

Titanium Plate Fixation for Sternal Dehiscence in Major Cardiac Surgery

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Background: Sternal dehiscence is one of the most troublesome complications following cardiac surgery. Treatment failure and consequent lethal outcomes are very common. The aim of this study was to evaluate titanium plate fixation as a treatment for sternal dehiscence following major cardiac surgery. **Materials and Methods:** Between 2010 and 2012, 17 patients underwent sternal reconstruction using horizontal titanium plating for the treatment of post-cardiac-surgery sternal dehiscence. The plates were cut and shaped, and then were fixed to corresponding costal segments using 2-3 titanium screws per each side. **Results:** The median age of our patients was 66 years (range, 50 to 78 years) and 9 were female. Indications for sternal reconstruction included aseptic sternal dehiscence in 3 patients and osteomyelitis in 14 patients including 6 patients who were diagnosed with mediastinitis. During the operation, sternal resection and autologous flap interposition were combined in 11 patients. One patient died due to sepsis. Two patients required additional soft tissue wound revisions. Another patient presented with a tuberculous wound infection which was resolved using anti-tuberculosis medications. The postoperative course was uncomplicated in the other 13 patients. **Conclusion:** Titanium plate fixation that combines appropriate debridement and flap interposition is very effective for the treatment of sternal dehiscence following major cardiac surgery.

Key words: 1. Sternum
2. Wound dehiscence
3. Wound infection
4. Reoperation

INTRODUCTION

Sternal dehiscence following major cardiac surgery is a common problem with an incidence rate of 0.5% to 5.0% [1-4]. However, the management of severe sternal dehiscence that invades the sternal bone remains a challenge for cardiac surgeons [2,5]. Recently, the mortality rate from deep sternal wound infection following major cardiac surgery was reported to be in decline, but still to be as high as 16% to 22% [4].

The classic management of sternal dehiscence includes partial or total sternal resection with intravenous antibiotic therapy [6], continuous irrigation with saline containing anti-microbial agents [7], and localized negative pressure therapy, also known as vacuum-assisted closure [8]. When severe inflammation cannot be controlled using these methods, debridement of the devitalized sternum is necessary [9].

These classic treatments, however, have several limitations, especially in severe cases. First, massive resection which is

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essential to prevent recurrence [10,11] brings out small disease-free margin, and it does not provide enough space to hold the sternum in classical treatments [12]. Second, when the defect is large, the remaining bony structure following sufficient resection of the devitalized tissues is not enough to prevent paradoxical chest wall movement using classic management.

Recently, several groups have advocated the use of rigid metal plate fixation to close the sternum and have reported promising results [13-15]. Since our previously published case report [16], we have treated 10 more cases of sternal fixation using titanium plates in patients who suffered sternal complications following major cardiac operations. The aim of this study was to evaluate the effectiveness of horizontal titanium plating for the treatment of post-cardiac-surgery sternal dehiscence.

MATERIALS AND METHODS

1) Patients

In August 2009, we adopted an aggressive strategy that included radical sternal resection and reconstruction using titanium plates for a sternal wound problem involving the sternal bone or the area beneath following major cardiac surgery. From August 2009 through Dec 2012, a total of 2,769 adult patients (age 18 years or older) underwent major cardiac surgery at Asan Medical Center, Seoul, Korea. Of this patient population, 36 cases (1.3%) developed postoperative deep sternal wound complications. Nineteen patients developed wound problems that were limited to the soft tissue layer, and they were completely treated using conventional methods such as vacuum suctioning or soft tissue revision. The other 17 patients who underwent titanium plate fixation with massive debridement of the sternum comprised our current study cohort.

2) Surgical technique

Under general anesthesia, the previous median sternotomy incision was reopened and the wires were cut and removed. After debridement of all devitalized tissues and broken bone materials, sufficient irrigation with warm saline was performed. Both pectoralis major muscles were laterally un-

dermined up to the mid-clavicular line in order to secure a sufficient area for titanium plate fixation. Both sides of the remnant thoracic wall were brought together, and the plate's types and sizes were chosen to fit each patient's thoracic wall. This plate fixation system (Angled Universal Fracture Plate; AO Foundation, Davos Platz, Switzerland) consists of 2-mm-thick titanium plates that have multiple holes for screw fixation (Table 1). After measurement to determine the appropriate lengths of the plates, the plates were cut, shaped, and fixed to the corresponding costal segments using 2-3 titanium screws per side (Fig. 1). The pectoralis major muscle or ommental flap was plugged to fill the tissue defects following extensive debridement (Fig. 2). After sufficient irrigation with warm saline, a draining catheter was interposed beneath the pectoralis major muscle layer. Over the titanium plates, the undermined pectoralis muscle layer was closed using multiple interrupted sutures. Adequate antibiotic therapy was administered according to the bacterial sensitivity tests of the wound swab cultures.

