



Optimizing Abdominal Wound Healing: Mass Versus Layered Closure in Myomectomy Patients

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ABSTRACT

Background: Optimal abdominal wound closure remains a critical determinant of postoperative outcomes following gynecological surgery. Midline laparotomy closure techniques, particularly mass closure and layered closure, continue to be debated with respect to operative efficiency and postoperative complications. **Aim of the Study was to:** compare mass closure versus layered closure techniques for midline laparotomy wounds in women undergoing myomectomy, focusing on operative time and postoperative wound-related complications. **Methods:** This prospective comparative study included 100 women undergoing elective myomectomy via midline laparotomy. Participants were equally randomized into two groups: mass closure (n = 50) and layered closure (n = 50). Operative time for abdominal closure and postoperative complications—including wound infection, wound dehiscence, and suture sinus formation—were recorded and analyzed. **Results:** Mass closure significantly reduced the time required for abdominal closure compared with layered closure ($p < 0.001$). The incidence of wound dehiscence was significantly lower in the mass closure group (2%) than in the layered closure group (12%) ($p = 0.049$). Although wound infection rates were lower with mass closure (12% vs. 24%), this difference did not reach statistical significance ($p = 0.11$). The occurrence of suture sinus was low and comparable between groups. **Conclusion:** Mass closure of midline laparotomy wounds in myomectomy is a safe, efficient, and reliable technique associated with shorter operative time and reduced wound dehiscence compared with layered closure. These findings support the routine use of mass closure in gynecological abdominal surgery.

Keywords: Mass closure, layered closure, midline laparotomy, myomectomy, wound complications

1. Introduction

In gynecological abdominal surgery, the optimal technique for abdominal wound closure should be simple, reproducible, and yield consistently favorable outcomes regardless of the surgeon's level of experience (Kumar and Raju, 2022). Ideally, it should minimize postoperative complications such as wound dehiscence, incisional hernia, and sinus formation while ensuring patient comfort and a cosmetically acceptable scar (Kumar and Raju, 2022; Murugan *et al.*, 2021).

Traditionally, layered closure was regarded as the standard approach, emphasizing meticulous repair of each anatomical layer, particularly the peritoneum. However, subsequent clinical and experimental evidence has demonstrated that wound healing primarily depends on the formation of a dense fibrous scar that unites the abdominal wall en masse, rather than on individual layer approximation (Jenkins, 1976).

This prospective comparative study evaluates mass closure versus layered closure of midline abdominal incisions in women undergoing myomectomy. The investigation aims to determine which

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technique provides superior wound strength, fewer postoperative complications, and greater patient satisfaction. Current evidence suggests that mass closure is associated with fewer wound complications, shorter operative time, and better patient compliance, supporting its increasing preference in modern surgical practice (Kumar and Raju, 2022; Israelsson and Jonsson, 1994; Shah *et al.*, 2023).

This study aims to compare the mass and layered closure techniques used in myomectomy operations involving midline laparotomy incisions, with respect to operative time, wound healing, postoperative complications and long-term outcomes.

2. Patients and Methods

2.1. Study Design

This was a prospective, randomized, parallel-group comparative study conducted to evaluate two techniques of midline abdominal wall closure in women undergoing elective myomectomy.

2.2. Study Population

The study was conducted between January 2023 and December 2024. Ethical approval was obtained from The Ethics Committee at Hawa Center Obstetrics and Gynecology, Benha, Egypt before study commencement [ETH2022-OBGYN15]. A total of 100 women scheduled for elective myomectomy via midline laparotomy were assessed for eligibility and enrolled. All participants provided written informed consent prior to participation.

2.3. Inclusion criteria

- Women undergoing elective myomectomy via midline laparotomy.

2.4. Exclusion criteria

- Previous midline laparotomy.
- History of wound dehiscence.
- Renal or hepatic disorders.
- Chronic respiratory or cardiac disease.
- Age above 60 years.

