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Original Research

# Tradition or Innovation in Sternal Dehiscence Repair: Robicsek Versus Titanium Plate

**Yasin Ozden,[1] Safa Ozcelik,[1] Osman Murat Bastopcu,[1] Seyma Ozden,[2] Ugur Kisa,[1] Huseyin Kuplay[1]**

[1]Department of Cardiovascular Surgery, University of Health Sciences Türkiye, Dr Siyami Ersek Thoracic and Cardiovascular Surgery Training and Research Hospital, Istanbul, Türkiye
[2]Department of Chest Diseases, Immunology and Allergy Clinic, University of Health Sciences Türkiye, Süreyyapaşa Chest Diseases and Thoracic Surgery Training and Research Hospital, Istanbul, Türkiye

## Abstract

**Objectives:** Sternotomy is still the most commonly used incision in cardiac surgery. Sternal complications are seen at a rate of 0.5% to 6.1%. Sternal dehiscence increases morbidity and mortality after cardiac surgery. To prevent dehiscence, the search for alternative sternum closure methods continues today. Titanium plates produced for this purpose can also be used in patients who are re-operated due to sternal dehiscence. In our study, we investigated the effects of titanium plate repair and robicsek repair on the results in patients who were reoperated due to sternal dehiscence.

**Methods:** Thirty-four patients who underwent reoperation due to sternal detachment in our hospital between September 2013 and December 2020 and had no signs of infection in the pre-operative period were analyzed retrospectively. The patients were divided into three groups according to the surgical method applied. These groups are as follows: Group 1: The cases in which the robicsek method was used, Group 2: the cases in which the titanium plate method was used, and Group 3: The cases where the robicsek + titanium plate methods were used together.

**Results:** There was no significant difference between the groups in terms of basic demographic characteristics and risk factors, leading to sternal dehiscence. There was no significant difference between the groups in terms of mortality and length of hospital stay. Considering the infection rates in the post-operative period, 20% and 21.4% post-operative infections were detected in Group 1 and Group 3, respectively, while 70% post-operative infection was observed in Group 2, which was repaired only with the Robicsek technique ($p<0.05$).

**Conclusion:** As supported by most studies in the literature, titanium plate application provides a superior sternum stabilization compared to the classical wire cerclage method. When evaluated in terms of cost-effectiveness, titanium plate method can be applied in high-risk patients in terms of sternal dehiscence.

**Keywords:** Cardiac surgery, Robicsek, sternal dehiscence, sternal detachment, titanium plate

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Sternotomy was first described by Milton in 1897. It was reintroduced by Julian in 1957 as the basic incision of open heart surgery and started to be used widely. The reasons such as providing easy, fast, and direct access to the heart and great vessels and being relatively less painful have made it the main incision in cardiac surgery.[1] Despite

**Address for correspondence:** Yasin Ozden, MD. Saglik Bilimleri Universitesi, Kalp Damar Cerrahisi Anabilim Dali, Dr Siyami Ersek Gogus Kalp ve Damar Cerrahisi Egitim ve Arastirma Hastanesi, Istanbul, Türkiye
**Phone:** +90 533 311 11 37 **E-mail:** dr.yasinozden@gmail.com

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the increasing use of minimally invasive techniques in cardiac surgery, sternotomy is still the most commonly used incision to access the heart and mediastinal great vessels.[2]

Sternal complications after cardiac surgery can be seen at a rate of 0.5–6.1%. The risk of dehiscence is between 0.5% and 2.5%. Deep sternal wound infections have been found to be associated with mortality between 14 and 47%. The main risk factors for sternal wound infections are advanced age, female gender, long pre-operative hospital stay, re-exploration and reoperation, duration of the surgical procedure, duration of cardiopulmonary bypass, amount of blood transfusion, mechanical ventilation, and length of stay in the intensive care unit.[3]

Sternal dehiscence leads to increased pain at the incision site, difficulty in coughing and breathing, and therefore prolonged hospitalization, increased treatment costs, and most importantly, increased morbidity and mortality. Regions of the sternum close to the lower end are at higher risk for sternal dehiscence. Three reasons are given for this. The first is that the circumferential forces that will cause dehiscence in the lower regions are more, the second is that the 5$^{th}$, 6$^{th}$, and 7$^{th}$ ribs hold close to each other at the lower end of the sternum, and the third is that the 7$^{th}$ rib also carries the extra forces from the 8$^{th}$, 9$^{th}$, and 10$^{th}$ ribs. It is like a reverse zipper that opens from bottom to top.[4]

