

Minimally invasive plate osteosynthesis for the treatment of sternal fracture in the lower chest: a case report

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Abstract

Sternal fracture is a common complication of chest trauma but has a low incidence. Various treatments have been developed to reconstruct sternal fractures. Among these approaches, analgesia, corset fixation, and open reduction with plate internal fixation have been suggested. The use of newly developed minimally invasive plate osteosynthesis is a feasible method. In this study, we report a case involving a 54-year-old man with a sternal fracture accompanied by bilateral pleural effusion and a small amount of right-sided pneumothorax. The patient was treated with minimally invasive plate osteosynthesis. The operation was successful and the post-operative recovery was good. No pneumothorax or complications such as chest pain, paresthesia, or wound infection were observed at the 1-year follow-up visit. Additionally, the bilateral pleural effusion had been completely absorbed. The incision in the lower chest was aesthetic and minimally traumatic. This case describes a novel method for internal fixation of sternal fractures.

Keywords

Sternal fracture, lower chest small incision, minimally invasive plate osteosynthesis, chest trauma, internal fixation, case report

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Introduction

The sternum is a flat bone located in the anterior midline of the thoracic wall. Sternal fracture, a common complication of chest trauma, is mostly caused by compression of the chest or a direct injury such as thoracic extrusion, a fall from a height, or a traffic accident.¹⁻³ Most stable sternal fractures are treated by conservative techniques, including analgesia, corset fixation, and bed rest for several months;^{3,4} however, unstable sternal fractures require open reduction and internal fixation. Conventional plate fixation (CPO) was historically considered the gold standard for surgical treatment. However, complications such as nonunion, devitalization of the soft tissue, and deep infection are still associated with open reduction with plate internal fixation.^{5,6}

Minimally invasive plate osteosynthesis (MIPO) is performed through a soft tissue incision located far away from the broken end of the fracture and does not open the fracture, thus reducing the exposure and damage of the fractured end and soft tissue.⁷ Most reports to date have only described the use of MIPO for fractures of the femur, tibia, and humerus;^{8,9} limited research has focused on MIPO for sternal fractures. We herein introduce the first reported case of MIPO for a sternal fracture in a 54-year-old man with chest pain. Compared with CPO, MIPO is more feasible and has the advantages of a smaller incision, soft tissue protection, and blood loss reduction, thus serving as a potentially valuable new method for internal fixation of sternal fractures.

Case report

A 54-year-old man experienced chest pain after being involved in a car accident. Two days later, he was admitted to our hospital. Computed tomography of the chest showed that the upper part of the sternum was

fractured with backward displacement of the upper end. After further examination, the patient was diagnosed with fractures of the second and third front ribs on the right side, bilateral pleural effusion, and a small amount of pneumothorax on the right side. After obtaining data from the 16-slice computed tomography scanner (BrightSpeed; GE Healthcare, Chicago, IL, USA), the Advantage Workstation 4.2 (GE Healthcare) was used to reconstruct a three-dimensional model. According to this three-dimensional model and the sternal fracture line at the sternal angle, a titanium alloy sternum locking plate was pre-formed while avoiding excessive or reverse bending the locking plate. Six screws were designed (two sternal stalks and two each for the upper and lower ends of the sternal body fracture). The thickness of the sternum and required nail height were measured, and double-cortex fixation was adopted. We ensured that the screws did not substantially exceed the posterior cortex to avoid deep injury (Figure 1). Informed consent was obtained from the patient and his family. This study was approved by the Ethics Committee of Shijiazhuang Third Hospital.

The patient underwent general anesthesia and was placed in the supine position. A small incision (approximately 3 cm) was made between the midpoint of the bilateral nipples' connection and xiphoid process (Figure 2(a)). The skin and subcutaneous tissue were then cut successively. Under the aid of a 5-mm-diameter thoracoscope, an ultrasonic knife was used to free the subcutaneous tissue upward along the surface to the suprasternal fovea. A subcutaneous tunnel was created along the surface of the sternum upward to the suprasternal fovea, and it was freed to the thoracic and costal joints on both sides. After establishment of the subcutaneous tunnel, the transverse sternal fracture was observed (Figure 2 (b)). The broken end was located at the

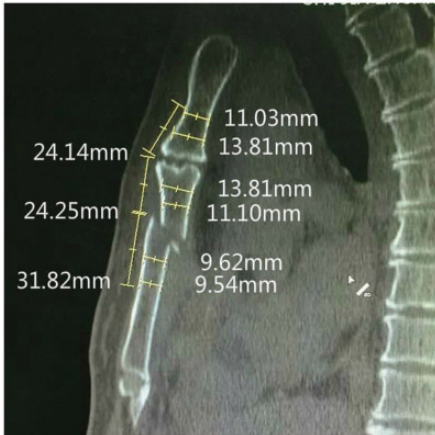


Figure 1. According to the computed tomography image, the upper part of the sternum was fractured with backward displacement of the upper end. A titanium alloy sternum locking plate was pre-formed, and the screw position and depth were designed before the operation.