2.5. Study Groups

Eligible participants were randomized into two equal groups (n = 50 per group):

Group I (Mass Closure): The peritoneum and linea alba were closed en masse in a single continuous layer using polydioxanone (PDS) No. 1 sutures. Suture bites were placed approximately 1.5 cm from the wound edge and 1.5 cm apart.

Group II (Layered Closure): The peritoneum and fascia were closed in separate layers using Vicryl 2-0 with continuous interlocking sutures.

In both groups, skin closure was performed using non-absorbable 2-0 Prolene sutures applied as interrupted mattress stitches.

2.6. Randomization Procedure

Randomization was computer based in a 1:1 ratio to mass or layered closure. Allocation concealment was maintained using sequentially numbered, sealed, opaque envelopes opened after enrollment and before surgery, with recruiting investigators unaware of assignment at inclusion. No stratification was performed, as baseline characteristics were expected to be comparable within this homogeneous cohort.

2.7. Sample Size Justification

The sample size was calculated a priori using Epi Info™ 7 (CDC, Atlanta) for comparison of proportions with a two-sided $\alpha = 0.05$ and 80% power. Assumptions were based on data from a randomized clinical comparison of mass versus layered abdominal wound closure by Chowdhury & Choudhury (1994), which reported clinically important differences in postoperative wound complications, including wound infection and dehiscence between techniques (e.g., 3.75% burst

abdomen in the layered closure group vs none in the mass closure group) in a cohort of 160 patients undergoing abdominal surgery (Chowdhury and Choudhury, 1994). We hypothesized a clinically meaningful reduction in the primary outcome (postoperative wound dehiscence) of at least 8–10% between groups. Based on these assumptions, the minimum sample size required to detect this difference with Epi Info 7 was 100 participants per group (total N = 200 women). To allow for potential dropouts or protocol deviations, enrollment was increased to 200 subjects.

2.8. Preoperative Preparation

All patients underwent optimization of general condition before surgery. Anemia, dehydration, and electrolyte imbalances were corrected, and comorbidities such as diabetes and hypertension were controlled. Renal and hepatic functions were evaluated and managed appropriately. Prophylactic antibiotics were administered preoperatively according to hospital protocol.

2.9. Operative Technique

All procedures were performed under general anesthesia. Surgical drains were inserted when clinically indicated through a separate incision away from the primary wound.

Abdominal wall closure was performed according to group allocation as described above. All wounds were irrigated with povidone–iodine solution and dressed with sterile gauze. The duration of abdominal wall closure was recorded in minutes for all participants.

2.10. Postoperative Care and Follow-Up

Postoperative management followed a standardized protocol. Patients received non-steroidal anti-inflammatory drugs for analgesia and intravenous antibiotics for 2–3 days, followed by oral antibiotics for 5–6 days. Antibiotic therapy was extended up to 14 days when clinically indicated. Blood transfusions were administered as required.

The surgical wound was inspected on postoperative days 5, 7, 9, and 11 for signs of infection, dehiscence, seroma, or sinus formation. Drains were removed following the return of bowel function, typically on postoperative day 5 or 6. Skin sutures were removed gradually between postoperative days 11 and 14.

Patients were followed at three-month intervals for one year.

2.11. Statistical Methods

Data were entered into Microsoft Excel and analyzed using the Statistical Package for the Social Sciences (SPSS), version 20.0. Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate. Continuous variables were analyzed using the independent samples t-test. A p-value < 0.05 was considered statistically significant.

Table 1: Summary of the study protocol

Parameter	Group I (Mass Closure)	Group II (Layered Closure)
Technique	Single-layer closure of peritoneum and fascia	Multi-layered closure of peritoneum and fascia
Suture Material	PDS No. 1	Vicryl No. 2
Skin Closure	2-0 Prolene or silk	2-0 Prolene
Evaluation	Complications, wound healing, scar outcome	Complications, wound healing, scar outcome
Follow-Up	1 year	1 year

3. Results

A total of 100 women were enrolled in this comparative study and were equally allocated to either the layered abdominal closure group (n=50) or the mass closure group (n=50). The outcomes pertaining to operative efficiency and postoperative complications are detailed below.

