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Comparison of three different sternal closure techniques after cardiac surgery in elderly patients

Yaşlı hastalarda kardiyak cerrahisi sonrası üç farklı sternum kapatma tekniğinin karşılaştırılması

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Abstract

Aim: To identify the effectivity of stainless steel wires (SSW), Robicsek technique (RT) and thermoreactive nitinol clips (TNC) for sternal closure in elderly patients.

Methods: We conducted a prospective randomized study to compare SSW, RT and TNC in the sternal closure between January 2015 and January 2017. Patients over 60 years old who required sternal closure following cardiac surgery were enrolled into the study. Preoperative characteristics, operative parameters and EuroSCORE were recorded for each patient. In postoperative period, duration of intensive care unit stay and hospitalization, complications and mortality rates were analyzed. All patients evaluated according to the Visual analogue scale score (VAS) on 1st, 3rd and 5th day after the operation.

Results: 96 patients (32 patients with SSW, 32 patients with RT and 32 patients with TNC) required sternal closure. Patients in which sternal closure was performed with TNC, achieved significantly shorter hospitalization period ($p=0.014$) and no any dehiscence ($p=0.014$). We achieved significantly better VAS scores in patients with TNC ($p<0.001$, $p<0.001$ and $p<0.001$, respectively). In multivariate regression analysis, superficial sternal wound infection (SSWI) and DSWI were the only predictive factors for sternal dehiscence ($p=0.029$ and $p=0.015$, respectively).

Conclusion: Our study showed that using TNC decreased the hospitalization duration, DSWI, sternal dehiscence development and postoperative pain intensity. SSWI and DSWI were found to be the only predictive factors for sternal dehiscence in multivariate regression analysis..

Keywords: Sternotomy, Sternal closure, Stainless steel wires, Nitinol clips, Robicsek technique

Öz

Amaç: Yaşlı hastalarda sternal kapanma için paslanmaz çelik tellerin (PÇT), Robicsek tekniğinin (RT) ve termoreaktif nitinol klipslerinin (TNK) etkinliğini saptamak.

Yöntemler: Ocak 2015 ile Ocak 2017 yılları arasındaki sternal kapamada PÇT, RT ve TNK'yi karşılaştırmak için prospektif randomize çalışma yaptık. Ameliyat öncesi veriler, operasyon parametreleri ve EuroSCORE değerleri her hasta için kaydedildi. Ameliyat sonrası dönemde yoğun bakım ünitesinde kalış süresi, hastanede yatış günü, komplikasyonlar ve mortalite oranları analiz edildi. Tüm hastalara operasyondan 1., 3. ve 5. günden sonra vizuel analog skala (VAS) ile skorlama yapıldı.

Bulgular: Çalışma protokolü sırasında 96 hastaya (PÇT'li 32 hasta, RT'li 32 hasta ve TNK'li 32 hasta) sternal kapama uygulandı. TNK ile sternal kapatma yapılan hastalarda hastanede yatış süresi önemli ölçüde kısaydı ($p=0.014$). Sternum ayrılması PÇT uygulanan hastalardan altısında, RT uygulanan hastaların dördünde gelişirken, TNK ile sternal kapama yapılan hastalarda açılma gelişmedi ($p=0.014$). TNK'li hastalarda anlamlı olarak daha iyi VAS skorları elde edildi (sırasıyla $p<0.001$, $p<0.001$ ve $p<0.001$). Çok değişkenli regresyon analizinde derin sternal yara enfeksiyonu (DSYE) ve yüzeyel sternal yara enfeksiyonu (YSYE) sternal dehisens için tek prediktif faktör olarak saptandı (sırasıyla $p=0.029$ ve $p=0.015$).

Sonuç: Çalışmamız TNK'nin sternal kapanış sonrasında hastaneye yatma süresi, DSYE, sternal ayrılma gelişimi ve postoperatif ağrı stresini azalttığını göstermiştir. Çok değişkenli regresyon analizinde YSYE ve DSYE sternal ayrılma için tek prediktif faktör olarak bulunmuştur.

Anahtar kelimeler: Sternotomi, Sternal kapatma, Paslanmaz çelik tel, Nitinol klipsler, Robicsek tekniği

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Introduction

In cardiovascular operations, median sternotomy (MS) is one of the most preferred technique to access the heart, aorta and pulmonary vessels [1]. The MS ensures wide mediastinal view for cardiovascular surgeons and also provides shorter operation time. Moreover, patients experience less pain and faster recovery time in postoperative period [2]. However, besides its advantages, MS includes some potential complications like; sternal wound infections, mediastinitis and sternal dehiscence, especially in patients with obesity, chronic obstructive pulmonary disease and in elderly patients [3].

