rates after SSRFs using various plating systems

Methods

This is a single-center, retrospective cohort study that was conducted on all patients who underwent SSRFs at MUSC from 1 January 2010 to 31 March 2023 and had a computed tomography (CT) of the chest performed greater than 6 months after SSRFs. The rib fracture locations were mapped on the initial trauma CT scan and evaluated on the follow-up CT scan for healing and HO formation.

Results

A total of 254 SSRF cases were evaluated, 21 patients met the inclusion criteria; out of 208 fractures, 109 underwent SSRFs. The median time to follow-up CT scan was 17 (7–88) months. Overall, 95% of the fractures healed completely. Seventy percent of the non-union fractures were in posterior or paraspinal locations on ribs 8–10. HO was noted in nine patients and seen as early as 8 months post-operatively. A significant association was identified between the fixation method used to perform SSRFs (89% vs. 11%, $p = 0.024$) and operative day (6(0–9) vs. 2(2–5), $p = 0.023$).

Table 1. Heatmap of the rib number and location of injuries. The incidence of fractures is color-coded, with lowest values in green and highest values displaying increasing red hues. The rows separate the ribs by number, 1–12. The columns are separated by anatomic region (CC – costal cartilage; A – anterior; L – lateral; P – posterior; PS – paraspinal).

Location of Fractures					
	CC	A	L	P	PS
1	1	0	1	1	1
2	1	0	4	2	1
3	1	3	5	4	1
4	1	4	5	4	2
5	1	5	9	7	4
6	1	4	10	10	4
7	0	4	11	11	5
8	0	3	10	11	6
9	0	1	8	10	7
10	0	1	4	6	6
11	0	0	2	2	1
12	0	0	0	2	0
Total	6	25	69	70	38



Figure 1. Chest X-ray showing HO at the tips of the red arrows.



Figure 2. Three-dimensional reconstruction of CT scan with HO between ribs.

Conclusions

- ❖ Data demonstrate that non-union is an uncommon complication, with occurrences primarily concentrated in the posterior and paraspinal segments of ribs 8 through 10. This anatomical distribution suggests that certain rib locations may be more prone to impaired healing, potentially due to biomechanical stressors, limited vascular supply, or difficulty in achieving optimal surgical stabilization in these regions.
- ❖ HO between fractures is common after SSRFs. Heterotopic ossification (HO) was detected in over 40% of patients during follow-up CT imaging. The presence of HO raises concerns not only for its frequency but also for its potential to contribute to persistent pain, reduced thoracic mobility, and long-term functional limitations. **This study was published in the Journal of Clinical Medicine August 7, 2025. PMID : 40807205.**