3.1. Patient Demographics and Comorbidities

The two groups were comparable at baseline regarding their diabetic status (Table 2). Diabetes Mellitus (DM) was present in 21 patients (42.0%) in the layered closure group and 22 patients (44.0%) in the mass closure group, a difference that was not statistically significant ($\chi^2 = 0.044$, $p = 0.834$).

Table 2 : Comparison of diabetes mellitus (DM) between groups

			Group		Total	X ²	P
			Layered closure	Mass closure			
DM	-VE	Count	29	28	57	0.044	0.834
		% Within group	58.0%	56.0%	57.0%		
	+VE	Count	21	22	43		
		% Within group	42.0%	44.0%	43.0%		

However, a significant difference was noted in the prevalence of hypertension between the cohorts (Table 3). The layered closure group had a higher proportion of hypertensive patients, 24 (48.0%), compared to 14 (28.0%) in the mass closure group ($\chi^2 = 4.219$, $p = 0.040$).

Table 3 : Comparison of hypertension between groups

			Group		Total	X ²	P
			Layered closure	Mass closure			
Hypertension	-VE	Count	26	36	62	4.219	0.040
		% Within group	52.0%	72.0%	62.0%		
	+VE	Count	24	14	38		
		% Within group	48.0%	28.0%	38.0%		

3.2. Operative Efficiency

As shown in (Table 4), a stark and statistically significant disparity was observed in the time required for fascial closure. The mass closure technique was unequivocally faster. Over half of the patients in the mass closure group (52.0%, $n=26$) were completed in under 10 minutes, compared to only 10.0% ($n=5$) in the layered closure group. Furthermore, no patient in the mass closure group required more than 15 minutes for closure, whereas the majority of patients in the layered closure group (64.0%, $n=32$) fell into this category. This distribution was highly significant ($\chi^2 = 49.441$, $p < 0.001$).

Table 4 : Comparison of time taken for closure between groups

			Group		Total	X ²	P
			Layered closure	Mass closure			
Time taken for closure	<10min	Count	5	26	31	49.441	<0.001**
		% Within group	10.0%	52.0%	31.0%		
	10-15 min	Count	13	24	37		
		% Within group	26.0%	48.0%	37.0%		
	>15 min	Count	32	0	32		
		% Within group	64.0%	0.0%	32.0%		

3.3. Postoperative Morbidity

The incidence of postoperative wound complications was assessed and compared between the two techniques (Figure 1).

