



Z-plasty as an alternative choice for the treatment of recurrent local sternal wound infections

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Abstract

Objective Sternal wound infections after sternotomy are associated with high morbidity, high mortality, and prolonged hospital stay. The recurrence rate of sternal wound infections after single-stage closure is greater than expected. The aim of the study is to present our results of a consecutive series of Z-plasty for the treatment of recurrent sternal wound infections.

Methods Between March 2015 and March 2017, a total of 9 patients were referred to our clinic with a recurrent sternal wound infection due to sternotomy with or without osteomyelitis. All patients previously underwent one or more surgical procedures for sternal infection. Negative pressure wound therapy and several debridement methods were performed before reconstruction. Two triangular double-transposition fasciocutaneous flap techniques as Z-plasty under local anesthesia was performed for all of the patients.

Results The flaps survived completely without any tissue loss. There were no major postoperative complications. One patient had recurrent infection after the flap procedure and was treated with antibiotic therapy. At 6 months of follow-up, all of the patients were able to return to normal activities of daily living with a high patient satisfaction rate.

Conclusions Local sternal wound reconstruction is an effective, rapid, and simple with Z-plasty associated with low recurrence risk. We believe that Z-plasty can be used for recurrent local sternal wound infections as an alternative treatment option for selected patients without mechanical dehiscence.

Keywords Z-plasty · Sternal wound infection · Sternotomy · Fasciocutaneous flap

Introduction

Median sternotomy incision is widely used in standard cardiac surgery. Sternal wound infections (SWI) remain as a complication for patients undergoing median sternotomy, in spite of advanced surgical techniques and adequate antibiotic prophylaxis. SWI has been reported ranging from 1 to 10% [1, 2]. In addition, failure rates after the treatment of SWIs have been reported between 5.1 and 39% in the literature [3–5]. SWIs are serious complications of cardiac surgeries

with high morbidity and mortality rates and prolonged hospital stay. SWIs, deep or superficial, must be treated aggressively at the time of diagnosis. The management approach often requires antibiotherapy, extensive debridement with negative pressure wound therapy (NPWT) system, and sternal wound closure with or without flap reconstruction [6, 7]. Various kinds of reconstructive options such as myocutaneous and omental flaps can be used to cover the sternal wounds with high success rates [7]. Although these procedures have a good outcome, fasciocutaneous flaps is used to be an alternative treatment option for SWIs [8, 9].

Z-plasty is used not only to provide functionality of contracted scars, but also to improve the appearance of the patient's face or other body parts in plastic surgery practice [10]. Z-plasty is a simple and effective method and, therefore, a number of design of Z-plasty have been used by various surgical specialties, including general surgery (for sinus plonidalis treatment), oromaxillofacial surgery (for cleft palate repair), and neurosurgery (for myelomeningoceles treatment) [11]. The fundamental unit of Z-plasty is a triangular

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double-transposition fasciocutaneous flap based on geometric principles [10–12]. This technique allows a wound or scar to change both in the length and direction. Although various angles can be used for basic Z-plasty, 60° is the most common angle to achieve accurate lengthening [13].

In this study, we present our results of a consecutive series of Z-plasty for the treatment of recurrent local SWIs.

Patients and methods

This retrospective study was carried out at Karabük Training and Research Hospital between March 2015 and March 2017. A total of 38 patients were referred to our clinic with an SWI due to sternotomy with or without osteomyelitis. This study included patients who underwent primary sternal saturation at least once due to local SWI and sternal reconstruction with Z-plasty technique due to recurrent sternal infection. Patients presenting with SWI for the first time who did not undergo primary saturation, patients who underwent sternal reconstruction using the flap procedure for sternal wound infection, patients with a sternal infection wound through the whole sternum, and those with severe mechanical dehiscence in the sternal region were excluded from the study.