As it is well known from orthopedic practice and current literature, the most important way to allow bone re-healing in cases of impaired bone integrity is to ensure reassembly and fixation stability.[1] Contrary to any extremity in the body, stabilizing the bony structures in the rib cage is not easy. For the continuity of life, it is impossible to completely immobilize the thorax, which actively moves as you breathe, like an extremity. Factors in sternal instability may be related to the patient, procedure, surgical technique, or equipment. The ideal sternal closure method should be simple, fast, reproducible, radio-opaque, durable, easily removed in emergency situations and redo-operations, free from infection risk, cost-effective, and provide a tight fixation.[5] Sternum steel wire closure is widely used as a standard closure method due to its ease of application, rapid application, relatively low complication rates, and, of course, low cost.[1] A number of methods have been tried to prevent steel wire closure complications. To prevent the steel wire from cutting the bone, the method of inserting a double layer of parallel wire on both sides of the sternum has the most common use among them (Robicsek).[4] The ideal method for closure of the sternum and the ideal number of wires for closure with steel wires are still a matter of debate.

The search for alternative sternal closure methods continues today. Although the use of cost-increasing materials is in question, the costs due to sternal dehiscence are also quite high. For this reason, alternative methods for patient groups thought to be at high risk of dehiscence appear as cost-effective techniques. Titanium plate fixation, which is more widely used among these methods, comes to the fore especially in patients who have been re-operated due to sternal dehiscence.[6] We aimed to retrospectively analyze the surgical techniques and results that we used in patients who were re-operated for dehiscence in our cardiac surgery center and who had no signs of mediastinal infection.

## Methods

### Patients

Thirty-four patients who underwent reoperation due to sternal detachment in our hospital between September 2013 and December 2020 and had no signs of infection in the preoperative period (no positive culture results, infection markers within normal limits) were analyzed retrospectively. Since the aim of this retrospective study was to compare techniques in terms of sternal stabilization, patients were excluded from the study in the presence of infection accompanying sternal dehiscence. The patients were evaluated in three groups in terms of surgical technique. In the first group, there were patients who were fixed with a titanium plate, in the second group, patients who were supported with the Robicsek method and wired with steel wires, and in the third group, patients who were fixed with a titanium plate and supported with the Robicsek technique. Basic demographic information (age, gender), presence of possible risk factors for sternal dehiscence (diabetes mellitus (DM) and presence of chronic obstructive pulmonary disease (COPD), smoking, pre-operative ejection fraction (EF) value, etc.), type of first cardiac surgery, reoperation techniques used, hospitalization time for the postoperative period, need for postoperative infection treatment, and mortality were investigated and recorded.

### Surgical Technique

The sternal surface was reached by opening from the previous incision line. The pectoral muscles were dissected bilaterally from the ribs to form an 8–10 cm wide flap. Figure 1, the sternal steel wires from the previous operation were cut and removed. The mediastinal side of the sternum was separated from the mediastinal structures in patients to be repaired with Robicsek technique. Mediastinal dissection was not performed in patients who would undergo rigid plate fixation. Swabs and tissue cultures were taken intraoperatively and sent to the microbiology laboratory (Patients with growth in culture were excluded from the study). Sternal and costal thicknesses were measured and

noted to use materials of appropriate size in patients who will be plated. The materials to be used for the titanium plate (SternaLock® Blu Primer) application were configured in accordance with the defects in the bone structure of the patients. Figure 2 in patients who were strengthened with the Robicsek technique and rewired with steel wires, the broken points were marked and repaired with steel wires. Following the sternal closure, bilateral Jackson-Pratt drains were placed under the pectoral flap, and the pectoral flaps were approximated to each other. Figure 3, subcutaneous and skin tissue were closed in accordance with the anatomy.