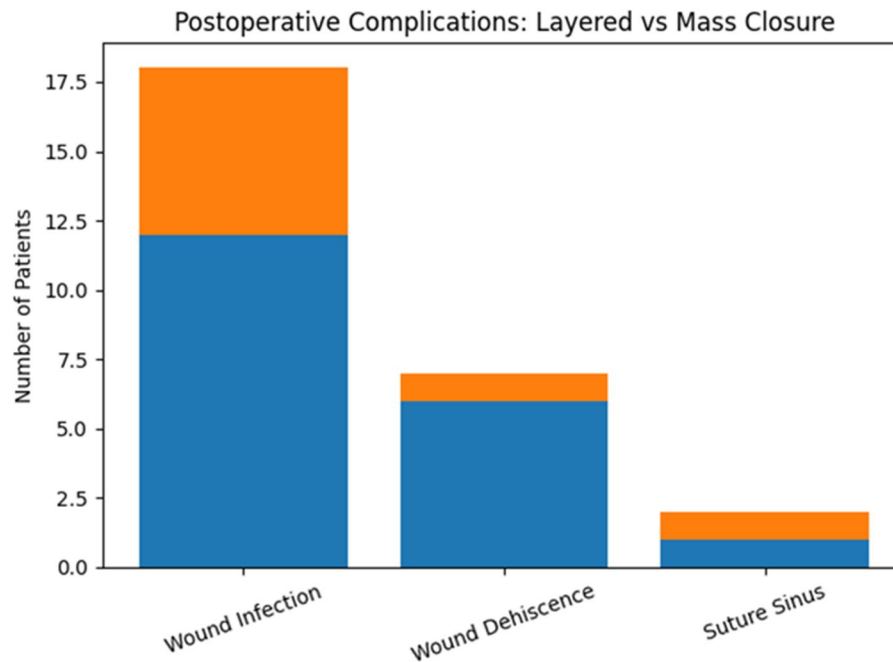


Fig. 1: Postoperative complications

Wound infection occurred in 12 patients (24.0%) in the layered closure group, compared to 6 patients (12.0%) in the mass closure group (Table 5). While this suggests a trend favoring the mass closure technique, the difference did not reach statistical significance ($\chi^2 = 2.273$, $p = 0.132$).

Table 5: Comparison of wound Infection between groups

		Group		Total	X ²	P
		Layered closure	Mass closure			
Wound infection	-VE	Count	38	44	88	2.273
	-VE	% Within group	76.0%	88.0%	88.0%	
	+VE	Count	12	6	12	
	+VE	% Within group	24.0%	12.0%	12.0%	

Regarding wound dehiscence, the event rate was low in both groups (Table 6). Six cases (12.0%) were reported in the layered closure group versus one case (2.0%) in the mass closure group. Although the absolute rate was higher in the layered closure group, statistical analysis with Yates's correction found this difference not to be significant ($\chi^2 = 2.538$, $p = 0.111$).

Table 6 : Comparison of wound dehiscence between groups

		Group		Total	X ²	P
		Layered closure	Mass closure			
Wound dehiscence	-VE	Count	44	49	93	2.538*
	-VE	% Within group	88.0%	98.0%	93.0%	
	+VE	Count	6	1	7	
	+VE	% Within group	12.0%	2.0%	7.0%	

As plotted in (Table 7), the occurrence of a suture sinus was a rare event, with only one case (2.0%) reported in each group, demonstrating no difference between the two surgical techniques ($p = 1.000$).

Table 7 : Comparison of suture sinus between groups

		Group		Total	X ²	P
		Layered closure	Mass closure			
Suture sinus	-VE	Count	49	49	98	
		%Within group	98.0%	98.0%	98.0%	
	+VE	Count	1	1	2	0.00
		% Within group	2.0%	2.0%	2.0%	1.00

As reported in (Table 8), the incidence of incisional hernia was low and comparable between the two groups, occurring in 2 patients (4.0%) in the layered closure group and 1 patient (2.0%) in the mass closure group ($p = 0.500$).

Table 8: Comparison of incisional hernia between groups

		Group		Total	X ²	P
		Layered closure	Mass closure			
Incisional hernia	-VE	Count	48	49	87	
		%Within group	96.0%	98.0%	87.0%	
	+VE	Count	2	1	3	0.000
		% Within group	4.0%	2.0%	3	0.500

Similarly in (Table 9), postoperative tenderness over the scar was infrequent and not significantly different, reported in 4 patients (8.0%) after layered closure and 3 patients (6.0%) after mass closure ($p = 0.500$).

Table 9: Comparison of tenderness over the scar between groups

		Group		Total	X ²	P
		Layered closure	Mass closure			
Tenderness over the scar	-VE	Count	46	47	93	
		%Within group	92.0%	94.0%	93.0%	
	+VE	Count	4	3	8	0.000
		% Within group	8.0%	6.0%	8.0%	0.500

3.4. Temporal Profile of Postoperative Complications

The postoperative course and complication profile for each surgical group were meticulously tracked from the immediate hospital stay through to the 12-month follow-up. The data revealed distinct temporal patterns and significant differences in early complication rates between the two closure techniques.

3.4.a. Complications in the Layered Closure Group

Within the layered closure cohort (Table 10), the most frequent complications occurred during the initial hospitalization. Wound infection was the predominant issue, presenting in 11 patients (22%) during this period, with a single additional case emerging within the first three months. Similarly, wound dehiscence was exclusively an early complication, observed in 6 patients (12%) during the hospital stay. Later follow-up revealed a single case of incisional hernia diagnosed at the 6-month mark.

