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Longitudinal plate fixation technique after gross resection of the sternum or multiple sternal fracture

Sternumun gross rezeksiyonu veya multipl kırıklarından sonra longitudinal plak fiksasyon tekniği

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In this article, we described an alternative way for complicated sternal closure by using a longitudinal plate fixation technique. A retrospective analysis between January 2008 and September 2011 was performed on patients who received primary longitudinal rigid plate fixation after sternotomy. Seven patients (3 males, 4 females; mean age 64.4±14.3 years; range 30 to 74 years) with multiple sternal fractures or near-total loss after sternal debridement were defined as having high-risk for sternal dehiscence. We performed 10 longitudinally sternal plate refixation in these patients with sternal nonunion. Two patients (29%) had near-total sternal loss, while five patients (71%) had multiple sternal fractures. The patients suffering from sternal instability were operated using the titanium plates and steel wires for the anterior chest wall. Postoperative chest pain disappeared in all patients with only minor discomfort in the long-term. Longitudinal sternal plating and steel wires are an effective option for the treatment in patients with near-total sternal loss and multiple sternal fractures. This technique which is easy to use seems to be associated with fewer complications.

Key words: Dehiscence; fixation; plate; sternum.

Bu yazıda komplike sternal kapamalarda alternatif bir yol olarak longitudinal plak fiksasyonu tekniği kullanımı tanımlandı. Ocak 2008 - Eylül 2011 tarihleri arasında sternotomi sonrası longitudinal rijit plak fiksasyonu yapılan hastalar retrospektif olarak değerlendirildi. Sternum debridmanı sonrası tama yakın sternal kaybı olan ya da çoklu sternal kırığı bulunan yedi hasta (3 erkek, 4 kadın; ort. yaş 64.42 yıl; dağılım 30-74 yıl) sternal ayrılma için yüksek riskli olarak tanımlandı. Sternal kaynamaması olan bu hastalarda 10 kez tekrar longitudinal plak fiksasyonu uygulandı. Hastaların ikisinde (%29) tama yakın sternal kayıp, beşinde (%71) ise çoklu sternal kırık vardı. Sternal instabilitesi olan bu hastalar ön göğüs duvarında titanyum plaklar ve çelik teller kullanılarak ameliyat edildi. Uzun dönemde çok az rahatsızlık hissinin dışında, bütün hastalarda ameliyat sonrası göğüs ağrısı kayboldu. Tama yakın sternal kayıp olgularında ve çoklu sternal kırıklarda, longitudinal sternal plak ve çelik tellerin kullanımı efektif bir seçenektir. Kullanımı kolay olan bu teknik, daha az komplikasyonla da ilişkilidir.

Anahtar sözcükler: Ayrılma; fiksasyon; plak; sternum.

Sternal dehiscence is a rare but serious complication associated with median sternotomies. In cases of poor bone quality, multiple transverse sternal fractures, or near-total sternal loss after debridement resulting in instability, steel wires often fail to prevent excessive motion.[1] To treat such patients, the principles related to a transverse rigid plate or muscle flap have been recommended by several authors for sternal refixation.[2]

The aim of this retrospective study was to evaluate the initial experience of the longitudinal plate-fixation technique following multiple sternal fractures or near-total sternal loss after debridement.

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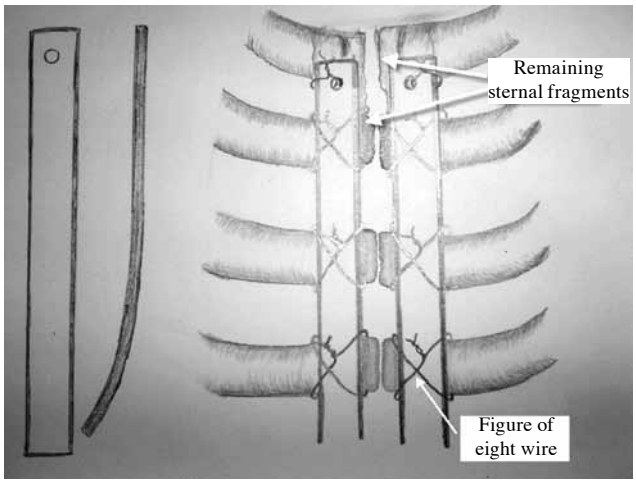

Figure 1. A plate used for the patients who had near total sternal loss. The plates were wired with figure-of-eight sutures to the medial aspects of the ribs and remaining sternum *(Patient no 1).*

In this study conducted between January 2008 and September 2011, 10 operations were performed on seven patients (3 males, 4 females; mean age 64.4±14.3 years; range 30 to 74 years) with multiple sternal fractures (more than 5 fragments) or near-total sternal loss after debridement using the longitudinal sternal plate-fixation technique. The clinical diagnosis of sternal non-union was confirmed by a thoracic computed tomographic (CT) scan. All patients had gross instability at the time of plating and had cultures taken from the wound at the time of surgery. The preoperative and intraoperative cultures of the patients showed no growth. The decision to proceed with plating was made based on clinical assessment of the sternum. All patients in the study were followed up in the hospital, with careful attention being given to possible complications that might arise, and this type of follow-up continued for two months after discharge.