A total of 9 patients were included this retrospective study. All patients previously underwent one or more surgical procedures for sternal infection (Table 1). Cardiac operations were performed in an external center in 8 patients. Demographic and clinical characteristics of the patients were recorded. A written informed consent was obtained from each patient. The study protocol was approved by the Ethics Committee of the Karabük University (Date: 29.03.2017; No. 3/16). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Preoperative preparation

At least one debridement (range 1–6) was performed for all patients before definitive closure of the sternum. Bone scintigraphy was performed for all patients to evaluate sternal osteomyelitis (Fig. 1a). Microbiological samples were taken from the debrided area and cultured in each debridement of the wound. Second-generation cephalosporin was initially started and, then, an appropriate antibiotic therapy was instituted according to the results of the antibiogram. The NPWT system was used in all patients. Final closure with Z-plasty was performed, when bacterial culture taken from the sternal wound yielded negative results.

Surgical procedure

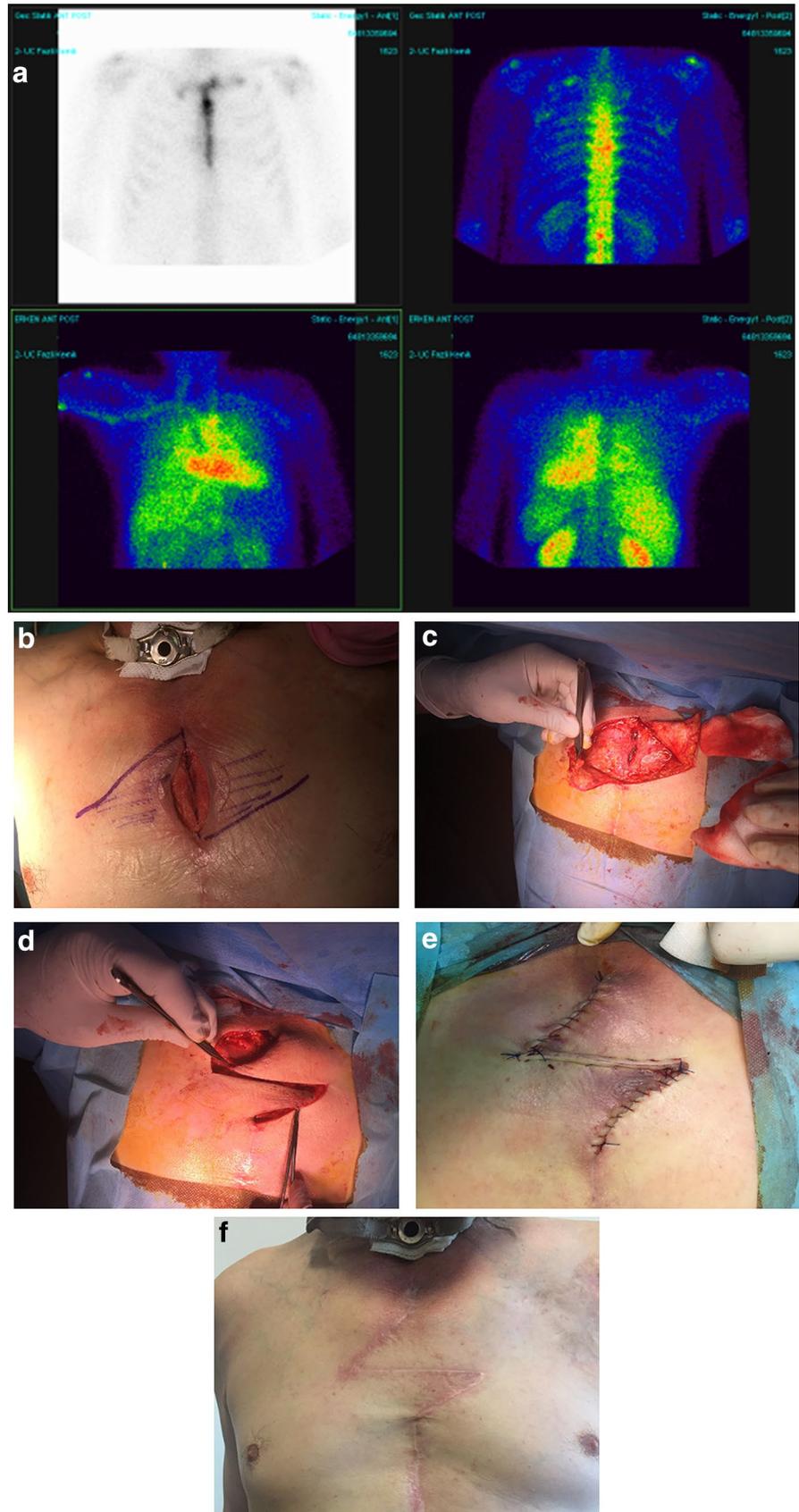
In the first step, the length of the wound was measured and the central vertical line of the wound was drawn with a marking pen. In addition, two lateral limbs were drawn at 60° angles from the end of the central line. The length of the lateral limb should be exactly twofold the length of the central vertical line (Fig. 1b). The operation area was cleaned with 10% povidone-iodine solution (Batticon, Samsun, Turkey). The operation was performed under local anesthesia. Two full-thickness triangular fasciocutaneous flaps of equal size and shape were elevated at the level of subcutaneous fat (Fig. 1c). Hemostasis was applied to the base of the flaps and donor site. The two flaps were rotated around each other and the direction of the original wound surface was converted (Fig. 1d). The tips of the flaps were held in place according to their respective opposite corners with a few anchoring sutures and the flaps were sutured around each other and to the sternocostal periosteum (Fig. 1e). Hence, the risk for seroma development was reduced by minimizing the dead spaces. No suture was applied to the base of the flap to preserve the circulation.

