

Case
Report

Successful Surgical Fixation Using Bio-Absorbable Plates for Frail Chest in a Severe Osteoporotic Octogenarian

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We present a case of a severe osteoporotic octogenarian who sustained serious flail chest from a traffic accident. The 3rd–9th ribs of the right chest wall were fractured. Non-operative management was unsuccessful. We performed a surgical fixation using a bio-absorbable and bio-active mini-plating set. This plating set is unsintered hydroxyapatite (u-HA) particles/poly-L-lactide (PLLA) composite osteosynthesis device commonly used for cranial, oral, and maxillofacial surgeries. The use of the u-HA/PLLA device for chest wall reconstruction has previously been reported, but no long-term results have been included. This case showed several advantages of the procedure with 4-year follow-up over other reported methods, especially in an osteoporotic elderly patient.

Keywords: rib fracture, flail chest, surgical fixation, absorbable plate

Introduction

Blunt chest wall trauma is a major cause of morbidity and mortality, especially in the presence of a flail chest. When four or more consecutive ribs are fractured in two places, a flail segment is diagnosed, with a historical mortality rate of 10%–36%. The cause of mortality may be from associated injuries or impaired ventilation, leading to pulmonary sepsis. Patients with a flail chest require

aggressive pain control, pulmonary toilet, and often intubation and mechanical ventilation to establish an internal pneumatic stabilization. This may result in a prolonged intensive care unit (ICU) stay and pulmonary complications including pneumonia, septicemia, and barotrauma.¹⁾

Several potential advantages of surgical chest wall fixation in selected patients have been reported. These include reduced duration of mechanical ventilation, shortened ICU and hospitalization, and decreased likelihood of clinically significant long-term respiratory dysfunction and skeletal deformity. Despite the advantages of surgical fixation, little consensus on the fixation technique exists.²⁾

The present report describes a surgical fixation using a bio-absorbable and bio-active mini-plates and screws set (Super FIXSORB MX, Takiron Co Ltd, Osaka, Japan) for serious flail chest. This plating set is unsintered hydroxyapatite (u-HA) particles/poly-L-Lactide (PLLA) composite osteosynthesis device commonly used cranial, oral, and maxillofacial surgeries. There have been several reports of chest wall repair with the plating set; however, no long-term results have been reported. Our procedure achieved successful outcome with more than 4-year follow-up, even in a severe osteoporotic octogenarian.

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Case Report

The patient was a 83-year-old female who had been under treatment for severe osteoporosis and diabetes. She was hit by a car and admitted to our emergency room. Examinations revealed severe multiple left-sided rib fractures with mild pulmonary contusion and hemothorax of left lung. A chest drainage tube was placed and intubation with mechanical ventilation instituted. On the day 2 after the injury, her right hemothorax had resolved. Despite conventional efforts, she was unable to be weaned from the ventilator. During a weaning trial on the day 7, deformity of thoracic cage became severe (**Fig. 1A**), and she developed hypoventilation respiratory failure. Volume rendering three-dimensional (3D) image using computed tomography (CT) (**Fig. 1B**) revealed the 3rd–8th ribs fracture of the right side (3rd–6th, 8th ribs at two sites, 7th and 9th ribs at one site).

On the day 8 post injury, she underwent surgical fixation of flail segments with the bio-absorbable and bio-active plates. The surgical plan was as follows. Surgery was performed in the right lateral decubitus position. The approximately 20 cm longitudinal incision on anterior axially line and division of latissimus and serratus muscles exposed the fracture sites of chest wall. The shape and size of u-HA/PLLA mini-plating set was selected for each fracture site. The number and site of fixation was decided according to operative findings to achieve an ideal stabilization. Three different straight-type plates (**Fig. 2A**) were used and contoured to fracture sites and fixed by 6 mm the same material screws. When the fixation of a plate with screws was insufficient due to osteoporotic change of ribs, 2 vicryl suture (Ethicon, Inc, Somerville, NJ, USA) ligature between plate and rib was added. A total of eight fracture sites were repaired with these plates (4th, 6th, 7th, and 9th ribs at only posterior fracture, 5th and 8th ribs at both fractures) (**Fig. 2B**). Thoracoscope was inserted through the previous incision of chest tube in the third intercostal space and checked thoracic cavity avoiding lung injury during the procedure. The operation was finished without any problem, then an information drain was placed in the chest cavity and the wound was closed in layers.

