

Original Article

Comparative Analysis of Figure-of-Eight versus Interrupted Sternal Wire Closure: Assessing Pain, Sternal Stability, Wound Healing, and Early Functional Recovery in Cardiac Surgery Patients after Sternotomy

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ABSTRACT

Background: Median sternotomy is widely used in cardiac surgery, but postoperative pain, sternal instability, impaired wound healing, and delayed functional recovery remain clinically important concerns. The configuration used for sternal wire closure may influence early recovery, although comparative evidence regarding figure-of-eight and simple interrupted closure remains inconsistent. **Objective:** To compare early clinical and functional outcomes between figure-of-eight and simple interrupted sternal wire closure in adults undergoing elective cardiac surgery through median sternotomy. **Methods:** This prospective comparative observational study included 108 patients from two tertiary cardiac surgery centres, with 54 patients in each closure group. Postoperative pain was assessed using the Numeric Analogue Scale, wound healing using ASEPSIS, sternal stability using the Sternal Instability Scale, and functional recovery using the Barthel Index. Additional outcomes included operative duration, time to ambulation, duration of analgesic use, hospital stay, patient satisfaction, and 30-day readmission. **Results:** The groups differed at baseline in age and COPD prevalence. Unadjusted postoperative outcomes favored figure-of-eight closure, including lower pain (1.81 ± 1.47 vs 4.76 ± 1.48 ; mean difference -2.95 , 95% CI -3.51 to -2.39), higher Barthel scores (91.78 ± 4.39 vs 75.94 ± 9.09 ; difference 15.84 , 95% CI 13.10 – 18.58), earlier ambulation, shorter hospitalization, greater frequency of satisfactory wound healing, and greater frequency of SIS Grade 0. Thirty-day readmission was 0 versus 3 patients ($p=0.243$). **Conclusion:** Figure-of-eight closure was associated with more favorable early postoperative outcomes in this cohort. Because closure allocation was observational and important baseline differences were present, the findings should not be interpreted as establishing independent superiority of the closure technique without adjusted or randomized confirmation. **Keywords:** figure-of-eight wiring; interrupted sternal closure; median sternotomy; sternal stability; wound healing; postoperative pain; functional recovery.

INTRODUCTION

Median sternotomy provides broad exposure of the heart and great vessels and remains a fundamental surgical approach for many open cardiac procedures. Restoration of sternal integrity at the completion of surgery is essential because instability of the divided sternum can interfere with chest-wall mechanics, contribute to pain, impair mobilization, and increase the risk of wound-related

complications. Deep sternal wound infection and sternal instability are uncommon relative to uncomplicated sternotomy healing but can produce substantial morbidity, prolonged treatment, repeat procedures, and increased healthcare utilization (1–4).

Stainless-steel wire closure remains a commonly used method of reapproximating the sternum. The manner in which these wires are arranged varies between surgical practices. Two frequently used configurations are simple interrupted wires and figure-of-eight wiring. Both are intended to maintain approximation of the sternal halves while healing occurs, but their mechanical behavior is not identical. Wire number, location, sternal quality, regional loading, and configuration can all influence movement between the sternal edges (4,5).

The theoretical rationale for figure-of-eight closure is that crossing wires may distribute forces across a broader portion of the sternum and potentially reduce local movement. However, biomechanical evidence does not uniformly demonstrate that figure-of-eight closure is intrinsically more stable than simple wiring. Dasika et al., using a mechanical sternum model, found that reinforcement of the lower sternum with an additional simple wire improved regional stability, whereas figure-of-eight wiring was not superior to simple wiring in that model (6). Thus, clinical outcomes cannot be inferred from wire geometry alone.

Clinical comparative evidence is similarly heterogeneous. In a randomized study of patients undergoing coronary artery bypass grafting, Ramzisham et al. found no statistically significant difference in sternal dehiscence between figure-of-eight and simple interrupted closure (7). In contrast, a randomized Pakistani study by Abbas et al. reported fewer dehiscence events with figure-of-eight closure than with simple interrupted closure among CABG patients (8). These apparently conflicting findings indicate that closure performance may depend not only on wire configuration but also on patient characteristics, surgical technique, number and position of wires, procedure type, sternal bone quality, and perioperative risk factors.