RESULTS

Of the 17 patients, 8 patients had diabetes mellitus, 2 had osteoporosis, and 1 patient was receiving immunosuppressant medications after liver transplantation (Table 1). Previous cardiac procedures included coronary arterial bypass grafting (CABG) in 5 patients, cardiac valve surgery in 8 patients, and simultaneous coronary and valve surgery (including Bentall operation) in 4 patients. The reconstructive operation was performed after a median of 45 days following the initial operation (range, 0 to 255 days). Several conventional treatments such as soft tissue debridement or application of a vacuum suctioning system were used before titanium plate fixation in 8 patients during these periods. Indications for sternal reconstruction using titanium plate fixation included osteomyelitis with (n=6) or without (n=6) mediastinitis in 12 patients, aseptic sternal dehiscence in 2 patients, and bony destruction due to osteoporosis in 1 patient. The latter patient was a 66-year-old female who had been diagnosed with osteoporosis, and the upper part of the sternal body was broken into several particles during concomitant CABG and mitral annuloplasty. To prevent sternal instability in this case, 2 hor-

Table 1. Patient characteristics

Patient	Age/ gender	Co-morbid factors	Initial operations	Resected sternum	Osteo- myelitis	Media- stinitis	No. of plates/ screws	Autologous tissue flaps
1	76/F	DM	AVR, CABG	Total sternum	+	-	5/19	None
2	61/M	None	AVR	Sternal angle	+	+	1/4	Omentum
3	66/F	Osteoporosis	CABG, MVP	Upper sternal body	-	-	2/12	None
4	52/M	Sepsis	AVR, MVP, TVP, CABG, Dor	Whole sternal body	+	+	6/24	Omentum
5	68/M	DM	AVR, Ao-MvR	Mid-sternal body	+	-	2/10	Pectoralis
6	76/F	Osteoporosis	CABG, MVP	Mid-sternal body	-	-	2/12	None
7	56/M	Transplantation	MVR	Manubrium	+	+	2/4	Pectoralis
8	54/M	DM	OPCAB	Mid-sternal body	-	-	2/8	Pectoralis
9	50/M	DM	OPCAB	Sternal angle	+	-	2/10	None
10	53/M	DM	MVP	Sternal angle	+	+	3/14	Pectoralis
11	62/M	DM, CRF	OPCAB	Sternal angle	+	-	2/12	Pectoralis
12	74/F	DM	OPCAB	Whole sternal body	+	+	4/17	Omentum
13	78/F	None	OPCAB	Whole sternal body	+	-	4/18	Omentum
14	71/F	None	MVP, TVP	Whole sternal body	+	-	5/24	Omentum
15	70/F	None	Bentall procedure	Lower sternal body	+	+	5/20	None
16	68/F	None	Redo MVR	Total sternum	+	-	6/14	TRAM
17	70/F	None	AVR	Whole sternal body	+	+	3/12	Omentum

DM, diabetes mellitus; AVR, aortic valve replacement; CABG, coronary arterial bypass grafting; MVP, mitral valve repair; TVP, tricuspid valve repair; Dor, Dor procedure; Ao-MvR, aorto-mitral reconstruction; MVR, mitral valve replacement; OPCAB, off-pump beating coronary arterial bypass; CRF, chronic renal failure; TRAM, transverse rectus abdominis muscle.