Table 1 List of patients submitted to post-sternotomy resuturing

Patient	Age	Gender	Sternal wound type	Prior cardiac operation	Number of prior resuturing	Length of sternal wound (cm)
1	73	M	DSWI	CABG	Two	12.4
2	69	F	SSWI	CABG	One	10.3
3	80	M	SSWI	CABG	One	11.3
4	76	F	SSWI	CABG	One	9.5
5	62	M	SSWI	SAAR + CABG	One	11.4
6	56	M	DSWI	CABG	One	12.9
7	66	M	DSWI	CABG	Two	10.8
8	51	M	DSWI	CABG	Three	12.1
9	58	M	SSWI	CABG	One	13.0

M male, *F* female, *DSWI* deep sternal wound infection, *SSWI* superficial sternal wound infection, *CABG* coronary artery bypass grafting, *SAAR* supracoronary ascending aorta replacement

Fig. 1 Recurrent wound infection treated with Z-plasty. **a** Focal elevated activity involvement relevant with sternal osteomyelitis at the upper end of the sternum corpus in the late static phase of the patient's bone scintigraphy. **b** Central vertical line and two lateral limb was drawn at 60° angles according to central line with a marking pen. **c** Two full-thickness triangular fasciocutaneous flaps in an equal size and shape were elevated at the level of subcutaneous fat. **d** The two flaps were rotated around each other and the direction of the original wound surface was converted. **e** Transposed flaps were sutured primarily. **f** Healed sternal wound at postoperative sixth months



Postoperative evaluation

Antibiotic treatment was given with adequate antibiotic in the postoperative period for 6 weeks according to the suggestion of the Department of Infectious Disease. The patients were examined for signs of infection and donor site-related complications such as flap necrosis and hematoma. The duration of hospital stay was also recorded.

Statistical analysis

All statistical analyses were performed using the SPSS (SPSS for Windows 15.0, Inc, Chicago, IL, USA) statistics software. Continuous variables were expressed as mean values \pm standard deviation. Categorical variables were expressed as numbers and percentage.

Results

Of 9 patients, seven were male and two were female with a mean age of 65.7 ± 9.7 (range 51–80) years. The mean body mass index (BMI) was 29.1 ± 2.5 (range 25.6–33.6) kg/m^2 . In all patients, the sternal wound developed after a median sternotomy procedure during coronary artery bypass grafting (CABG) and was referred to as Type II according to the Anger's classification of SWI [14]. Five patients had superficial SWI and four patients had deep SWI (Table 1). Focal sternal osteomyelitis, according to the result of bone scintigraphy, was considered as deep SWI (Fig. 1a). The most common pathogenic agent found among these nine patients was coagulase-negative staphylococci (4/9). *Staphylococcus aureus* was found in two patients. Bacterial isolation was not determined in the remaining cases (3/9).

The most common comorbidity was diabetes mellitus ($n=6$, 66.7%), followed by hypertension ($n=5$, 55.6%) and chronic obstructive pulmonary disease ($n=3$, 33.3%). Among the patients, two (22.2%) were smokers. One patient had also a history of total laryngectomy due to laryngeal cancer.