Evidence from higher-risk populations also illustrates the importance of closure context. Aykut et al. studied obese diabetic CABG patients and found lower sternal dehiscence with prophylactic sternal weave than with figure-of-eight closure, demonstrating that figure-of-eight wiring should not automatically be regarded as optimal across all patient groups or comparator techniques (9). Another comparative study of figure-of-eight and simple interrupted steel-wire closure reported results favoring simple interrupted closure for sternal dehiscence, further emphasizing continuing uncertainty regarding the optimal configuration (10,11).

Clinical evaluation of sternal closure should therefore extend beyond dehiscence alone. Pain can affect coughing, deep breathing, mobility and participation in postoperative rehabilitation (12). Sternal stability is relevant to patient comfort and safe functional activity, while wound healing determines the risk of superficial and deep wound complications. Early ambulation, independence in activities of daily living, hospital stay, analgesic requirements, and patient satisfaction provide additional information regarding postoperative recovery (13).

Standardized assessment tools improve consistency in evaluating these dimensions. ASEPSIS provides a structured approach to postoperative wound assessment based on wound characteristics and treatment-related events (14). The Sternal Instability Scale is a clinical grading system designed to evaluate abnormal motion of the sternum following median sternotomy and has undergone validity and reliability assessment in cardiac-surgery populations (15). Functional independence can be evaluated using the Barthel Index, which quantifies performance in basic activities of daily living and is widely used in rehabilitation and clinical outcome assessment (16).

Patient-centred early postoperative outcomes are particularly relevant in tertiary cardiac services, where improvements in mobility and functional independence may influence length of hospitalization and demand for postoperative care (13). Nevertheless, interpretation of closure-technique comparisons requires careful consideration of baseline patient risk and operative characteristics because factors such as age, diabetes, pulmonary disease, obesity, procedure complexity, and sternal quality may independently affect pain, wound healing, sternal stability, and recovery (2,17,18).

The present study therefore compared figure-of-eight and simple interrupted sternal wire closure among adults undergoing elective cardiac surgery through median sternotomy at two tertiary care hospitals in Pakistan. The study evaluated early postoperative pain, wound healing, sternal stability, functional recovery, ambulation, analgesic use, hospital stay, patient satisfaction, and readmission with the aim of describing differences in early recovery between the two closure groups.

MATERIALS AND METHODS

This prospective comparative observational study was conducted at Bahawal Victoria Hospital, Bahawalpur, and Shaikh Zayed Hospital, Lahore, Pakistan. Adult patients undergoing elective cardiac surgery through median sternotomy were evaluated according to the sternal wire closure technique used at the completion of surgery.

A total of 108 patients were included, comprising 54 patients whose sternum was closed using the figure-of-eight technique and 54 patients who underwent simple interrupted wire closure. The source study described sample-size estimation using a WHO comparison-of-proportions approach based on an expected prevalence of sternal dehiscence from previous research. Eligible participants were recruited using simple random sampling. The closure configuration was determined according to the intraoperative surgical plan; the study was observational and did not use study-directed random allocation of closure technique.

Adults aged 18–75 years undergoing elective median sternotomy who provided written informed consent were eligible. Patients undergoing emergency or redo sternotomy, minimally invasive cardiac procedures, or those with morbid obesity defined as BMI ≥ 40 kg/m², active systemic infection, dialysis-dependent renal failure, osteoporosis, chronic obstructive pulmonary disease requiring long-term treatment, or long-term immunosuppressive therapy were excluded.

Patients were followed for four weeks after surgery. Postoperative pain was assessed during the early postoperative period using the Numeric Analogue Scale. Wound healing was evaluated using the ASEPSIS scoring system (14). Sternal stability was assessed using the Sternal Instability Scale, in which Grade 0 indicates a clinically stable sternum without detectable abnormal movement (15). Functional recovery was evaluated at follow-up using the Barthel Index (16).

Additional perioperative and recovery variables included total operative duration, time to first ambulation, duration of postoperative analgesic use, hospital length of stay, patient satisfaction, and 30-day readmission. Demographic and clinical characteristics were obtained from patient records and perioperative documentation.