**Figure 1.** Post-operative dehiscence sternum.

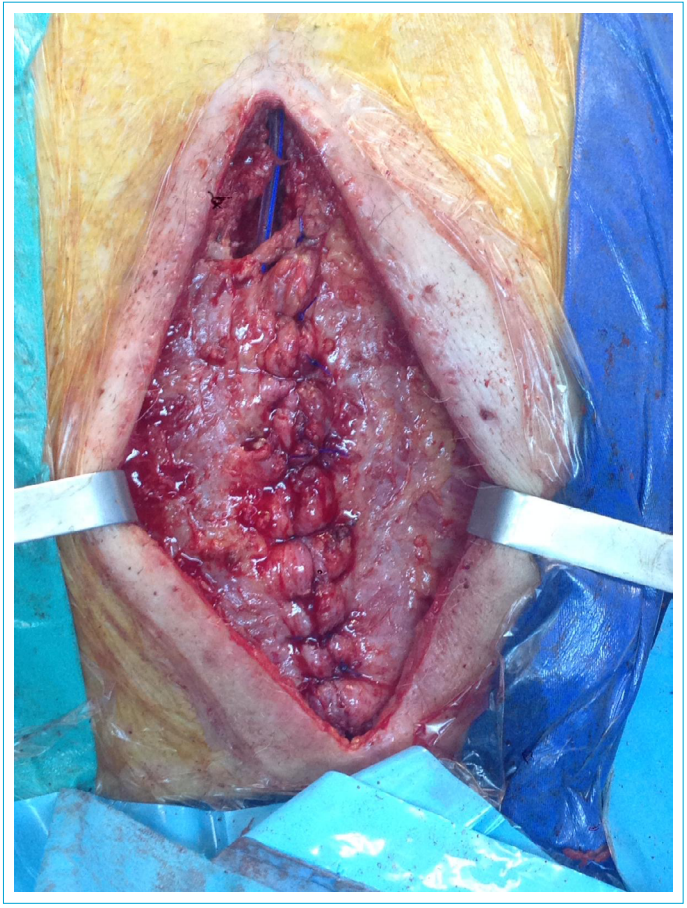

**Figure 3.** A drain was placed and the pectoral flaps were brought closer together.

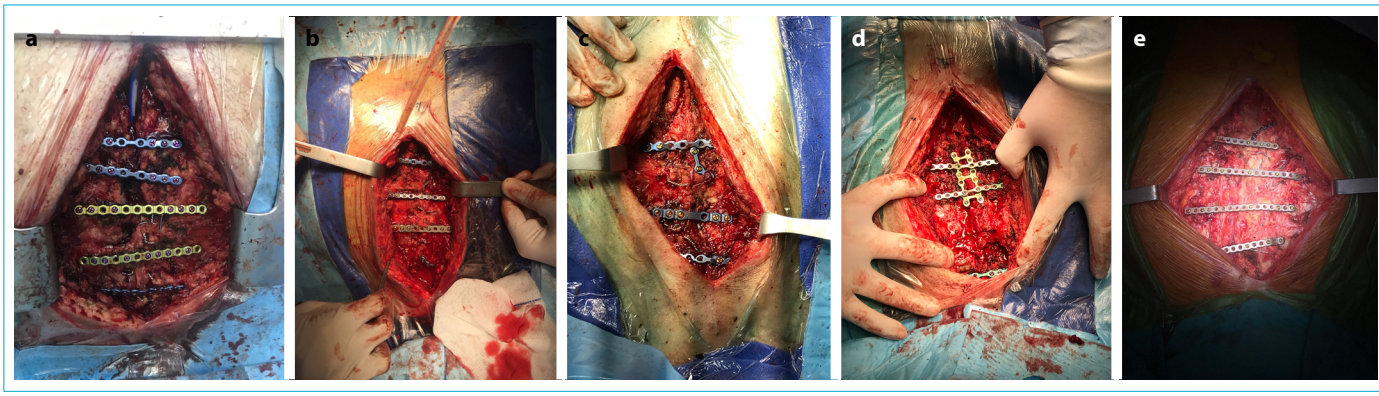


**Figure 2.** Application of sternal plate in various ways according to sternal dehiscence. **(a)** Five linear titanium plates + steel wire for fixing ribs, **(b)** three linear titanium plates + 1 H shape titanium plate + steel wire for fixing ribs, **(c)** three linear titanium plates + 1 V shape titanium plate + steel wire for fixing ribs, **(d)** three linear titanium plates + 1 big H shape titanium plate, and **(e)** three long linear titanium plates + 1 V shape titanium plate + steel wire for fixing ribs.

## Statistical Analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 15.0 software (SPSS Inc., Chicago, IL, USA). Descriptive data were presented in mean ± standard deviation or median (min–max) for quantitative variables and in number and frequency for qualitative variables. Demographics and clinical characteristics of the patients were tested for normal distribution using the Kolmogorov–Smirnov test. Parametric test assumptions were compared using the one-way ANOVA test or Kruskal–Wallis H test for quantitative variables, and using the Chi-square or Fisher's exact test for qualitative variables. $p<0.05$ was considered statistically significant.