The patient was extubated on postoperative day 2. Physical examination and chest radiograph revealed nearly symmetrical chest wall with pulmonary re-expansion (**Fig. 3A**). She was discharged on postoperative day 20 without any complications. No clinical symptoms and abnormal values in the biochemical analysis

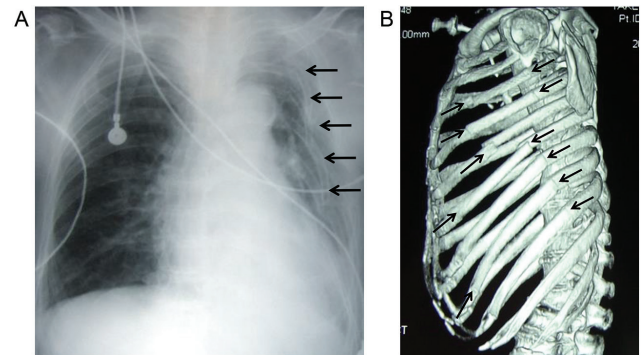


Fig. 1 (A) Antero-posterior chest X-ray shows flail chest during the weaning trial. (B) Preoperative volume rendering 3D-CT under pneumatic stabilization, arrows point fracture sites of ribs. 3D-CT: three-dimensional computed tomography

of blood suggestive of inflammatory reactions were found during the postoperative follow-up period. 3D-CT revealed securely fixations with these plates at 6 months after surgery (**Fig. 3B**), and partial absorption of plates without any deviations of ribs at 4 years after surgery (**Fig. 3C**).

Discussion and Conclusion

A surgical fixation of flail segments is an acceptable form of management for selected chest trauma patients, but is not required in all cases. Indications for surgical fixation are severe pulmonary restrictions due to the paradoxical movement of flail segments, progressive lung volume loss or deteriorating pulmonary function, and persistent instability which does not allow to wean from the ventilator.^{1,2} The main indication is a highly mobile flail segment. But, despite the advantages of surgical fixation, little consensus on the fixation technique exists. A review of the literature shows that rib fixation has been achieved using various methods: plates, intramedullary devices, vertical bridging, and wiring.³ The features of each method are following. Plates: Most general osteosynthesis plates exceed by far the bending stiffness of ribs, screw loosening due to stiff plate against flexible rib, conversely the special plates like Judet-struts have a very low stiffness. Intramedullary devices: lack of rotational stability and difficulty of insertion. Vertical bridging: the ease of implant insertion and removal, but non-physiological movement of rib cage. Wiring: simple and convenient, but insufficient stability. After all, the problem of surgical approach is the lack of the stability due to the loosening and migration of implants, especially in osteoporotic ribs.

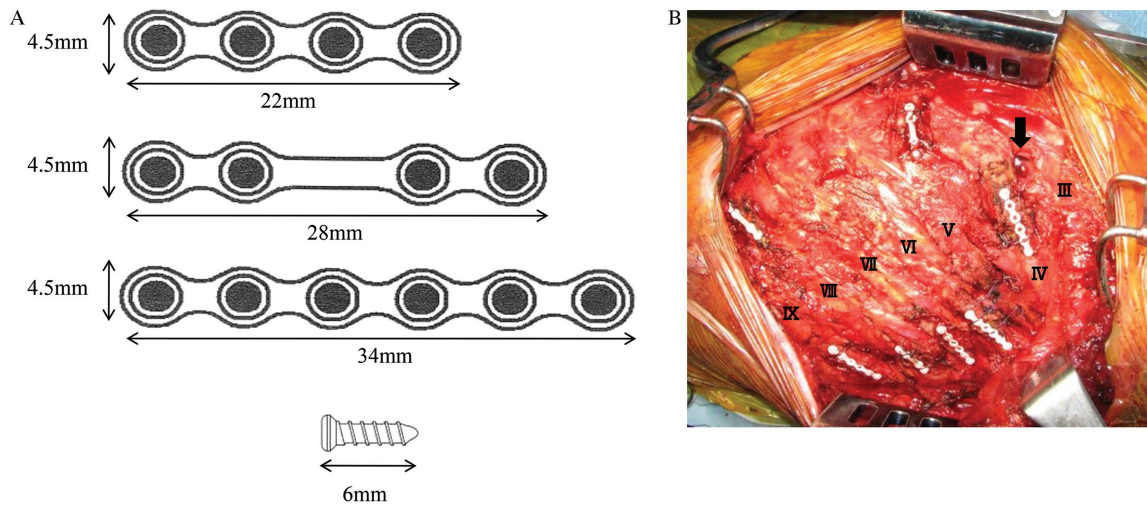


Fig. 2 (A) Plates and screw. (B) Operative findings. The number of ribs is on each rib, an arrow points a hole for a thoracoscope in the 3rd intercostal space.