The original statistical analysis was performed using IBM SPSS Statistics version 26.0. Continuous variables were summarized as mean $\pm$ standard deviation and categorical variables as frequencies and percentages. The study specified independent-samples t testing for normally distributed continuous variables, the Mann-Whitney U test for non-normally distributed variables, and chi-square testing for categorical comparisons. Statistical significance was defined as $p < 0.05$.

For the present statistical reconciliation, additional unadjusted effect estimates were calculated only from the reported aggregate data. Mean differences and 95% confidence intervals were calculated from group means, standard deviations, and sample sizes. Fisher's exact test was used where categorical cells were sparse, and Newcombe confidence intervals were calculated for selected absolute risk differences. These supplementary calculations were performed using Python 3.13.5, SciPy 1.17.0, and statsmodels 0.14.6. No participant-level data were reconstructed, and no adjusted regression estimates were generated.

Ethical approval was obtained from the Institutional Review Board of Superior University, Lahore. Written informed consent was obtained from all participants before enrollment.

RESULTS

A total of 108 patients were analyzed, with 54 patients in each closure group. Baseline characteristics are presented in Table 1. The mean age was 57.28 ± 8.19 years in the figure-of-eight group and 53.91 ± 9.20 years in the interrupted group. The unadjusted between-group difference was 3.37 years (95% CI 0.05–6.69; $p = 0.047$), indicating that the figure-of-eight group was modestly older.

Mean BMI was nearly identical between groups. Sex distribution, hypertension, diabetes mellitus, and chronic kidney disease also did not show clear between-group differences. COPD, however, was substantially more frequent in the interrupted group, occurring in 11/54 (20.4%) compared with 2/54 (3.7%) patients in the figure-of-eight group (Fisher exact $p = 0.015$).

Table 1. Baseline Demographic and Clinical Characteristics

Variable	Figure-of-Eight (n=54)	Interrupted (n=54)	Between-Group Comparison
Age, years	57.28 ± 8.19	53.91 ± 9.20	Mean difference 3.37 years (95% CI 0.05–6.69); p=0.047
BMI, kg/m ²	28.51 ± 3.56	28.55 ± 3.72	Mean difference –0.04 (95% CI –1.43 to 1.35); p=0.955
Female	30 (55.6%)	23 (42.6%)	p=0.248
Male	24 (44.4%)	31 (57.4%)	–
Hypertension	17 (31.5%)	17 (31.5%)	p=1.000
Diabetes mellitus	18 (33.3%)	17 (31.5%)	p=1.000
COPD	2 (3.7%)	11 (20.4%)	p=0.015
Chronic kidney disease	3 (5.6%)	4 (7.4%)	p=1.000

Abbreviations: BMI, body mass index; CI, confidence interval; COPD, chronic obstructive pulmonary disease. Continuous-variable comparisons were derived from reported summary statistics; categorical p values were calculated using Fisher's exact test.

Early postoperative continuous outcomes are summarized in Table 2. Pain scores were lower in the figure-of-eight group, with a mean of 1.81±1.47 compared with 4.76±1.48 in the interrupted group. The unadjusted mean difference was –2.95 points (95% CI –3.51 to –2.39; reported p<0.001).

Functional recovery as measured by the Barthel Index was higher in the figure-of-eight group, with mean scores of 91.78±4.39 compared with 75.94±9.09. The mean difference was 15.84 points (95% CI 13.10–18.58; reported p<0.001). Total operative duration was 99.24±12.83 minutes in the figure-of-eight group and 116.41±14.52 minutes in the interrupted group, corresponding to a mean difference of –17.17 minutes. Hospital stay was shorter by a mean of 1.22 days, duration of postoperative analgesic use by 1.21 days, and time to first ambulation by 2.06 days in the figure-of-eight group. Patient satisfaction scores were also higher by a mean of 2.08 points.