Previous reports have stated that sternal closure techniques have an important role in operation success and prevention of operative and postoperative complications after MS [4,5]. Recently, stainless steel wires (SSW) are accepted as standard method for closure of sternum with acceptable complication rates [6]. However, to achieve superior sternum resistance to tension, cardiovascular surgeons developed new techniques and fixation materials for sternum closure. Robicsek et al. [7] have stated that bilateral and longitudinal parasternal fixation with SSW is associated with lesser sternal dehiscence. On the other hand, Sarıkaya et al. [8] have demonstrated that thermoreactive nitinol clips (TNC) were safe and effective for sternal closure with shorter operation time and lower costs.

Although previous studies evaluated the role of SSW, Robicsek technique (RT) and TNC, there is no prospective study in the literature which compared the efficiency of three different sternal closure techniques in patients older than 60 years of age. In present study, we for the first time, aimed to identify the efficiency of SSW, RT and TNC in the sternal closure in elderly patients.

Materials and methods

After obtaining ethical approval from the Haseki Teaching and Research Hospital regional ethical committee with the study ID number 498, we conducted a prospective randomized study to compare SSW, RT and TNC in the sternal closure. Patients >60 years old who required sternal closure following cardiac surgery were enrolled into the study. The study was held between January 2015 and January 2017, and all operations were performed by a single experienced surgeon. The randomization was done by a computer based random number sequencing program and the surgeon was informed from the result of the randomization in the morning of surgery with a non-transparent envelope. Operations under emergency conditions, patient with a history of sternotomy, patients with a body mass index >40 and patients in which internal mammillary artery could not be used were excluded from the study. Also, patients which have a severe chronic obstructive pulmonary disease and a history of opioid use were excluded from the study. Written consent was obtained from patients and/or relatives one day before surgery.

In our clinic protocol, all patients were showered with 4% chlorhexidine scrub the evening before surgery. After general anesthesia induction, skin surface of operation area was shaved and skin was scrubbed with alcoholic iodine. Antibiotic prophylaxis was begun 30 minutes before the surgery and continued for at least 24 hours with 4x1 gr cefazolin sodium. At the end of the operation, sternum closure technique was performed according to the randomization result. In first group, sternal closure was done with six to eight stainless steel wires which pass through sternum (Figure 1a). In group 2, RT which can be defined as application of appropriate two circumferential wires on each side of the sternum (Figure 1b). In third group, an electrocautery and scalpel was used in presternal layers. After sufficient intercostal groove distance was obtained, sternum was measured for adequate clip size. Then, the cooled clips were applied around sternum in the previously created area. At the temperature of body, clips regained their original shape and strength (Figure 1c). After sternotomy closure, the deep fascia and skin was closed with 0 PDS and 3-0 monocryl intradermal sutures.

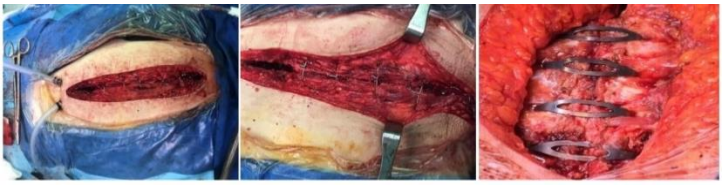

Figure 1: Sternal closure techniques; stainless steel wire (a: left), Robicsek technique (b: middle) and thermoreactive nitinol clips (c: right), respectively

EuroSCORE

European System for Cardiac Operative Risk Evaluation (EuroSCORE) is a relatively new nomogram which was developed in 1999 to assess the surgical risk of patients who have underwent cardiac surgery [9]. The scoring system aims to predict patient mortality in the first 30 days following cardiac surgery by using patient related factors including age, sex, presence of obstructive pulmonary disease, extracardiac arteriopathy, neurological dysfunction disease, previous cardiac surgery, serum creatinine level, presence of active endocarditis and presence of critical preoperative state. Also, EuroSCORE evaluates cardiac related factors including unstable angina, left ventricular dysfunction, presence of myocardial infarct, pulmonary hypertension and operation related factors such as operations in emergency conditions, procedures other than cardiopulmonary arterial bypass graft, surgery on thoracic aorta and post-infarct septal rupture.