## Declarations

Informed consent was obtained from the patients who agreed to take part in the study. Study approval was obtained from the Instituion Scientific Committee (November 12, 2021/E-28001928-604.01.01). This study was conducted in accordance with the Declaration of Helsinki.

## Results

Thirty-four patients who met the criteria in the date range subject to the study were included in the study. The patients were evaluated in three groups in terms of surgical technique. In the first group, there were patients who were fixed with a titanium plate, in the second group, patients who were supported with the Robicsek technique and wired with steel wires, and in the third group, and patients who were fixed with a titanium plate and supported with the Robicsek technique. There were ten patients each in Group 1 and Group 2, and 14 patients in Group 3. Considering the total of the patients, 26 of 34 patients were male and eight were female. The mean age of the patients was 63.44 years. Mean serum creatinine values were 0.88 mg/dL and mean EF values were 50.7%. Twenty-four patients had a diagnosis of DM and 16 patients had a diagnosis of COPD. Twenty-four patients were active smokers. No statistically significant difference was found between the groups, when the demographic characteristics of the patients and possible risk factors for sternal dehiscence were examined. Table 1, it was seen that there was no statistically significant difference between the groups, when the distribution of previous heart operations to the groups was examined, as shown in Table 2.

It was seen that one patient (10%) in Group 1 and four patients (28.5%) in Group 3 died, when the treatment groups were examined in terms of mortality There was no statistically significant difference in mortality between the groups ($p>0.05$). When the infection rates in the post-reoperation

**Table 1.** Baseline characteristics

| | Group I (TitaniumPlate, n=10) | Group II (Robicsek, n=10) | Group III (TitaniumPlate+ Robicsek, n=14) | p |
|---|---|---|---|---|
| Male gender, n (%) | 8 (80%) | 8 (80%) | 10 (71.4%) | 0.86 |
| Age, mean±SD | 60.80±7.52 | 62.60±8.10 | 65.93±9.20 | 0.33 |
| DM, n (%) | 5 (50%) | 9 (90%) | 10 (71.4%) | 0.14 |
| COPD, n (%) | 5 (50%) | 3 (30%) | 8 (57.1%) | 0.41 |
| Smoker, n (%) | 9 (90%) | 7 (70%) | 8 (57.1%) | 0.21 |
| Creatinine (mg/dL), median (min–max) | 0.84 (0.70–1.02) | 0.86 (0.80–1.05) | 0.94 (0.73–1.14) | 0.46 |
| LVEF, median (min–max) | 50.0 (50.0–60.0) | 52.50 (43.75–60.0) | 50.0 (47.5–60.0) | 0.98 |
| EF>%40, n (%) | 9 (90%) | 8 (80%) | 11 (78.6) | 0.75 |

DM: Diabetes mellitus; COPD: Chronic obstructive pulmonary disease; LVEF: Left ventricular ejection fraction; EF: Ejection fraction; SD: Standard deviation.

**Table 2.** Initial surgical procedures

| | Group I (TitaniumPlate, n=10) | Group II (Robicsek, n=10) | Group III (TitaniumPlate + Robicsek, n=14) | p |
|---|---|---|---|---|
| CABG, n (%) | 9 (90%) | 8 (80%) | 12 (85.7%) | 0.81 |
| CABG-LIMA harvesting, n (%) | 6 (60%) | 8 (80%) | 10 (71.4%) | 0.61 |
| MVR, n (%) | - | 1 (10%) | - | - |
| Aorticsurgery, n (%) | - | 1 (10%) | 2 (14.3%) | 0.47 |
| pulmonaryendarterectomy, n (%) | 1 (10%) | 0 (30%) | - | - |

CAGB: Coronary artery bypass grafting; LIMA: Left ınternal mammarian artery.

period due to sternal detachment were examined, 20% and 21.4% infected patients were detected in Group 1 and Group 3, respectively; 70% of the patients in Group 2, who were repaired with Robicsek only, were diagnosed with post-operative infection ($p<0.05$). Despite the significant difference between the infection rates, no significant difference was found between the groups when the duration of hospitalization was evaluated ($p>0.05$), as shown in Table 3.

## Discussion

As a result of the data, we obtained in this study, it was determined that the Robicsek method is superior to the sternal wire closure method in terms of post-operative infection. However, it was observed that this superiority did not make any difference in terms of post-operative mortality and hospital stay.