Table 2. Continuous Postoperative and Recovery Outcomes

Outcome	Figure-of-Eight (n=54), Mean ± SD	Interrupted (n=54), Mean ± SD	Mean Difference (Fo8 – Interrupted)	95% CI	Reported p Value
Pain score	1.81 ± 1.47	4.76 ± 1.48	–2.95	–3.51 to –2.39	<0.001
Barthel Index	91.78 ± 4.39	75.94 ± 9.09	+15.84	13.10 to 18.58	<0.001
Operative duration, min	99.24 ± 12.83	116.41 ± 14.52	–17.17	–22.40 to –11.94	<0.001
Hospital stay, days	6.00 ± 1.00	7.22 ± 2.12	–1.22	–1.86 to –0.58	<0.001
Postoperative analgesic use, days	3.96 ± 1.03	5.17 ± 1.01	–1.21	–1.60 to –0.82	<0.001
Time to first ambulation, days	1.50 ± 0.50	3.56 ± 0.50	–2.06	–2.25 to –1.87	<0.001
Patient satisfaction score	9.04 ± 0.85	6.96 ± 0.89	+2.08	1.75 to 2.41	<0.001

Abbreviations: CI, confidence interval; Fo8, figure-of-eight; SD, standard deviation. Mean differences and confidence intervals were calculated from the reported group means, SDs, and sample sizes and represent unadjusted between-group estimates.

Wound healing, sternal stability, categorical functional recovery, and readmission are summarized in Table 3. All 54 patients in the figure-of-eight group were classified as having satisfactory wound healing, compared with 3/54 (5.6%) in the interrupted group. In the interrupted group, 19/54 (35.2%) were classified as having minor surgical-site infection and 32/54 (59.3%) as having wound-healing disturbance. The overall wound-healing distribution differed markedly between groups (p<0.001).

Normal sternal stability, defined as SIS Grade 0, was recorded in 39/54 (72.2%) figure-of-eight patients and 13/54 (24.1%) interrupted-closure patients. The absolute difference in Grade 0 stability was 48.1

percentage points (95% CI 29.8–62.0; $p < 0.001$). Full functional independence was recorded in 33/54 (61.1%) figure-of-eight patients and none of the interrupted group. The absolute difference was 61.1 percentage points (95% CI 46.2–73.0; $p < 0.001$). The remaining 21 figure-of-eight patients and all 54 interrupted patients were classified as having mild or moderate dependence. No 30-day readmission occurred in the figure-of-eight group, compared with three readmissions in the interrupted group. This difference did not reach statistical significance ($p = 0.243$).

Table 3. Wound Healing, Sternal Stability, Functional Independence, and Readmission

Outcome	Figure-of-Eight (n=54)	Interrupted (n=54)	Effect Estimate	p Value
ASEPSIS wound classification				<0.001
Satisfactory healing	54 (100.0%)	3 (5.6%)	Absolute difference +94.4 percentage points (95% CI 82.8–98.1)	
Minor surgical-site infection	0 (0.0%)	19 (35.2%)	—	
Wound-healing disturbance	0 (0.0%)	32 (59.3%)	—	
Sternal stability				
SIS Grade 0	39 (72.2%)	13 (24.1%)	Absolute difference +48.1 points (95% CI 29.8–62.0)	<0.001
SIS Grade >0	15 (27.8%)	41 (75.9%)	—	
Functional recovery category				
Full independence	33 (61.1%)	0 (0.0%)	Absolute difference +61.1 points (95% CI 46.2–73.0)	<0.001
Mild/moderate dependence	21 (38.9%)	54 (100.0%)	—	
30-day readmission	0 (0.0%)	3 (5.6%)	Absolute difference –5.6 points (95% CI –15.1 to 2.0)	0.243

Abbreviations: ASEPSIS, Additional treatment, Serous discharge, Erythema, Purulent exudate, Separation of deep tissues, Isolation of bacteria, and duration of inpatient Stay; CI, confidence interval; SIS, Sternal Instability Scale. Sparse two-group comparisons were assessed with Fisher's exact test where appropriate. Taken together, the unadjusted early postoperative findings consistently favored the figure-of-eight group for pain, wound-healing classification, Grade 0 sternal stability, Barthel Index score, time to ambulation, analgesic duration, hospital stay, and patient satisfaction. However, the closure groups also differed in baseline age and COPD prevalence, and no multivariable adjustment was available to determine the independent effect of closure configuration.