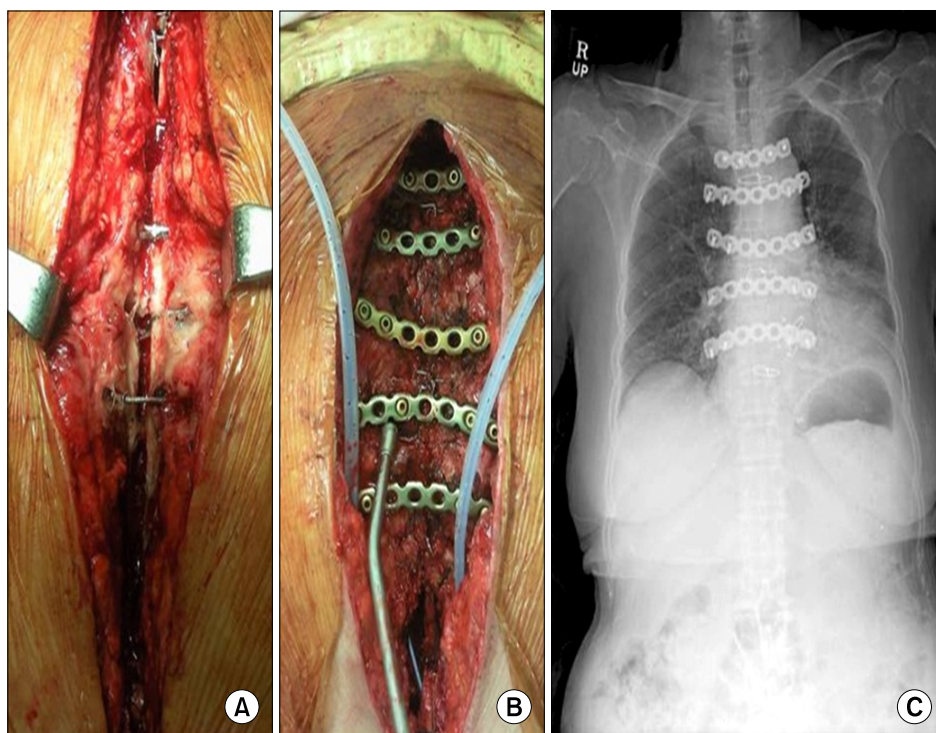


Fig. 1. Fixation of transverse titanium plates for dehisced sternum (patient #1). (A) Intra-operative findings of sternal dehiscence with purulent discharge which are indicative of sternal osteomyelitis (following aortic valve replacement and coronary artery bypass). (B) Horizontal fixation of the titanium plates was performed on the same patient. Two drainage catheters were placed under the pectoralis muscle layer. (C) Postoperative simple chest radiograph.

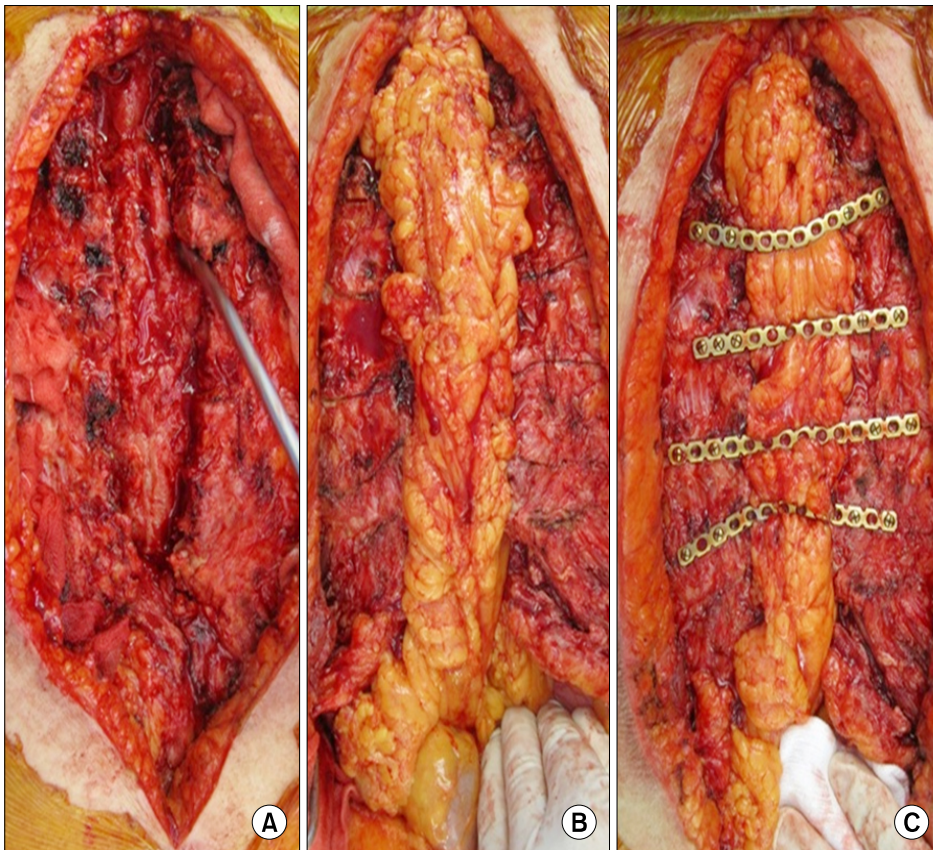


Fig. 2. Total sternectomy followed by omental flap interposition and titanium plating (patient #13). (A) The dead space occurring after total sternectomy is seen. (B) The omental flap is interposed to the defect following debridement. (C) Titanium plates are laid over the omental flap, and fixed to the thoracic wall with screws.

izontal titanium plates were placed on the sternal body during initial sternal closure.

For the other 16 patients, segmental (n=13) or total (n=3) sternal resection was performed. Flap interposition of the omental (n=6), the rectus abdominis muscle (n=1), or pectoralis major muscle (n=5) was done to fill in the empty space according to the extent of the tissue defects following sternal resection. The median number of inserted titanium plates and screws was 5 (range, 1 to 6 plates) and 19 (range, 4 to 24 screws), respectively.