Visual analogue scale (VAS) score

The VAS score is the assessment method for evaluating subjective pain intensity [10]. For evaluation of VAS pain score, usually 10 centimeter continuous scale with horizontal and vertical line is used. In this scale, score of zero means ‘no pain’, higher VAS scores show increment in pain intensity and score of 10 means ‘the worst imaginable pain’ or/and ‘pain as bad as it could be’.

Medical history of patients was obtained and detailed physical examination was performed for all patients. Preoperative characteristics and operative parameters were recorded. Also, EuroSCORE was calculated for each patient. In postoperative period, duration of intensive care unit stay, hospitalization duration, complications and mortality rates were analyzed. Mild sternal wound erythema without clinical symptoms was regarded as superficial sternal wound infection (SSWI). Purulent exudates discharge from wound, sternal osteomyelitis, lack of sternal stability with elevated inflammatory parameters was accepted as deep sternal wound

infection (DSWI). Also, presence of mediastinitis and sternal dehiscence were noted. Postoperative analgesia was managed with non-steroidal anti-inflammatory agents (twice a day routinely and extra dose given if patients require more analgesia and had a VAS score under six) and tramadol (dose given if patients had a VAS score above six). All patients VAS scores were noted in 1st, 3rd and 5th day after the operation. Preoperative, intraoperative and postoperative variables were compared between three groups according to sternal closure method, as mentioned above. Additionally, patients were compared according to the presence of sternal dehiscence.

Statistical analysis

The Statistical Package of Social Sciences for Windows (SPSS) version 20 was used for statistical analysis. We divided patients into three groups based on sternal closure method. Categorical variables were presented as numbers and percentages and compared with Chi Square test. Continuous variables were presented as means and standard deviations and compared with independent sample t test. Correlation analyses were evaluated using Pearson's correlation coefficient. Statistical significance was considered when two-tailed p value <0.05.

Results

During study protocol, 96 patients (32 patients with SSW, 32 patients with RT and 32 patients with TNC) underwent sternal closure. The gender distribution and mean age of patients between groups did not differ significantly (p=0.194 and p=0518, respectively). Diabetes mellitus and hypertension were the most common comorbidities in each group. The EuroSCORE was 3.6±0.9 in SSW group, 3.8±0.9 in RT group and 3.7±0.8 in TNC group (p=0.660). Preoperative characteristics of patients were summarized in Table 1.

Table 1: Preoperative characteristics of patients

	Groups			
	SSW (n=32)	Robicsek (n=32)	TNC (n=32)	p value
Gender (male/female)	23/9	29/3	27/5	0.194
Age (year)*	70.5±4.3	70.8±4.2	71.3±5.3	0.518
Body Mass Index (kg/m2)*	28.7±3.7	29.3±4.2	29.3±3.4	0.490
Comorbidity				
Diabetes mellitus	8	15	12	0.304
Hypertension	13	17	12	0.804
Chronic Renal Failure	1	2	3	0.307
Chronic Obstructive Pulmonary Disease	2	4	6	0.133
Cancer	2	2	1	0.578
Smoking History	16	14	13	0.456
EUROSCORE*	3.6±0.9	3.8±0.9	3.7±0.8	0.660
Cardiac Ejection Fraction*	50.3±8.7	51.3±9.2	47.0±8.1	0.135

*: Mean ± standard deviation, SSW: Stainless steel wire, TNC: Thermoreactive nitinol clips

Coronary Artery Bypass Grafting was the most common operation type in each group (p= 0.529). The mean duration of cardiopulmonary bypass was 104.5±36.8, 112.8±36.9 and 105.6±46.2 minutes in SSW, RT and TNC groups, respectively (p= 0.924) Cross time was the longest in RT group (p= 0.153). The operative parameters listed in Table 2.