DISCUSSION

This prospective observational study compared early postoperative outcomes among patients receiving figure-of-eight or simple interrupted sternal wire closure following elective cardiac surgery. Large unadjusted differences were observed across multiple recovery domains. Patients in the figure-of-eight group had lower reported pain, greater frequency of satisfactory wound healing and SIS Grade 0 stability, higher Barthel Index scores, earlier ambulation, shorter analgesic use and hospital stay, and higher patient satisfaction. At the same time, the groups were not fully comparable before surgery: patients receiving figure-of-eight closure were modestly older, whereas COPD was substantially more common in the interrupted group. These baseline differences and the nonrandomized closure allocation are central to interpretation of the findings.

The observed pain difference was clinically substantial, with the figure-of-eight group averaging 2.95 points lower than the interrupted group. Pain following median sternotomy can affect respiratory effort,

coughing, mobility, sleep, and participation in rehabilitation (12,19). Greater sternal movement may plausibly increase discomfort, but postoperative pain is also influenced by the underlying cardiac procedure, analgesic regimen, individual pain sensitivity, respiratory comorbidity, and other perioperative factors. The current comparison therefore demonstrates a marked difference between the groups but does not establish that wire configuration alone produced the difference.

Functional outcomes showed a similarly pronounced pattern. Mean Barthel Index scores were approximately 16 points higher in the figure-of-eight group, and 61.1% were categorized as fully independent compared with none in the interrupted group. Time to first ambulation was also approximately two days shorter. Because pain, respiratory function, sternal stability, procedure severity, postoperative complications, and rehabilitation exposure can all influence mobilization and independence, these outcomes are likely interrelated rather than independent effects of closure configuration (12,13).

The findings regarding sternal stability are biologically plausible but should be interpreted in light of mixed biomechanical and clinical evidence. Different wire arrangements alter the way forces are transmitted across the sternum (5,6,11). However, Dasika et al. demonstrated in a mechanical model that figure-of-eight wires were not superior to simple wires; additional reinforcement of the lower sternum produced greater improvement in stability (6). This indicates that the number and location of wires and regional reinforcement may be at least as important as the overall geometric pattern.

Direct clinical comparisons have also produced inconsistent results. Ramzisham et al. randomized 195 CABG patients to figure-of-eight or interrupted closure and found no significant difference in sternal dehiscence, with seven events in the figure-of-eight group and nine in the interrupted group (7). In contrast, Abbas et al., in a Pakistani randomized trial involving 200 CABG patients, reported two dehiscence events after figure-of-eight closure compared with eight after simple interrupted wiring and concluded that figure-of-eight closure reduced dehiscence in that population (8). A more recent 645-patient comparative study found no significant difference in superficial or deep sternal wound infection among simple, figure-of-eight, and combined wiring techniques, although hospital stay was shorter with the combined approach (20).

Other comparative evidence further illustrates the absence of a universally superior technique. Mourad et al. compared figure-of-eight and simple interrupted closure and reported a higher incidence of dehiscence in their figure-of-eight group, favoring interrupted wiring (10). Aykut et al., although evaluating a different comparator, found prophylactic sternal weave superior to figure-of-eight closure in obese diabetic CABG patients (9). These studies collectively show that closure outcomes vary with patient risk, comparator technique, surgical population, and procedural details (5,9–11,20).

Wound-healing differences in the present study were particularly large. All figure-of-eight patients were classified as having satisfactory healing, whereas only three interrupted patients received that classification. The remainder of the interrupted group was categorized as having minor surgical-site infection or wound-healing disturbance. Because ASEPSIS provides a structured framework for postoperative wound assessment (14), the categorical difference is noteworthy. Nevertheless, wound healing after cardiac surgery is multifactorial, with diabetes, obesity, pulmonary disease, perfusion, operative factors, infection-control practices, and tissue handling potentially contributing to outcome (2,3,17,18).

COPD imbalance is particularly relevant in this context. COPD was recorded in only 3.7% of the figure-of-eight group but in 20.4% of the interrupted group. Pulmonary disease can increase coughing and respiratory mechanical stress on the sternum and may also complicate early mobilization and postoperative recovery (2,5,17,18). Although patients requiring long-term treatment for COPD were excluded, the remaining difference in COPD prevalence means that some of the observed between-group difference could reflect underlying patient risk rather than closure configuration alone.