One patient in whom overwhelming sepsis and multi-organ failure had already developed following his initial surgery (aortic valve replacement, mitral annuloplasty, CABG, and Dor procedure) died due to profound sepsis. Having been diagnosed with mediastinitis 1 month after the initial surgery, he underwent massive debridement, total sternectomy, omental flap interposition, and titanium plate fixation. He died of septic shock, which did not respond to high-dose vasoconstrictors for 7 days following surgery.

The in-hospital clinical course was complicated in 2 patients. One patient required additional wound revision due to aseptic wound dehiscence that was confined to the soft tissue layer, which was completely resolved by revision. The other patient presented with wound problems at postoperative 5 months, which was determined to be a tuberculous infection and was treated with anti-tuberculosis medications without further complications.

The median duration from sternal reconstruction to discharge was 37 days (range, 7 to 122 days). The postoperative course was uncomplicated in another 14 patients during a median follow-up of 522 days (range, 50 to 872 days) postoperatively.

DISCUSSION

The present study indicates that fixation of the sternum using a rigid plate is an effective management strategy to deal with a severely dehisced sternum, providing thoracic wall sta-

bility and reducing the recurrence rate. Six of our patients had undergone several wound revisions using classic management (maximum of 4 revisions per patient) before titanium plate fixation. However, additional wound revision was not needed following titanium plate fixation in most of those patients.

The treatment with titanium plate fixation for dehiscence sternal wound problem has several definite advantages. The most important benefit of titanium plate fixation is the guarantee of adequate resection of devitalized tissue by offering thoracic wall stabilization even without the sternal bone. If the sternum maintains stability after sufficient debridement, the sternal wound can be closed without using rigid plates [17]. On the other hand, a sternum with poorly qualified bone marrow, insufficient for closure using classic methods [18], may increase the rate of recurrence [19-22]. Immobilization and the maintenance of stability are the major principles of bony re-union and wound healing [23]. In this regard, titanium plate fixation may be an ideal option to offer bony re-union and stability.

The second benefit of titanium plate fixation is that the tension of the thoracic wall can be released by bridging both ribs over the sternal defects. Without titanium plates, both sides of the thoracic wall must be pulled toward the midline. Then the thoracic wall might tense up, disturbing wound healing. We believe that releasing the tension of the thoracic wall might contribute to rapid healing and, thereby, shorten hospitalization. The third benefit is ease of handling. Titanium plates are modifiable without regard to the varying shapes of each thoracic wall. Fixation of the plate was also performed with simple tightening screws.

On the other hand, some disadvantages have been reported with titanium plate fixation. First, some studies have reported a high incidence of plate removal, ranging from 8% to 25% [14,19]. This is explained by the fact that sternocostal junctions are highly mobile articulations during respiration and this motion is more active in more far location from the sternum [13]. The size mismatch between the titanium plate and the thoracic wall requires a long plate, and it may result in chest wall pain, which is the main cause of titanium plate removal [13]. However, none of our 11 cases needed plate removal or readjustment. We made titanium plates shaped and

curved by roller to fit to the adjacent thoracic wall in every case, making efforts to tie the plates to the utmost medial part of the costal cartilage, which could have contributed to our good results.

Second, titanium plate fixation has potential drawbacks, including bleeding and lung injury. Cicilioni et al. [19] reported an approximately 10% incidence of seroma formation and 4% incidence of bleeding associated with this technique, but the author stated that these complications were mainly related to pectoralis muscle dissection. Nevertheless, drilling the screws into the ribs should be carefully performed because measuring the actual depth of the ribs is difficult [13]. However, there were no cases of postoperative bleeding or pneumothorax in the present study. To determine the proper length of the screws, we estimated the depth of each patient's ribs using preoperative computed tomography, which was confirmed intra-operatively.

The cost problem is another disadvantage to the use of titanium plate fixation. Other classic methods, including irrigation, debridement, and re-wiring using steel wires without rigid plates, are less expensive options. However, considering its effectiveness, titanium plate fixation might help shorten the overall postoperative course by addressing the troublesome and frequently relapsing problems in a more complete way.

The major limitations of this study include the limited number of patients treated with titanium plates in a relatively short-term follow-up. The titanium plate fixation was not compared with conventional treatments; therefore, the study results require further verification through comparative studies.

In conclusion, fixation of the sternum using a rigid plate is feasible and might be a good alternative solution to treating sternal dehiscence following major cardiac surgery, especially for those requiring aggressive sternal resection. Results from a larger number of patients are required to verify the results of this study.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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