Minor complications were also noted, including one case of a suture sinus during hospitalization and 4 patients (8%) reporting pain over the scar at the 3-month follow-up.

Table 10 : Postoperative Complications - Layered Closure Group (n=50)

Complication	During hospital stay	Up to 3 months	Up to 6 months
Wound infection	11	1	0
Wound dehiscence	6	0	0
Incisional hernia	0	0	1
Suture sinus	1	0	0
Pain over the scar	0	4	0

3.4.b. Complications in the Mass Closure Group

The mass closure cohort (Table 11) demonstrated a notably more favorable early postoperative profile. The incidence of wound infection during hospitalization was less than half that of the layered group, occurring in 5 patients (10%), with one further case appearing by the three-month follow-up. A marked reduction was also observed in the rate of early wound dehiscence, which complicated the hospital stay of only a single patient (2%). The long-term complication profile was comparable to the layered group, with one incisional hernia identified at 6 months and minimal reports of other issues: one suture sinus during hospitalization and 3 patients (6%) with scar pain at 3 months.

Table 11 : Postoperative complications - mass closure group (n=50)

Complication	During hospital stay	Up to 3 months	Up to 6 months
Wound infection	5	1	0
Wound dehiscence	1	0	0
Incisional hernia	0	0	1
Suture sinus	1	0	0
Pain over the scar	0	3	0

3.4.c. Comparative statistical analysis

A direct statistical comparison of complication rates between the two groups (Table 12) confirmed the observed clinical differences. The mass closure technique was associated with a statistically significant reduction in two major early complications: the rate of wound infection during hospitalization was significantly lower ($p=0.034$), as was the rate of wound dehiscence ($p=0.049$). In contrast, the incidence of long-term and minor complications was equivalent between the groups. The development of incisional hernia at 6 months, suture sinus during hospitalization, and pain over the scar at the 3-month follow-up showed no statistically significant differences ($p=1.000$, $p=1.000$, and $p=0.500$, respectively).

Table 12 : Statistical comparison of complications between groups over time

Complication	Time period	p-value (Group 1 vs. Group 2)	Significance
Wound infection	Hospital stay	0.034*	*
Wound dehiscence	Hospital stay	0.049*	*
Incisional hernia	6 Months	1.000	NS
Suture sinus	Hospital stay	1.000	NS
Pain over the scar	3 Months	0.500	NS

NS: Not Significant ($p > 0.05$)

In summary, while the long-term outcomes for serious complications like incisional hernia were equivalent, the mass closure technique conferred a significant advantage in the critical immediate postoperative period by substantially reducing the risk of major wound morbidity.

3.5. Length of hospitalization

A highly significant difference was observed in the duration of hospital stay (Table 13). Patients in the mass closure group were far more likely to be discharged within two weeks (98.0%) compared to those in the layered closure group (80.0%). Conversely, a prolonged hospital stay exceeding 14 days was necessary for 20.0% of the layered closure patients versus only 2.0% of the mass closure patients ($\chi^2 = 8.270$, $p = 0.004$).

Table 13: Comparison of hospital stay duration between groups

		Group		Total	X ²	P
		Layered closure	Mass closure			
Hospital stay	<14 day	Count	40	49	89	8.270 0.004**
		%Within group	80.0%	98.0%	89.0%	
	>14 day	Count	10	1	11	
		% Within group	20.0%	2.0%	11.0%	

4. Discussion

The method of laparotomy wound closure plays a decisive role in determining postoperative outcomes, including wound infection, wound dehiscence, burst abdomen, and incisional hernia (Kumar and Raju, 2022; Alrashidi *et al.*, 2025). Over the past decades, accumulating experimental and clinical evidence has favored mass closure techniques, which demonstrated lower rates of wound failure when all layers of the abdominal wall are incorporated in a single closure compared with layered repair (Kumar and Raju, 2022).