In the retrospective study published by Vos et al., patients without mediastinitis and patients with mediastinitis who completed their antibiotherapy (culture results were negative) were included in the study. In our study, titanium plate application seemed superior in terms of infections that developed after sternal reoperation, but no significant difference was found in their study in terms of post-operative infection. Unlike our study, in the study, in which the criterion of sternal stability (immobility of the sternal halves with press during discharge) was evaluated. No significant difference was found between the two techniques in the group without mediastinitis. In patients who underwent sternal reoperation after mediastinitis treatment, 22.2% sternal stability was achieved in the classical wire cerclage group, while 100% sternal stability was reported in the titanium plate group ($p<0.05$). Contrary to this publication, which states that the titanium plate and classical wire cerclage method are not superior to each other in patients who are free from mediastinal infection, the titanium plate group seems to have superior results in terms of post-operative infections in our study.[7]

There are two randomized controlled studies published by Raman et al., and Allen et al., which included sternal primary closure procedures in contrast to the patients with detachment in our study, comparing titanium plate fixation systems and classical wire cerclage method. Patients at risk for sternal detachment were included in the study of Raman et al., sternal reunion detected by Computed Tomography (CT) at the end of the 6th month was 70% in the rigid titanium plate fixation group, while it was 24% in the classical wire cerclage group ($p<0.05$). There was no significant difference between the two groups in terms of complication (reoperation requirement due to sternal detachment) rates.[8] In the study of Allen et al., according to the CT results taken at the 3rd and 6th months, the titanium plate group had superior results in terms of both sternal healing and sternal reunion. Reoperations for sternal complications were reported as 0% in the titanium plate group and 5% in the classical wire cerclage group ($p<0.05$). Although sternal healing could not be evaluated with CT due to the retrospective nature of our study, the low rates of postoperative infection (mediastinitis) suggest that sternal healing is better in titanium plate group.[9]

In a study on cadavers by Fawzy et al., the intrathoracic pressure required to cause sternal dehiscence was calculated. By supporting the classical wire cerclage method with a titanium plate placed transversely at the 6th rib level, the intrathoracic pressure required for sternal dehiscence increases significantly. Closing the sternum with four titanium plates instead of supporting the classical wire cerclage method with a plate again significantly increases the pressure required for dehiscence.[10]

A study of 249 patients who underwent thymoma excision with transverse sternal incision and/or thymectomy compared patients with titanium plate or steel wire fixation for sternal healing. Patients in the titanium plate group compared with the steel wire group started out-of-bed activities earlier. The sternal healing rate in the titanium plate group was significantly higher than the steel wire group in long-term results.[11]

In many studies in the literature, it is seen that the titanium plate method provides superior sternal stabilization compared to the classical wire cerclage method. However, the classical closure method is still preferable in terms of cost-effectiveness. It is more reasonable to apply preventive measures in patients with a high risk of sternal dehiscence, instead of applying cost-increasing practices to all patients. Nooh et al. worked on a scale to determine the risk group

**Table 3.** Outcomes

| | Group I (TitaniumPlate, n=10) | Group II (Robicsek, n=10) | Group III (TitaniumPlate+ Robicsek, n=14) | p |
|---|---|---|---|---|
| Infection, n (%) | 2 (20%) | 7 (70%) | 3 (21.4%) | 0.02 |
| Lenght of stay (days), mean±SD | 6.30±5.89 | 7.50±4.55 | 8.14±7.99 | 0.79 |
| Mortality, n (%) | 1 (10%) | - | 4 (28.5%) | 0.13 |

for sternal detachment. It would be wise to direct health resources correctly with similar risk scoring and to use protective equipment to prevent high costs caused by complications in patients in need.[12]

## Conclusion

Titanium plates are used in many surgical fields today.[13] As in our patient series, possible new complications and new interventions can be prevented with titanium plate method in patients with sternal detachment. However which method to use for sternum detachment should be individually evaluated for each patient.

### Disclosures

**Ethics Committee Approval:** Study approval was obtained from the Instituion Scientific Committee (November 12, 2021/E-28001928-604.01.01).

**Peer-review:** Externally peer-reviewed.

**Conflict of Interest:** None declared.

**Authorship Contributions:** Concept – O.M.B.; Design – Y.O., S.O.; Supervision – H.K., U.K.; Materials – Y.O., U.K.; Data collection &/or processing – Y.O., O.M.B.; Analysis and/or interpretation – Y.O., Se.O., S.O.; Literature search – Y.O., S.O., H.K.; Writing – Y.O., Se.O., S.O.; Critical review – Y.O., H.K.

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