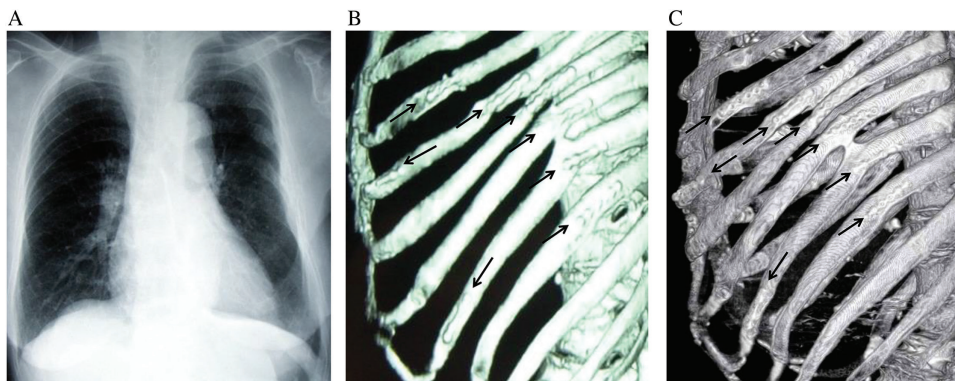


Fig. 3 (A) Postoperative antero-posterior chest X-ray shows nearly symmetrical chest wall with lung expansion. (B) Postoperative 3D-CT at 6 months after surgery, arrows point the implanted plates. (C) Postoperative 3D-CT at 4 years after surgery, arrows point the implanted plates, partial absorption of plates are observed without deviation of ribs. 3D-CT: three-dimensional computed tomography

The u-HA/PLLA mini-plates and screws set is a bio-active and bio-absorbable device commonly used for bone reconstructions in cranial, oral, and maxillofacial surgeries.⁴⁻⁷⁾ The features of this plating set are as follows. At first, although this plating set is small and thin, it possesses very high strength, excellent torque in screws and bending strength in plates higher than that of human cortical bone. Second, it possesses bioactivity enabling the promotion of bonding and the total replacement with bone, and direct binding with surrounding bone without intervention of fibrous tissues. Third, it degrades homogenously and is totally absorbed more rapidly than conventional PLLA only devices. The features mentioned above make it possible for even severe osteoporotic ribs to form the stable fixation of flail segments

and to dispense removal of plates and screws. Furthermore, this device is composed entirely materials with proven track records as safe biomaterials, and can be observed postoperatively from X-ray images depending on the condition of surrounding bone without a strong artifact.⁴⁻⁷⁾

There have been several reports regarding the same u-HA/PLLA material in the field of chest surgery.⁸⁻¹⁰⁾ Those mentioned their different techniques from our techniques. Ito et al.⁸⁾ performed fixation for rib-costal cartilage after thoracotomy using the mesh-type u-HA/PLLA device, and Oyamatsu et al.¹⁰⁾ also used mesh-type device for rib fractures. Tsunekawa et al.⁹⁾ reported the use of intramedullary u-HA/PLLA pin after median sternotomy induce an earlier sternal fusion. All of them

described successful short-term results, but no follow-up more than 1 year after surgery.

In this case, we selected plating fixation using this u-HA/PLLA mini-plating device because of remarkably thin and fragile ribs due to severe osteoporosis. This device is small and thin, but has an enough strength, flexibility, various shapes, and bioactivity to promote bone healing. We thus consider this approach as suitable for bone fractures in osteoporotic patients. Moreover, implanted plates were partially absorbed without complications or deviation of the ribs after 4 years. The materials would be totally absorbed within another 2 years. Dispensing with the need to remove plates must be a great advantage for this fragile patient.

In conclusion, surgical fixation of flail chest using the u-HA/PLLA mini-plating device for an extremely fragile patient has been successfully achieved. We would certainly use this method in the future.

Disclosure Statement

We have no conflicts of interest or financial ties to disclose.

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