The physiological principle that mass closure prevents wound breakdown by distributing tension and minimizing ischemic necrosis at the suture line, as proposed by Dudley, has been validated by clinical evidence (Dudley, 1970). Randomized trials, such as that by Jenkins, and modern meta-analyses have consistently demonstrated that mass closure with wide, deep bites and an adequate suture length to wound length ratio (SL: WL) significantly reduces the rates of acute wound dehiscence and chronic incisional hernia compared to layered closure techniques (Leaper *et al.*, 1985; Diener *et al.*, 2010; Poole, 1985).

In the present study, mass closure demonstrated a clear and statistically significant advantage in operative efficiency. The time required for abdominal wall closure was nearly halved compared with layered closure ($p < 0.001$). This finding is consistent with previous reports by Niggebrugg *et al.* (1997), who showed that, in animals, continuous closure techniques are faster and provide adequate mechanical strength, making them particularly suitable for routine midline laparotomy.

With regard to postoperative morbidity, the most important benefit of mass closure in this study was observed during the immediate postoperative period. Rates of wound infection and wound dehiscence during hospital stay were significantly lower in the mass closure group ($p = 0.034$ and $p = 0.049$, respectively). Although the cumulative incidence of these complications at one year remained numerically lower with mass closure, the differences did not reach statistical significance. This pattern aligns with previous study by Frank *et al.* (2014). reporting that mass closure primarily reduces early wound complications, while long-term outcomes may converge over time due to the influence of other patient-related risk factors. The reduction in early wound infection is clinically meaningful, given the well-established association between wound infection and a markedly increased risk of burst abdomen and subsequent incisional hernia (van't *et al.*, 2004). This mechanistic pathway is supported by trials like STITCH, which demonstrated that an optimized mass closure technique ('small bites') simultaneously reduced both surgical site infection and incisional hernia rates at one year (Deerenberg *et al.*, 2022).

Incisional hernia rates in the present study were low and comparable between the two groups at one-year follow-up, with no statistically significant difference. This observation supports the concept that incisional hernia development is multifactorial and influenced not only by closure technique but also by patient-related factors such as age, wound infection, postoperative chest complications, and early wound disruption (Alrashidi *et al.*, 2025; Deerenberg *et al.*, 2022). As incisional hernias may

present several years after surgery, a longer follow-up period would be required to draw definitive conclusions regarding late outcomes (Dias Rasador *et al.*, 2024).

Minor complications, including suture sinus formation and postoperative scar tenderness, were infrequent and showed no difference between techniques. This finding likely reflects the uniform use of monofilament sutures in both groups, consistent with prior studies demonstrating lower sinus formation rates compared with multifilament materials (Bucknall *et al.*, 1982).

The present findings are further supported by published meta-analyses. Weiland *et al.* (1998) and Rucinski *et al.* (2001) concluded that mass closure is superior or at least equivalent to layered closure, with no clear advantage of nonabsorbable over absorbable monofilament sutures. Our results are concordant with these conclusions, demonstrating favorable early outcomes using absorbable monofilament continuous mass closure.

Recent comparative studies have reported similar trends. Kumar and Raju, (2022). observed higher rates of early wound complications and longer closure times with layered closure, concluding that mass closure is more time-efficient and cost-effective Shah *et al.* (2023). similarly reported significantly lower postoperative wound infection rates with single-layer closure compared with multilayer techniques. Other comparative trials have also demonstrated significantly reduced wound infection, burst abdomen, and operative time with mass closure compared to layered closure techniques. In contrast, Tocchi *et al.* (2000) reported higher rates of wound infection and incisional hernia with mass closure in a large retrospective cohort. Differences in study design, suture materials, patient populations, and risk profiles may account for this discrepancy. Such findings highlight the importance of patient selection and standardized technique when interpreting comparative outcomes.

Finally, the significantly shorter hospital stay observed in the mass closure group ($p = 0.004$) reinforces the overall clinical benefit of this technique, reflecting reduced early wound morbidity and faster postoperative recovery.

