Stability of Surgical Rib Fixation Hardware after Repeat Chest Trauma

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Abstract
Surgical management of rib fractures has long been a controversial topic, but improvements in rib plating technology have led to a recent increase in interest among surgeons. Unfortunately, follow-up data are limited in patients following rib fracture plating. We present a unique case of an adult male who had multiple ribs plated for symptomatic rib fracture nonunions and developed periprosthetic fractures following repeat trauma several months later. A 57-year-old male with a history of trauma was treated for symptomatic nonunion of several left lateral ribs with surgical rib fixation. He tolerated the procedure well and had significant improvement in his symptoms on follow-up. Several months later, he was hit by a motor vehicle while riding his bicycle. He was found to have flail chest with lateral segmental rib fractures of the first through second ribs, posterior periprosthetic fractures of the seventh through tenth ribs, and lateral fractures of the eleventh and twelfth ribs. The rib plating hardware was completely intact, except for a single displaced seventh rib screw. To our knowledge, this is the first case report of repeat chest trauma following rib plating. Interestingly, the patient developed posterior periprosthetic fractures, and hardware was completely intact except for a single screw that was displaced. The goal of this report is to describe the unique fracture pattern of a flail chest with prior rib plating and to describe potential revision plating techniques and complications that surgeons may encounter in the management of trauma patients with prior rib plating.

Keywords: Flail chest, periprosthetic fracture, rib fracture, surgical rib fixation

Introduction
Rib fractures are extremely common in acute trauma patients and are associated with a significant degree of morbidity and mortality. Studies have shown that prognosis is worse in rib fracture patients with increasing age, number of rib fractures, and presence of flail chest. Despite the high incidence of rib fractures, outcomes remain poor and treatment options have not made significant improvements over the years.[1-3]

Classically, treatment was centered around pain control, pulmonary hygiene, and sometimes positive pressure mechanical ventilation. Surgical management of the rib fractures has long been a controversial topic, but improvements in rib plating technology have led to a recent increase in interest among surgeons.[1,2,4-11] Acute indications include five or more rib fractures with a flail segment, especially in those requiring mechanical ventilation or in those with severe pain not managed medically.[12] Relative indications include three or more rib fractures with a flail segment not requiring mechanical ventilation, three or more severely displaced rib fractures, and three or more ribs with mild-to-moderate displacement with at least a 50% reduction of expected forced vital capacity.[5] Chronic indications for rib fixation include symptomatic nonunion (pain with deep inspiration, upper body movement, popping sensation, dyspnea on exertion, etc.) which can be lifestyle limiting.[13] Reported benefits of rib fixation versus nonoperative management include better controlled pain, decreased narcotic requirement, decreased need for tracheostomy, decreased days in the intensive care unit (ICU), decreased days on the ventilator, and overall improved quality of life.[8,11,12] Potential risks of rib fixation include pain, scar, bleeding, pneumothorax, infection, need for hardware removal, and hardware failure.[14]
Unfortunately, follow-up data are limited in patients following rib fracture plating. We present a unique case of an adult male who had multiple ribs plated for symptomatic rib fracture nonunions and developed periprosthetic fractures following repeat trauma several months later.

**Case Report**
A 57-year-old previously homeless male with a history of trauma from a bicycle crash originally presented to our level 1 trauma center for the evaluation of back and flank pain and a “click” in his chest. He was found to have an acute fracture of the left seventh rib and chronic nonunion of left eighth through twelfth ribs [Figure 1 and Table 1]. He underwent elective rib plating for symptom management in addition to evacuation of hemothorax and pulmonary decortication for fibrothorax and trapped lung. The seventh through tenth ribs were plated with a bicortical locking rib fixation system, and a 28 Blake chest tube was placed [Figure 2]. At least three bicortical locking screws were placed proximal and distal to the fracture locations. He tolerated the procedure well and had significant improvement in his symptoms on follow-up. He denied any residual pain or clicking of the ribs and could finally get a good night’s sleep. An improvement in his symptoms greatly improved his quality of life so that he was able to obtain a job, was able to rent an apartment, and was no longer homeless.

Three months later, he was riding his bicycle when he was again hit by a motor vehicle. In addition to numerous devastating injuries including a significant traumatic brain injury (TBI) prompting admission to our ICU, he was found to have flail chest with lateral and posterolateral rib fractures of the first through tenth ribs and periprosthetic fractures of the seventh through tenth ribs [Figure 3 and Table 1]. The rib plating hardware was completely intact, except for a single displaced screw from the seventh rib plate [Figure 4]. He was also found to have a hemothorax, for which a chest tube was placed. Notably, there was increased difficulty of the chest tube placement due to the prior pulmonary decortication and rib plating. His new rib fractures were treated nonoperatively due to his poor clinical status from his TBI. Unfortunately, he expired from his injuries.

**Discussion**
Currently, there are no papers describing rib fracture patterns following repeat trauma in a patient with prior rib plating. Interestingly, the pattern observed in this case was mainly perivertebral and lateral in the unplated ribs. The ribs that were previously plated had posterior lateral fractures with periprosthetic fractures immediately adjacent to the plates posteriorly. This suggests that the plates transmitted the force from lateral fractures to the posterior aspect of the plate, resulting in posterior lateral fractures. This information is important for revision planning if indicated.