upper edge of the third rib, and the upper end was displaced backward. We used a special long towel clamp to hold the upper and lower broken ends and reset the fracture (Figure 2(c)). The long right-angle hooks were pulled upward to enlarge the subcutaneous tunnel space. We placed a preoperative well-formed 11-hole titanium sternum locking plate on the sternal surface (Figure 2(d)). The first and second holes were in the sternal stem, and the fracture line was at the eighth and ninth holes. The first hole near the locking plate was drilled by the MIPO technique (Figure 2(e)), and the locking nail was loosely fixed. We adjusted the position of the titanium alloy sternum locking plate so that it fitted perfectly with the bone surface. The hole was drilled in the 11th hole at the distal end, and the locking nail was firmly fixed. The locking nail was firmly fixed again at the proximal end of the first hole. We then drilled holes in the 2nd, 5th, 7th, and 10th holes in turn, and all of the locking nails were firmly fixed. The titanium alloy sternum locking plate was

installed. Finally, a negative-pressure drainage tube was placed in the wound.

As mentioned earlier, the patient also had bilateral pleural effusion and a small amount of right-sided pneumothorax. Therefore, the operation was performed gently to avoid extrusion of the thorax and to reduce secondary injury to the rib fracture. A ventilator (tidal volume of 5 mL/kg) was used to increase the air ratio and thus reduce the damage of pure oxygen to the lungs and avoid aggravating the pneumothorax. The operation was smoothly performed with 10 mL of intraoperative bleeding.

The patient got out of bed 6 hours after the surgery, and 50 mL of blood had been suctioned from the drainage tube. Twenty-four hours later, the patient's numerical rating scale pain score had decreased from 8 to 3. The drainage tube was then removed, and the patient was able to adequately perform self-care. Four days after surgery, the wound was free of infection, the small amount of right-sided pneumothorax had disappeared, the pleural effusion on the left side had basically been absorbed, and the pleural effusion on the right side was significantly reduced. The patient was then discharged from the hospital without complications, and the sternal locking plate was well fixed (Figure 3). One month after the operation, the patient was able to perform heavy physical activity. One year after the operation, the internal fixator was left in place at the patient's request. The patient was normally engaged in heavy physical construction work. No pneumothorax or complications such as chest pain, paresthesia, or wound infection were observed at the 1-year follow-up visit. Additionally, the bilateral pleural effusion had been completely absorbed.

Discussion

The incidence of sternal fractures is <0.5% of all fractures and is estimated to range