Intensive care unit stay did not show significant difference according to sternal closure technique (p=0.532). However, hospitalization period was 7.5±2.3 days in SSW group, 7.5±2.5 days in RT group and 6.3±0.5 days in TNC group and these results demonstrated that patients in which sternal closure was performed by TNC achieved significantly shorter hospitalization period (p=0.014). Hemorrhage and SSWI development were comparable between groups (p=0.610 and p=0.224, respectively). However, DSWI was significantly less common after sternal closure with TNC. DSWI was detected in five patients in SSW group, in four patients in RT group and none of the patients in TNC group (p=0.032). We also faced mediastinitis in two patients (one patient's sternal closure was performed by SSW and another's was performed by RT). Dehiscence was observed in six cases in which sternal closure was performed with SSW and in four cases in which sternal closure was performed with RT. We did not face any dehiscence in patients in which TNC was used for sternal closure (p=0.014). The TNC was the common technique to manage sternal dehiscence (five cases after SSW and four cases after RT). Dehiscence time was significantly longer in patients with SSW than in patients with RT (p=0.009). According to the VAS score, we have seen a trend in pain reduction following days after operation. The VAS score of patients in which TNC used was 5.2±0.6 in 1st postoperative day, 3.6±0.8 in 3rd postoperative day, 3.3±0.6 in 5th postoperative day and we have achieved significantly better VAS scores in patients with TNC (p<0.001, p<0.001 and p<0.001, respectively). The death occurred in two patients (Table 3).

Table 2: Operative parameters between groups

	Groups			
	SSW (n=32)	Robicsek (n=32)	TNC (n=32)	p value
Operation type				0.529
CABG	23	24	25	
Mitral valve replacement	3	2	1	
Aortic valve replacement	3	1	1	
Cardiac tumor	0	2	0	
Bentall procedure	2	1	2	
Ascending aorta replacement	0	2	0	
CABG + Mitral valve replacement	1	0	1	
CABG + Ascending aorta replacement	0	0	2	
CABG*	2.5±1.6	2.4±1.6	2.7±1.3	0.504
Off Pump technique	3	4	4	0.698
Single IMA	29	25	21	0.133
CPB Time (minute)*	104.5±36.8	112.8±36.9	105.6±46.2	0.924
Cross Time (minute)*	51.5±26.7	67.3±35.1	63.5±32.5	0.153
Hemorrhage (cc)*	562.5±336.5	485.9±340.4	489.1±236.1	0.341
Post extubation time (hour)*	5.8±2.5	9.1±4.8	6.5±3.6	0.540
Atrial fibrillation	11	11	14	0.444
IABP	2	2	2	1.000

*: Mean ± standard deviation, SSW: Stainless steel wire, TNC: Thermoreactive nitinol clips, CABG: Coronary artery bypass graft, IMA: Internal mammillary artery, CPB: Cardiopulmonary bypass, IABP: Intra-aortic balloon pump

Table 3: Post-operative values of patients who underwent sternal closure

	Groups			
	SSW (n=32)	Robicsek (n=32)	TNC (n=32)	p value
Intensive Care Unit Stay (day)*	2.5±0.9	2.6±1.0	2.3±0.5	0.532
Hospitalization Time (day)*	7.5±2.2	7.5±2.5	6.3±0.5	0.014
Complications				
Hemorrhage	2	3	1	0.610
Superficial Sternal Wound Infection	5	3	2	0.224
Deep Sternal Wound Infection	5	4	0	0.032
Mediastinitis	1	1	0	0.387
Reproduction in Wound Culture	4	5	3	0.709
Dehiscence	6	4	0	0.014
Time of Dehiscence (day)*	3.2±7.2	1.5±4.2	N/A	0.009**
Sternum Revision Method				0.017
SSW	0	0	0	
Robicsek	1	0	0	
TNC	5	4	0	
Second Revision Requirement	0	0	0	
Visual Pain Score*				
Post-op first day	6.8±1.2	7.4±0.8	5.2±0.6	<0.001
Post-op third day	5.5±1.4	5.4±1.1	3.6±0.8	<0.001
Post-op fifth day	4.6±1.0	4.7±1.1	3.3±0.6	<0.001
Mortality	1	1	0	0.387

*: mean ± standard deviation, **: SSW vs Robicsek technique, SSW: Stainless steel wire, TNC: Thermoreactive nitinol clips

When we divided the patients according to the presence of dehiscence, all preoperative and operative parameters were similar between groups. We detected infectious complications in

all patients with sternal dehiscence including SSWI in 3/10 patients (30%), DSWI in 5/10 patients (50%) and mediastinitis in 2/10 patients (20%). However, we only faced SSWI in 7/86 patients (8.1%) and DSWI in 4/86 (4.7%) patients in which dehiscence did not occur. The VAS scores were significantly higher in patients with sternal dehiscence. Moreover, sternal closure with SSW and RT was more common in patients with dehiscence (p=0.014) (Table 4). In multivariate regression analysis, SSWI and DSWI were the only predictive factors for sternal dehiscence (p=0.029 and p=0.015, respectively) (Table 5).