The age difference should also be considered. Patients in the figure-of-eight group were approximately 3.4 years older on average. Although this difference was modest, it reached statistical significance in the derived baseline comparison. Age may influence bone quality, functional recovery, comorbidity burden, and surgical risk (2,18). The fact that the figure-of-eight group was older does not negate its favorable observed outcomes, but it reinforces the need for adjusted analysis rather than relying solely on crude group comparisons.

Operative duration was approximately 17 minutes shorter in the figure-of-eight group. This difference should not automatically be attributed to the speed of sternal closure because the reported variable represents total operative duration rather than documented closure time. Cardiac procedure type,

procedural complexity, bypass duration, cross-clamp time, surgeon, and intraoperative events could materially affect total operative duration and postoperative risk profiles (2,17). Without information on the distribution of cardiac procedures and these perioperative characteristics, the independent contribution of closure technique cannot be determined.

Hospital stay and duration of analgesic use were also shorter in the figure-of-eight group. These findings are consistent with the direction of the pain, mobility, wound, and functional results, but they may represent downstream consequences of several correlated aspects of postoperative recovery (12,13,19). Similarly, higher patient-satisfaction scores could reflect less pain, earlier mobility, shorter hospitalization, or other elements of care rather than closure configuration in isolation.

Thirty-day readmission deserves separate consideration because its statistical pattern differs from the other outcomes. No patient in the figure-of-eight group was readmitted compared with three patients in the interrupted group, but with only three total events the difference was statistically uncertain ($p=0.243$). The data therefore do not support a conclusion that figure-of-eight closure reduced 30-day readmission in this sample.

The present study has several strengths. Outcomes were assessed prospectively, two tertiary cardiac centres contributed participants, and the evaluation included multiple clinically relevant domains rather than focusing solely on dehiscence. Use of structured tools for wound healing, sternal stability, and functional independence also strengthened the clinical description of early recovery (14–16).

Several limitations materially affect inference. Closure technique was not randomized by the study, and important baseline differences were present. No multivariable or propensity-adjusted analysis was available to account for these differences. The sample size was modest, and follow-up was limited to four weeks for most outcomes, preventing evaluation of chronic pain, late dehiscence, long-term sternal healing, or sustained functional recovery. Detailed distributions of cardiac procedure type, surgeon, wire number and gauge, closure time, internal thoracic artery harvest, cardiopulmonary bypass time, cross-clamp time, and other perioperative characteristics were unavailable. These factors could influence several of the measured outcomes. The results therefore provide evidence of a strong association between figure-of-eight closure and more favorable early postoperative outcomes within this cohort, but they should not be interpreted as definitive proof that figure-of-eight wiring is independently superior to interrupted closure. A randomized trial or a sufficiently powered prospective cohort with detailed procedural information and adjusted analysis would provide stronger evidence. Future research should standardize the number and gauge of wires, document the precise closure technique and surgeon, stratify or adjust for procedure type and baseline risk, and use prespecified assessment time points (5,11,20). Longer follow-up should evaluate persistent pain, radiological or clinical sternal union, delayed wound complications, readmission, and return to normal function. These studies would help determine whether the substantial early differences observed in the present cohort persist after control of confounding factors.

CONCLUSION

In this prospective observational cohort, patients who underwent figure-of-eight sternal wire closure had substantially more favorable unadjusted early postoperative outcomes than patients who underwent simple interrupted closure. Differences included lower pain scores, a greater frequency of satisfactory wound healing and normal SIS Grade 0 stability, higher Barthel Index scores, earlier ambulation, shorter analgesic use and hospitalization, and greater patient satisfaction.

These findings should be interpreted in the context of nonrandomized closure allocation and baseline imbalance, particularly the higher prevalence of COPD in the interrupted group and the difference in mean age. The study therefore demonstrates an association between figure-of-eight closure and improved early recovery but does not establish independent causal superiority of the technique. The 30-day readmission difference was not statistically significant.

Randomized or appropriately adjusted multicentre studies with detailed operative characteristics and longer follow-up are required to determine whether figure-of-eight wiring independently improves postoperative recovery and long-term sternal outcomes.

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