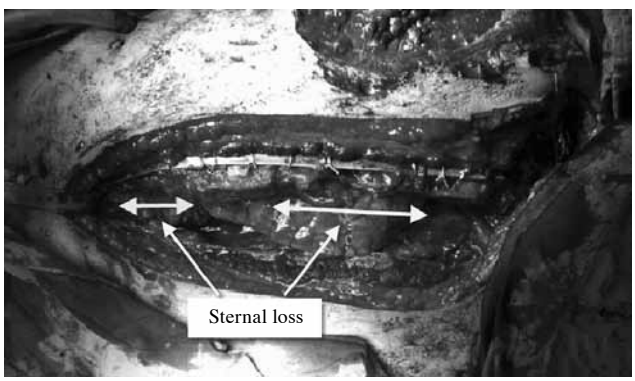

Figure 2. A plate fixed to the medial sides of the ribs and manubrium in a patient with a unilateral sternal loss *(Patient no 2).*

Technique

The major pectoral muscle was elevated bilaterally from the insertion along the medial aspects of the ribs to the mid-clavicle line until it was sufficiently mobile for longitudinal plate placement and for later approximation. After the sternal debridement, a very large but inevitable defect with a few sternal fragments in the sternal area was detected in two patients. Titanium plates were then fixed on the medial parts of the ribs, and the area of the remaining sternal fragments was closed with figure-of-eight wire sutures (Figures 1 and 2).

On the other hand, multiple sternal fracture (more than 5 fragments) and minimal sternal loss were observed in the other five patients. In these cases, a longitudinal plate was fixed to the sternal fragments (>2 cm) by also using figure-of-eight wire sutures (Figure 2).

After these procedures, the left and right side of the remaining medial part of the ribs and remaining sternal fragments were approximated by using surgical steel wires, and five or six figure-of-eight wire sutures were placed in very close proximity (Figure 3).

Patients were followed up clinically, and their sternal wounds were assessed both during their hospital stay and in the outpatient follow-up setting by the cardiac surgical team. The criteria for discharge and routine follow-up care did not vary. Successful sternal closure was defined by a physical exam devoid of instability, pain, and complications in wound healing. In addition, radiographs showing the unchanged location of hardware for a minimum of eight weeks were required.

The primary characteristics of the patients along with their comorbid factors are shown in Table 1. Chronic obstructive pulmonary disease (COPD)

Figure 3. A view of the sternum of a patient with a near-total sternal loss after plate fixation *(Patient no 1).*

Table 1. Clinical characteristics of patients

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Patient 7	%
Age (years)	69	30	74	72	68	65	73	64.42*
Gender	Female	Male	Male	Male	Female	Female	Female	
Morbid obesity (BMI >30)	+	–	+	+	–	+	–	57.1
Chronic obstructive pulmonary disease	+	–	+	+	+	–	+	71.4
Diabetes mellitus	+	–	+	–	+	+	–	57.1
Osteporosis	+	–	–	–	+	+	+	57.1
Unsuccessful conventional Sternal re-fixation	+	–	+	–	–	+	–	42.8
Paramedian sternotomy	–	+	–	–	–	–	–	14.2
Intraoperative sternum								
Nearly complete sternal loss (bilaterally)	+	–	–	–	–	–	–	14.2
Nearly complete sternal loss (unilaterally)	–	+	–	–	–	–	–	14.2
Multiple sternal fracture bilaterally)	–	–	–	–	+	+	–	28.5
Multiple sternal fracture (unilaterally)	–	–	+	+	–	–	+	42.8

* Mean.

was the most common preoperative risk factor. Two patients (Nos. 3 and 6) had undergone two previous unsuccessful attempts of conventional sternal wire fixation, and one patient (No. 1) had undergone three unsuccessful attempts using the same procedure.