5. Conclusion

In conclusion, while long-term outcomes such as incisional hernia were comparable between techniques within the follow-up period, mass closure offered clear advantages in operative time, early wound integrity, and length of hospital stay. These findings support the routine use of mass closure for midline laparotomy in myomectomy patients.

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Conflict of interest

All authors have no conflict of interest.

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Author contribution

Sameh Abdelmoneim Abdelhamed: (corresponding author): Research idea, design of work, data collection, clinical assessment;

Heba M. Mohammed: Data collection, supervision, clinical assessment; **Ahmed Abdelkareem Abdelaleem Badr:** Data collection, supervision, clinical assessment; **Kareem El-Nahhas:** Manuscript writing, data collection, supervision, clinical assessment. All the authors have read and approved the final version of the manuscript. **Sameh Abdelmoneim Abdelhamed**, had full access to all of the data in this study and takes complete responsibility for the integrity of the data and the accuracy of the data analysis.

References

Alrashidi, A., A.W. Hageen, M. Rifai, M. Sameh, A.G. Elshaar, J.A. ALAmri, M.M. Dabi, M. Imam, H. Talaq, M. Ebrahim, Y.F. Almazyad, A.A. Ibrahim and M. Elmahi, 2025. Small Bites Versus Large Bites for Closure of Midline Abdominal Incisions: A Systematic Review and Meta-Analysis

- With Trial Sequential Analysis of Randomized Controlled Trials. *World J Surg.* 2025 Jun;49(6):1449-1465. doi: 10.1002/wjs.12619.
- Bucknall, T.E., P.J. Cox and H.Ellis, 1982. Burst abdomen and incisional hernia: a prospective study of 1129 major laparotomies. *Br Med J (Clin Res Ed)*. 1982 Mar 27;284(6320):931-3. doi: 10.1136/bmj.284.6320.931.
- Chowdhury, S.K. and S.D. Choudhury, 1994. Mass closure versus layer closure of abdominal wound: a prospective clinical study. *J Indian Med Assoc.*, 92(7):229-32.
- Deerenberg, E. B, N. A. Henriksen, G. A. Antoniou, S. A. Antoniou, W. M. Bramer, J. P Fischer, R. H Fortelny, H. Gök, H. W. Harris, W. Hope, C.M Horne, T. K Jensen, F. Köckerling, A. Kretschmer, M. López-Cano, F. Malcher, J. M Shao, J. C. Sliker, G. H. J. de Smet, C. Stabilini, J. Torkington, F. E .Muysoms, 2022. Updated guideline for closure of abdominal wall incisions from the European and American Hernia Societies, *BJS*, Volume 109, Issue 12, December 2022, Pages 1239–1250, <https://doi.org/10.1093/bjs/znac302>.
- Deerenberg, E.B., J.J. Harlaar, E.W. Steyerberg, H.E. Lont, H.C. van Doorn, J. Heisterkamp, B.P. Wijnhoven, W.R. Schouten, H.A. Cense, H.B. Stockmann, F.J. Berends, F.P.H. Dijkhuizen, R.S. Dwarkasing, A.P. Jairam, G.H. van Ramshorst, G.J. Kleinrensink, J. Jeekel and J.F. Lange, 2015. Small bites versus large bites for closure of abdominal midline incisions (STITCH): a double-blind, multicentre, randomised controlled trial. *Lancet*, 26;386(10000):1254-1260. doi: 10.1016/S0140-6736(15)60459-7.
- Dias Rasador, A.C., S. Mazzola Poli de Figueiredo, M.G. Fernandez, Y.J.M. Dias, R.R.H. Martin, C.A.B. da Silveira and R.Lu, 2024. Small bites versus large bites during fascial closure of midline laparotomies: a systematic review and meta-analysis. *Langenbecks Arch Surg.*, 22;409(1):104. doi: 10.1007/s00423-024-03293-0.
- Diener, M.K., S. Voss, K. Jensen, M.W. Büchler and C.M.Seiler Elective, 2010. midline laparotomy closure: the INLINE systematic review and meta-analysis. *Ann Surg.*,;251(5):843-56. doi: 10.1097/SLA.0b013e3181d973e4.
- Dudley, H.A., 1970. Layered and mass closure of the abdominal wall. A theoretical and experimental analysis. *Br J Surg.*, 57(9):664-7. doi: 10.1002/bjs.1800570908.
- Fink, C., P. Baumann, M.N. Wente, P. Knebel, T. Bruckner, A. Ulrich J. Werner, M.W. Büchler and M.K. Diener, 2014. Incisional hernia rate 3 years after midline laparotomy. *Br J Surg.*, 101(2):51-4. doi: 10.1002/bjs.9364.
- Israelsson, L.A. and T.Jonsson, 1994. Closure of midline laparotomy incisions with polydioxanone and nylon: the importance of suture technique. *Br J Surg.* 1994 Nov;81(11):1606-8. doi: 10.1002/bjs.1800811114.
- Jenkins, T.P., 1976. The burst abdominal wound: a mechanical approach. *Br J Surg.*, 63(11):873-6. doi: 10.1002/bjs.1800631110.
- Kumar, K.L.S. and M S. S. Raju 2022.. A comparative study of mass closure versus layered closure in midline laparotomy incisions. *Int. J. Surg. Sci.* 2022;6(1):39-41. DOI: 10.33545/surgery.2022.v6.i1a.816
- Leaper, D.J., A. Allan, R.E. May, A.P. Corfield and R.H. Kennedy, 1985. Abdominal wound closure: a controlled trial of polyamide (nylon) and polydioxanone suture (PDS). *Ann R Coll Surg Engl.*, 67(5):273-5.
- Murugan, A., M. Karthik and A. Nilakantan, 2021. Layered Closure Versus Retention Closure Technique for the Abdominal Wall in Midline Laparotomy: A Longitudinal Cohort Study. *Journal of Clinical and Diagnostic Research*, 15(10): PC01-PC05. DOI: 10.7860/JCDR/2021/50007.15497
- Niggebrugge, A.H., J.B. Trimbos, J. Hermans, B. Knippenberg and C.J.van de Velde, 1997. Continuous double loop closure: a new technique for repair of laparotomy wounds. *Br J Surg.*, 84(2):258-61.
- Poole, G.V. Jr., 1985. Mechanical factors in abdominal wound closure: the prevention of fascial dehiscence. *Surgery.* 1985 Jun;97(6):631-40.
- Rucinski, J., M . Margolis, G. Panagopoulos and L. Wise, 2001. Closure of the abdominal midline fascia: meta-analysis delineates the optimal technique. *Am Surg.* 2001 May;67(5):421-6.