Table 4: Comparison of patients with and without dehiscence occurrence

	Dehiscence (n=10)	Non-dehiscence (n=86)	p value
Gender (male/female)	8/2	71/15	0.843
Age (year)*	68.9±2.2	71.1±4.8	0.162
Body Mass Index (kg/m2)*	28.8±4.6	29.2±3.7	0.799
Comorbidity			
Diabetes mellitus	3 (30%)	32 (37.2%)	0.658
Hypertension	4 (40%)	38 (44.2%)	0.803
Chronic Renal Failure	0	6 (7%)	0.394
Chronic Obstructive Pulmonary Disease	0	12 (14%)	0.211
Cancer	1 (10%)	4 (4.7%)	0.476
Smoking History	3 (30%)	40 (46.5%)	0.325
EUROSCORE*	4.0±0.9	3.7±0.8	0.251
Cardiac Ejection Fraction*	52.0±9.2	49.2±8.7	0.350
Operation			0.271
CABG	8 (80%)	64 (74.4%)	
Mitral valve replacement	1 (10%)	5 (5.8%)	
Aortic valve replacement	1 (10%)	4 (4.7%)	
Cardiac tumor	0	2 (2.3%)	
Bentall procedure	0	5 (5.8)	
Ascending aorta replacement	0	2 (2.3%)	
CABG + Mitral valve replacement	0	2 (2.3%)	
CABG + Ascending aorta replacement	0	2 (2.3%)	
CABG*	2.8±1.6	2.5±1.5	0.533
Off Pump technique	2 (20%)	9 (10.5%)	0.376
Single IMA	8 (80%)	67 (70.9%)	0.881
CPB Time (minute)*	89.8±18.8	109.4±41.2	0.188
Cross Time (minute)*	43.5±11.1	62.4±32.9	0.110
Hemorrhage (cc)*	530.0±310.9	510.5±308.1	0.850
Post extubation time (hour)*	4.7±1.1	7.4±4.1	0.135
Atrial fibrillation	5 (50%)	31 (36%)	0.394
IABP	0	6 (7%)	0.394
Superficial Sternal Wound Infection	3 (30%)	7 (8.1%)	0.032
Deep Sternal Wound Infection	7 (70%)	2 (2.3%)	<0.001
Mediastinitis	2 (20%)	0	<0.001
Sternal Closure Method			0.014
SSW	6 (60%)	26 (30.2%)	
Robicsek	4 (40%)	28 (32.6%)	
TNC	0	32 (37.2%)	
Reproduction in Wound Culture	6 (60%)	6 (7%)	<0.001
Visual Pain Score*			
Post-op first day	8.0±0.9	6.3±1.2	<0.001
Post-op third day	6.3±1.3	4.7±1.3	<0.001
Post-op fifth day	5.2±0. 9	4.1±1.1	0.002
Mortality	2 (20%)	0	<0.001

*: Mean ± standard deviation, SSW: Stainless steel wire, TNC: Thermoreactive nitinol clips, CABG: Coronary artery bypass graft, IMA: Internal mammillary artery, CPB: Cardiopulmonary bypass, IABP: Intraaortic balloon pump

Table 5: Multivariate regression analysis for dehiscence occurrence

	Odds Ratio*	p value
Deep Sternal Wound Infection	15.3 (1.7-169.1)	0.015
Superficial Sternal Wound Infection	11.7 (1.3-107.1)	0.029
Reproduction in Wound Culture	0.5 (0.1-12.9)	0.676
Mediastinitis	2.4 (0.1-68.2)	0.998
Sternal Closure Method	0.4 (0.1-2.9)	0.999

*: 95% confidence interval

Discussion

Although, many different definition of elderly population is available, there is no standard numerical criterion on the age at which a person becomes old. Recently, United Nation accepted the cutoff value as 60+ years of age to refer to the older population [11]. With developments in the field of health, life expectancy has become longer in the last century, thus, the number of elderly people who require treatment for cardiac surgery with sternotomy has increased. However, elderly patients carry additional risk factors such as; immobilization, vitamin D deficiency, chronic renal failure for sternum fragility [12]. Also, decrease in osteoblastic activity delays the bone healing in elderly patients, thus, technique of sternal closure require special attention in elderly patients.