A prior sternotomy with sternal wire placement had been performed on all of the patients because of coronary artery bypass grafting (CABG, n=4), mitral valve replacement (MVR, n=1), CABG (n=1), and aortic valve replacement (AVR, n=1). In one post-traumatic patient (No. 2), a paramedian sternotomy had been urgently performed; thus, we used the plate-fixation technique for this particular patient (Figure 2). The initial heart operation had been performed on the patients between eight and 67 days (median, 22 days) prior to the sternal plate reconstruction.

The mean operation time was 103±21 minutes. Seven patients could be extubated within the first four postoperative hours. The longest intubation time was 20 hours in a patient with congestive heart failure. In the postoperative period, there were no wound complications.

The median length of postoperative ICU stay was one day, with a range from one to two days. The median time from operation to hospital discharge was seven days, (with a range from two to 15 days and a mean of 8.2±1.7 days).

Postoperative chest pain disappeared in all of the patients, with some having only minor discomfort in the long-term. The postoperative controls with a median follow-up time of 250 days revealed thoracic stability in all patients. There was one death (No. 2) that was unrelated to the sternal closure. The patient had multivisceral failure two weeks postoperatively that was caused by a bomb explosion which resulted in multiple trauma and multiorgan failure. The other six patients have now completed a one-year follow-up, and no complications related to the plate have occurred.

In conclusion, the parasternal Robicsek weave is still the standard technique used for sternal rewiring in many centers.[3] As a supplement to the sternal wires, longitudinal plates have been used to fix the sternum together with circumferential wire.[4-6] Another technique that has been employed is the use of X-shaped and box-shaped plates placed over the sternum with two figures-of-eight wires in position around the manubrium and the xiphisternal junction.[6] We performed "re-sternal" repair in three of our patients (patients no 1, 3 and 6). If the patient only had sternal wires that were breaking off or had a partial sternal fracture, the Robiscek procedure was applied as a standard treatment. When these patients presented with sternal detachment again, the longitudinal plate-fixation technique was used during the reoperation after the debridement, which showed a nearly complete sternal loss bilaterally (No. 1), unilateral multiple sternal fracture (No. 3), and bilateral multiple sternal fracture (No. 6).

Large sternal defects associated with partial and total sternotomy have also been covered using the omentum, rectus muscle, and latissimus muscle flap.[7-10] Muscle flaps can be used alone or in combination with sternal rewiring. If complete resection of the sternum is required, reconstruction can become problematic as muscle flaps may not prevent paradoxical chest wall movement, and thoracic instability may occur necessitating prolonged ventilatory support, which increases the risk of complications such as pneumonia, thrombosis, and muscle weakening. Many studies have shown the superiority of rigid plate fixation over wire circulation for aggressive resection of the sternum.[11-13] The technique that we utilized has none of these complications, and thoracic stability was achieved in all of our patients.

Transverse and longitudinal sternal plates can be used for treatment of sternal loss in cases in which little residual sternum is left for fixation. The use of transverse plate stabilization is achieved on the anterior surface of the ribs, and more dissection is necessary than when using the longitudinal plate-fixation technique. In addition, this large dissection can increase the risk of seroma development. Cicilioni et al.[14] reported a higher rate of seroma formation in five patients (10%) in their series of 50 consecutive sternal wound reconstructions using transverse plate fixation. Moreover, in cases of transverse plate fracture, plate excision was needed due to the chronic pain that was reported.[15,16] In contrast, none of these complications were observed in our patients.

A delay in unscrewing and removing the plates could be potentially catastrophic when emergency re-entry into the chest is warranted in intensive care unit (ICU) settings. With the technique that was used in our patients, emergency re-entry was accomplished with the same ease as in conventional sternotomies by cutting the wires immediately after approximating the plates.

Drilling holes in the rib may actually cause fractures. Furthermore, drilling too deep or using screws that are too long can increase the risk of pneumothorax. Also, bicortically placed screws may lead to the potential risk of graft damage due to the tip of the screw being located in the region of the underlying bypasses.[12,13,17,18] We fixed the plates to the ribs or sternum fragments with figure-of-eight wires because we believe that this technique leads to less damage to the ribs and sternum, and it provides more stability.

In patients undergoing a very large sternum resection, the plates can be placed over the medial part of the ribs by using figure-of-eight wire sutures, and plate stability can be achieved without screws. We think that the longitudinal plate-fixation system is a better technique than the transverse plate technique for the treatment of multiple sternal fractures and for use after gross sternal debridement. This technique is safe, effective, easily reproducible, and economical. However, long-term follow-up in more patients is needed to evaluate any risks that may be associated with this procedure.

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