- Shah, Z., Abdul Jabbar, N. Manzoor, M. Zubair and M. Y. Shah, 2023. The Frequency of Wound Infection with Single Layer versus Multiple Layer Closure of Wound in Patients undergoing Major Surgeries. *Pakistan Armed Forces medical journal: a journal of Army Medical Corps*, v.73 suppl.-1, 2023.
- Tocchi, A., G. Liotta, G. Mazzoni, L. Lepre, G. Costa, N. Agostini, B. Tomei, M. Miccini and A. Giuliani, 2000. Sutura per strati e in piano unico nella chiusura di laparotomie mediane [Layered and mass sutures in the closure of median laparotomies]. *G Chir.* 2000 Nov-Dec;21(11-12):463-8. Italian.
- van't, R.M., P.J. De Vos Van Steenwijk, H.J. Bonjer, E.W. Steyerberg and J. Jeekel, 2004. Incisional hernia after repair of wound dehiscence: incidence and risk factors. *Am Surg.* 2004 Apr;70(4):281-6.
- Weiland, D.E., R.C. Bay and S. Del Sordi, 1998. Choosing the best abdominal closure by meta-analysis. *Am J Surg.*, 176(6):666-70. doi: [10.1016/s0002-9610\(98\)00277-3](https://doi.org/10.1016/s0002-9610(98)00277-3).