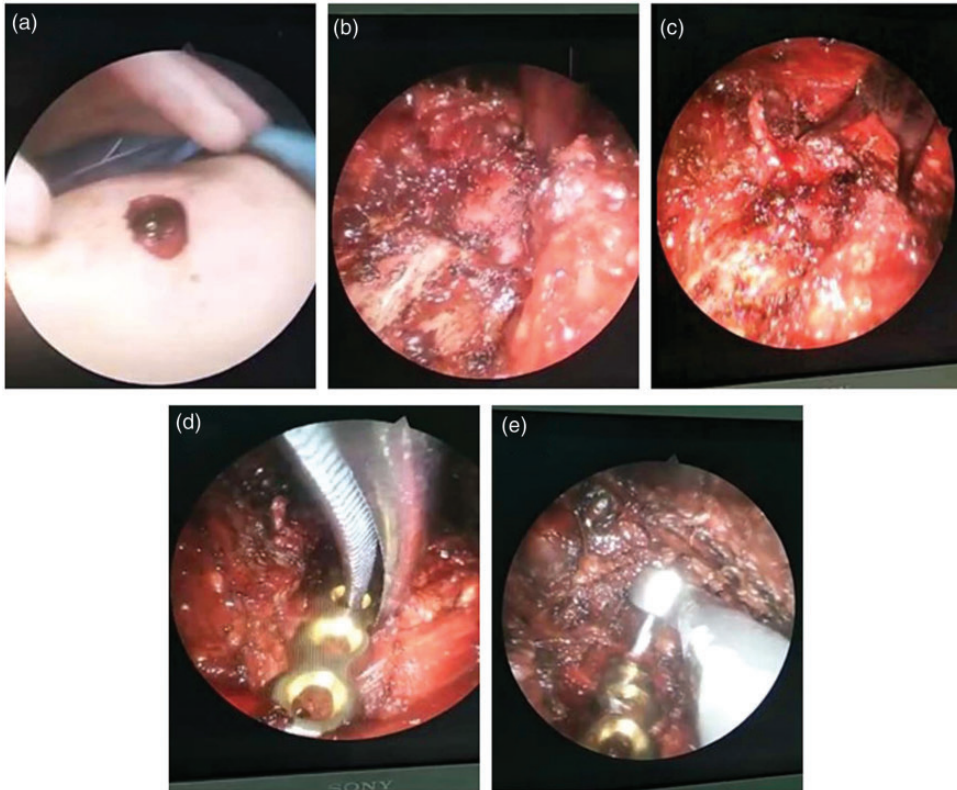


Figure 2. (a) A small incision was made between the midpoint of the bilateral nipples' connection and the xiphoid process. (b) A subcutaneous tunnel was established, and the transverse sternal fracture was observed. (c) A special long towel clamp was used to hold the upper and lower broken ends and reset the fracture. (d) A preoperative well-formed 11-hole titanium sternum locking plate was placed on the sternal surface. (e) The first hole near the locking plate was drilled by the minimally invasive plate osteosynthesis technique.

from 3% to 8% in patients with blunt trauma.¹⁰ The mechanism of injury should be considered first in the diagnosis and treatment of sternal fracture. Velissaris et al.¹¹ demonstrated that most sternal fractures are simple, and patients are usually treated with oral analgesia and routine observation. Yoldas et al.¹² suggested that surgery is necessary for patients with severely displaced fractures or complex analgesic requirements, which is consistent with the present case. Therefore, for isolated or stable sternal fractures without injury to other organs or the bone marrow,

analgesic treatment and thoracic band fixation is recommended;³ for injuries caused by high-speed impact or a fall from a height, which can result in serious displacement of the fracture, open reduction and fixation is required.¹³ In the present case, the indication for surgery was severe chest pain.

When performing CPO, large incisions are often needed for adequate exposure to complete the reduction and ultimately stabilize the fixation of the fracture. Such incisions compromise the soft tissues and bone, creating an unfavorable environment for

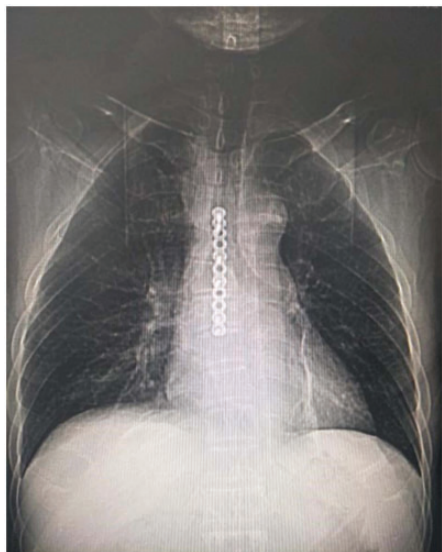


Figure 3. Postoperative chest radiographs.

bone healing and increasing the risk of infection.^{2,14} As a result, many orthopedic surgeons are trying to find a solution to resolve these problems. In recent years, minimally invasive surgery has become a research hotspot. As a representative minimally invasive technique, MIPO has been continuously developed in the field of orthopedic surgery. It is based on biological fixation and requires only a small incision (3–5 cm) at the proximal and distal ends of the fracture line. Previous studies have shown that MIPO can reduce postoperative pain, decrease the incidence of surgical site infection, and maintain the blood supply.¹⁵ A meta-analysis by Yu et al.¹⁶ showed that the incidence of nonunion and delayed union was lower in the MIPO group than CPO group. However, the difference was negligible which was also observed in the study by Esmailiejah et al.¹⁷

The principle of the MIPO technique is to avoid direct exposure of the fracture site and thus protect the wrapped soft tissue and periosteal blood supply. Therefore, MIPO requires a longer operation time

than CPO. However, as surgeons become more skilled, the time taken to operate can be reduced. Additionally, because of the indirect reduction, the periosteum and fracture site can maintain integrity of the hematoma and thus improve the healing rate and shorten the healing time.¹⁸ In the present case, the intraoperative blood loss was minimal, which is consistent with the results obtained by Miller and Goswami.¹⁹

Conclusions

The results of this case show that if patients with sternal fractures require rapid postoperative recovery, a short hospitalization time, and a small incision, MIPO is a better choice than CPO. A limitation of this study is that it was based on a single case involving a middle-aged patient. Further research is needed to demonstrate the superiority of MIPO for sternal fractures.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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