Numerous papers have investigated the best technique for sternal closure following cardiac surgery. Dunne et al. [13] reported both SSW and cabling systems are safe options for sternal closure and one technique is not superior to another (0.7% and 3.7% rewiring rate for SSW and cabling system, respectively, p=0.12). In another study, Sarıkaya et al. [14] compared RT and TNC. They stated that the dehiscence rate was similar between groups (6.3% for RT and 7.7% for TNC with p value >0.005). In contrast, Bejko et al. [15] achieved significantly better dehiscence rates with using TNC than SSW (0% and 1.6% rewiring requirement following TNC and SSW respectively, p=0.003). In present study, we did not face any sternal dehiscence in patients in which sternal closure was performed with TNC when compared with other patients in which sternal closure was performed with SSW or RT (p=0.017). However, multivariate regression analysis showed that sternal closure technique was not a predictive factor for sternal dehiscence in present study (p=0.999).

Sternal wound infections are one of the most serious conditions after sternotomy and occurred between 0.5% and 6.8% according to the literature [16]. It's well known that being elderly is a risk factor for sternal wound infections and also, presence of diabetes mellitus, kidney dysfunction, chronic obstructive pulmonary disease and peripheral vascular disease, which are more common in elderly population, contribute to infectious complications following sternotomy. The classification of sternal wound infections and mediastinitis enables a better comparison of researches. The infection of surgical wounds of sternotomies should be considered as (A) SSWI if only the skin and subcutaneous tissue are involved, (B) DSWI ıf wound infection associated with sternal osteomyelitis without infected retrosternal space, and (C) Mediastinitis when infected retrosternal space occurs with sternal osteomyelitis [17]. Nikolaidis et al. [18] stated that incidence of DSWI was lower with TNC than SSW after sternal closure (1.7% vs 2.3%). Additionally, they claimed that infectious complications were associated with mortality. In another study, Sarıkaya et al. [8] suggested the use of TNC for the management of sternal dehiscence and they claimed that TNC breaks infection-dehiscence circle and decreases the risk of mediastinitis. Similarly, Bejko et al. [15] faced significantly less DSWI in cases in which TNC was used when compared with the cases in which SSW was used (0.2% vs 1.6%, p=0.02). In present study, we did not face any DSWI following TNC (in five cases after SSW and in four cases after RT, p=0.032) and our study demonstrated that the use of TNC for sternal closure significantly decreases sternal infectious complications.

Superior stability of sternal closure may reduce the mediastinitis incidence. Borger et al. [19] reviewed the data of 12,267 consecutive cardiac surgical patients who had undergone sternotomy and stated that TNC had superior results for the prevention of mediastinitis when compared with SSW. Also, Bejko et al. [20] compared 1702 patients with SSW and 572 patients received TNC. They found that the use of the TNC was

a better sternal closure technique in prevention of mediastinitis. In present study, we did not face any mediastinitis cases following TNC and only faced two mediastinitis cases (one case with SSW and one case with RT). However, we could not show the importance of sternal closure technique on mediastinitis. We believe that our relatively small study sample led to this outcome.

Postoperative pain deteriorates patients comfort, breathing movements and is associated with delay in patient mobilization. Previous reports about effect of sternal closure technique on postoperative period pain had controversial results. Hashim et al. [21] showed superiority of biological bone adhesive molecule on VAS score after sternal closure, over SSW. In contrast, Dunne et al. [13] found statically significant difference in VAS score in favor of sternal closure with SSW over sternal cables. In another study, Elghonemy et al. [22] found that sternal plating procedure had a benefit of lesser postoperative pain and reduced narcotic use. In present study, we achieved significantly better VAS scores after sternal closure with TNC. We think that with the TNC there will be less sternal dehiscence, infection and pain.

Although, this paper is the first prospective randomized study that investigated effectivity and safety of SSW, RT and TNC for sternal closure in elderly patients, our study has some limitations. First of all, our study sample included relatively small number of patients. Secondly, we did not analyze the cost of these three sternal closure techniques, which may be the possible subject of another investigation. Lastly, present study only analyzed the short-term outcomes and we consider future researches with long-term follow-up results will clarify the superiority of these techniques to one another.

In conclusion, our study, for the first time, showed that use of TNC decreases the hospitalization duration, DSWI and sternal dehiscence development and postoperative pain intensity following sternal closure due to cardiac surgeries. Moreover, SSWI and DSWI were found as the only predictive factors for sternal dehiscence in multivariate regression analysis. The present study findings must be supported by further prospective, randomized studies with a higher patient volume.

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