Revision fixation of periprosthetic rib fractures is a challenging condition that surgeons may encounter, and currently, there are several options available. One option is to utilize a longer plate that spans the segmental fractures and provide stabilization to the unstable injury. One concern in using this approach would be deciding how to manage the holes in the bone from the original plates. When using this approach, a surgeon may choose to shift the plate placement or use a different system to avoid using old screw holes in the bone. Shifting the plate will result in new holes in the bone for fixation but could weaken the overall repair depending on the proximity to the old holes. A unicortical fixation system provides different locations for the screws to be placed but still has the issue of the previous screw holes. Another option is to use a bioabsorbable plate to suture around the ribs or remove the old plates and suture through the previous screw holes. Theoretically, one could over-drill the previous holes with a larger diameter screw to create fresh fixation to span both segments of a fracture, using the previous screw holes, and place a longer plate. A third option would be to use a U-plate to provide fracture fixation around the upper portion of the rib, but the placement of screws through the middle portion of these plates will still be close to the previous fixation holes in the ribs.
Since rib plating is relatively new, there are no papers describing the integrity of rib plating hardware after sustaining repeat trauma. In the case described above, the four plates remained intact. The only evidence of trauma to the plates was displacement of one screw from the seventh rib [Figure 4]. Our institution has published a case report describing the performance of rib plating hardware in a patient who had a code event requiring chest compressions.\textsuperscript{14} She had rib plating hardware on ribs 4–8, and after the code, computed tomographic scan showed posterior periprosthetic rib fractures of ribs 6 and 7 as well as a new fracture of the tenth rib on the ipsilateral side. Her fracture pattern was consistent with the patient in this case report. In both cases, the previously placed hardware remained intact and mostly unaffected by the trauma with resulting posterior periprosthetic rib fractures. Other than one displaced screw (of 40 total screws), the hardware remained completely intact. Further studies with larger sample sizes would be beneficial to better understand the overall durability of rib plating hardware in trauma, though these two cases show that rib plating hardware is quite durable despite compressive forces and repeat trauma.

An obstacle that was encountered during this patient’s care was uncertain magnetic resonance imaging (MRI) compatibility of rib plating hardware. Currently, all implantable orthopedic hardware, including rib plating hardware, is considered MRI compatible. A recent literature review study by Mosher et al. reviewed 15 articles discussed safety parameters such as radiofrequency-induced heating and implant displacement from various implant systems.\textsuperscript{15} Most plates were made of either titanium or stainless steel and were considered safe to use in an MRI. We hope to make this information commonplace in the medical field as to prevent any delays in patient care.

**Conclusion**

To our knowledge, this is the first case report of repeat chest trauma following rib plating. Interestingly, the patient

### Table 1: Initial and repeat trauma fracture patterns

| Rib number | Fractures at presentation | Plate location | Fractures after repeat trauma |
|------------|---------------------------|----------------|-----------------------------|
| 2          | Lateral (nondisplaced) and anterolateral (50% displaced) | Lateral (nondisplaced) and anterolateral (50% displaced) | Lateral (nondisplaced) and anterolateral (50% displaced) |
| 3          | Perivertebral (nondisplaced), lateral (displaced), anterolateral (nondisplaced) | Perivertebral (nondisplaced) | Perivertebral (nondisplaced) |
| 4          | Perivertebral (nondisplaced), lateral (displaced) | Perivertebral (nondisplaced) | Perivertebral (nondisplaced) |
| 5          | Posterior (nondisplaced) and lateral (displaced) | Posterior (nondisplaced) and lateral (displaced) | Posterior (nondisplaced) |
| 6          | Posterior (nondisplaced) and lateral (displaced) | Posterior (nondisplaced) and lateral (displaced) | Posterior (nondisplaced) |
| 7          | Posterolateral (50% displaced) | Posterolateral (7 hole, 3 screws either side of fx) | Perivertebral (nondisplaced), posterior lateral (posterior edge of plate (displaced), most posterior screw pulled out) |
| 8          | Posterolateral (nondisplaced) | Posterolateral (8 hole, 4 and 3 screws either side of fx) | Perivertebral (nondisplaced), Posterior lateral (posterior edge of plate (displaced)) Lateral (nondisplaced) |
| 9          | Lateral (nondisplaced) | Posterolateral (8 hole, 3 screws either side of fx) | Perivertebral (nondisplaced) and posterior lateral (posterior edge of plate (displaced)) |
| 10         | Posterolateral (nondisplaced) | Posterolateral (10 hole, 3 and 5 screws either side of fx) | Perivertebral (nondisplaced) and posterior lateral (posterior edge of plate (displaced)) |
| 11         | Posterior (nondisplaced) | | Posterior (nondisplaced) |
| 12         | Posterior (nondisplaced) | | Posterior (nondisplaced) |

Displacement descriptions are in parentheses, new or unchanged fractures and hardware failure are in bold. fx: Fracture

**Figure 3:** Anteroposterior chest radiograph following repeat trauma with fractures of left ribs 2–12

**Figure 4:** Axial computed tomographic imaging showing the displaced periprosthetic rib hardware with a pulled out screw from the seventh rib plate
developed periprosthetic fractures and hardware was completely intact except for a single screw that was displaced. The goal of this report is to describe the unique fracture pattern of a flail chest with prior rib plating, potential revision plating techniques, and complications that surgeons may encounter in the management of trauma patients with prior rib plating.

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Conflicts of interest
There are no conflicts of interest.

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