The main debridement number was 2.4 ± 1.7 (range 1–6). After debridement, preoperative mean defect size in the surface was 28.1 ± 3.9 (range 23.9–34.3) cm^2 and mean length of the wound was 11.5 ± 1.2 (range 9.5–13) cm. The mean duration of operation was 19.9 ± 3.9 (range 16–29) min.

SWI recurrence after flap treatment due to coagulase-negative staphylococcus was observed in only one patient, a 56 years old male, and the patient was treated with antibiotic therapy. At 6 months of follow-up, all of the patients were able to return to normal activities of daily living with a high patient satisfaction rate (Fig. 1f). No partial or total flap necrosis, wound dehiscence, or fistulas were observed in any of the patients. The mean total hospital stay was

18.4 ± 5.6 days (range 13–30). All patients were discharged on postoperative day 7 with healed sternum. The mean follow-up was 14.3 ± 4.2 months (range 8–21).

Discussion

In the present study, we evaluated the results of a consecutive series of Z-plasty for the treatment of recurrent local SWIs. Our study results showed that Z-plasty was a good treatment of choice for recurrent local sternal wall defects. We treated all patients with the fasciocutaneous flap strategy and observed no complication in any of the patients.

In the literature, several classifications have been suggested for SWIs to propose the best treatment algorithm for surgeons [3, 14–17]. In 1984, Pairolero and Arnold described the first classification according to the time of onset of the SWI [15]. Later on, some authors modified this classification by adding criteria such as risk factors, anatomical location, and infection status [3, 14, 16, 17]. Although Oakley and Wright used the same criteria as Pairolero and Arnold's classification, they added to the classification risk factors of infection such as diabetes, obesity and usage of immunosuppressive agents [16]. Nonetheless, there is no clear distinction between sternal osteitis and mediastinitis. In 1997, Jones et al. [3] suggested a classification based on the depth of the wound and the condition of the sternal bone, but septicemia was used as a criterion for the existence of infection. Although Greig et al. [17] recommended a classification based on the affected anatomical site, especially the vertical position of the wound, it failed to categorize sternal or wound conditions, such as dehiscence and bone viability. The most recent classification was described by Anger et al. [14] in 2015, attributed to the anatomical region, including the deepness and location of the sternal wound. Using this classification, SWIs were divided into four main types, and each type was defined with two subgroups according to the vertical extent (partial or total) and vertical position (higher or lower) [14]. The lower edge of the pectoralis major muscle was defined as a determining point of the vertical position [14]. Pectoralis major muscle cannot cover 1/3 distal part of the sternum, so other alternative treatment approaches are required in this area [14]. We consider that Anger's classification is an easy method to classify the wound and it is more suitable for the choice of the treatment strategy for SWI. Therefore, we used the Anger's classification system in this study.

The NPWT technique can be used preoperatively as a bridge between debridement and final closure and to shorten the hospital stays [18, 19]. It also promotes a lower therapeutic failure rate and recurrent infection; consequently, the morbidity and mortality are diminished [5, 18, 19]. This technique is adopted in wound management to assist in the

drainage of necrotic tissues and effusions. In an experimental study, Morykwas et al. showed that intermittent sub-atmospheric negative pressure therapy increased local blood perfusion in the wound by four folds and granulation tissue formation by two folds, compared to continuous therapy [20]. It was also found that bacterial counts and edema were mitigated in the wound in the same study [20]. In our study, the NPWT technique with intermittent sub-atmospheric negative pressure was used in all patients, as it not only achieves ameliorated wound surface, but also acts as a bridge to a fasciocutaneous flap.

The current standard treatment of SWI is debridement and immediate closure with flap procedures [7, 21, 22]. Myocutaneous, omental, and fasciocutaneous flaps are usually used for reconstruction to SWI [4, 6–9, 21, 22]. The pectoralis major, rectus abdominis, and latissimus dorsi muscles can be used as a myocutaneous flap for sternal reconstruction [21, 22]. The pectoralis major muscle flap is most commonly used for chest reconstructive surgery, as it can provide sternal stability in case of dehiscence and close the defect without tension [21]. If the sternal wound is localized in the lower part of the sternum, usage of this flap is not suitable for sternal reconstruction due to insufficient coverage of the wound. In addition, reduced power and mobility of the shoulder and arm, especially of the right arm, were observed in one-third of patients in the long-term period [23]. At the present time, the rectus abdominis muscle is not considered as a first option flap for sternal reconstruction. Although this flap provides abundant volume to cover the sternal defect, it can cause ventral hernia formation with worse postoperative lung functions [7]. Although harvesting of the M. latissimus dorsi flap does not affect collateral circulation to the sternum, there are some disadvantages such as possible complications at the donor site, need to change the patient's position during surgery, and coverage of the upper two-thirds of the sternal defects [7]. Another good alternative flap for sternal infection is omental transposition which has a well-developed vascular and lymphatic network, covering every dimension of a sternal defect [7, 24]. Although the omental flap has good properties, some complications have been reported, such as the potential for spread of infection to the abdominal cavity and the risk for abdominal hernia formation and bowel obstruction [7, 24]. These procedures have often good outcomes, but they have a high risk of donor-site morbidity, reduced activity of muscles, and prolonged operation times in accordance with the surgery type. Therefore, various fasciocutaneous flap methods were developed by some authors [8, 9, 25]. Second intercostal internal mammary artery perforator fasciocutaneous flap, pectoralis major fasciocutaneous flap, and superior epigastric artery perforator flap were used for treatment of SWI with good outcome [8, 9, 25]. The usage of musculocutaneous or fasciocutaneous flaps in SWI is controversial. In an experimental study,

it was shown that myocutaneous flaps were more effective in reducing the number of bacteria in the wound compared to skin grafts [26]. On the other hand, early increased skin oxygen tension has been found to a larger degree in fasciocutaneous flaps [26]. In our study, we treated 9 cases of recurrent sternal wound infection with Z-plasty technique using a fasciocutaneous transposition flap. Recurrent infection was observed in a heavy smoker patient and the patient was treated with antibiotic therapy. Wound healing might have been disrupted by smoking in this patient. The mean defect size was 28.1 ± 3.9 (range 23.9–34.3) cm² and mean length of the wound was 11.5 ± 1.2 (range 9.5–13) cm. Sternal dead space was relatively small in the study population (mean 28.1 ± 3.9 cm²). Therefore, sternal cavity was successfully covered with fasciocutaneous flap surface.

The 60° Z-plasty was used for the treatment because this angle can allow the surgeon to easily rotate flaps and lower skin tension in the sternum. We did not observe any major complication after reconstruction (mean follow-up, 14.3 ± 4.2 months). We believe that the reason of these good results depends on adequate sternal debridement, wound conditioning with NPWT before coverage, sufficient perioperative antibiotic treatment, and good planning of the flap preparation.

Z-plasty technique for sternal wound treatment has several advantages. First, using this technique, the sternal surface and dead space are covered with clean subcutaneous tissues. This is the main advantage of Z-plasty technique for localized sternal osteomyelitis patients. Second, all raw surfaces face at least one clean new raw surface. In this way, the wound healing process is healthier. Third, Z-plasty technique can be used in all locations of the sternum with low donor site morbidity. Fourth, this technique does not affect the functions of the arm, shoulder and respiratory muscles. Finally, it can be performed with local anesthesia. The main disadvantage of this technique, however, is that it cannot be used for large sternal defects, as this flap is unable to fill the large dead spaces.

Nonetheless, there are some limitations to this study. The major limitation is its retrospective design with a small sample size. However, SWI is a serious complication of sternotomy and this technique can be used only for selected patients such as those with local sternal wound infections. Another limitation is that this surgical technique cannot be used for severe mechanical dehiscences of the sternotomy. Therefore, the success of this technique cannot be predicted for such cases.

In conclusion, local sternal wound reconstruction is effective, rapid, and simple with Z-plasty and associated with low recurrence risk. Although myocutaneous flaps would be a good option in case of relapses, this methods should be used as the last option for treatment due to muscle disability risk. We believe that Z-plasty can be used for recurrent local

SWIs as an alternative treatment option for selected patients without mechanical dehiscence.

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