Incisional Hernia Prevention By Modification of The Abdominal Wall Closure Technique: Systematic Review And Meta-analysis

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Research Article

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Abstract

Background: Incisional hernia (IH) is the main complication after laparotomy. The objective of this meta-analysis was to evaluate the effectiveness of closure technique modification (CTM) for reducing the incidence of IH to provide objective support for its recommendation.

Methods: A meta-analysis was performed according to the PRISMA guidelines. The primary objective was to determine the incidence of IH, and the secondary objective was to determine the incidence of acute evisceration and postoperative complications. Only published clinical trials were included. The risk of bias was analyzed, and the random effects model was used to determine statistical significance.

Results: Nine studies comparing 2,612 patients were inclued. The incidence of IH was significantly lower in the CTM group than in the control group, with an OR of 0.39 (95% CI 0.26-0.57). The incidence of acute postoperative evisceration was also reduced, with an OR of 0.46 (95% CI 0.23-0.92). Associated complications, including hematoma, seroma, and postoperative pain, could not be analyzed; however, CTM did not increase the risk of surgical site infection.

Conclusion: CTM for midline laparotomy significantly reduces the incidence of IH compared to conventional closure. Limitations of the analysis included differences in follow-up, patient selection, diagnostic methods, and the reporting of postoperative complications among the studies.

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Registration: This study was prospectively registered in the PROSPERO database under registration number CRD42021231107.

Background

The main complication after laparotomy is incisional hernia (IH), which has an incidence of 10-23% (1), although this can increase to up to 40% in specific risk groups (2). IH is often asymptomatic; however, in some patients, it is a significant a cause of morbidity (pain), in addition to having a negative effect on the patient's quality of life and body image (3). The European Hernia Society (EHS) established the current recommendations for abdominal wall closure: avoid the midline as much as possible, perform continuous suturing, avoid the use of rapidly absorbable suture materials, suture in a single layer without closure of the peritoneum, and follow the Jenkins 4:1 rule (for suture length/wound length) (4). The objective is for the incidence of IH in low-risk patients to remain at an acceptable level and for the incidence of IH in high-risk patients to approach the incidence for low-risk patients. The economic impact of this complication is estimated to be close to 3 billion dollars annually in the United States; therefore, efforts have been made to reduce its incidence. The prevention of IH is focused on 3 strategies: 1. Prehabilitation, 2. Modifying the closure technique and 3. Using meshes to reinforce the closure (5). The actual impact of prehabilitation on the reduction of IH has not yet been determined, and in patients undergoing emergency surgery, prehabilitation is not possible. Therefore, at present, the options for reducing the incidence of this complication focus on the use of prophylactic meshes (2-3,6-11) and on modifying the laparotomy closure technique. Evidence indicates that the use of prophylactic mesh is a safe and effective procedure in both clean and clean-contaminated surgery, but there is insufficient evidence for contaminated or dirty surgeries (12-14); nonetheless, its use has not yet become widespread. A survey conducted by Fisher et al. (2019) found that 85% of the surgeons surveyed did not use a prophylactic mesh because they were not familiar with the literature or because they did not generally use meshes for this purpose (15). Regarding modification of the abdominal wall closure technique, studies report good results for the prevention of this

complication (1,16-18,23,26); however, no closure modifications have obtained reductions in IH like those obtained with the use of mesh. The objective of this meta-analysis is to evaluate the safety and efficacy of modified closure techniques for reducing the incidence of IH and decreasing acute postoperative evisceration and to describe the complications associated with the implementation of these techniques to provide objective support for their recommendation.

Methods

This study was conducted and reported according to the PRISMA 2020 guidelines (19). It was prospectively registered in the PROSPERO database on February 13, 2021, under registration number CRD42021231107.

Data sources and search terms

An electronic search was performed until February 26, 2021, using 8 databases: Web of Science, PubMed, Cochrane Library, SCOPUS, ScienceDirect, Proquest, MEDLINE and Google Scholar. The following terms were used in the search strategy: “abdominal wall closure technique” OR “suture technique for abdominal wall closure” OR “laparotomy closure” OR “midline laparotomy closure” OR “closure of abdominal wall” OR “prevention of incisional hernia” OR “prophylactic of incisional hernia” OR “prevent incisional hernia” OR “adjuvant to abdominal wall closure” OR “prevent fascial dehiscence” OR “prophylaxis of incisional hernia” OR “abdominal closure hernia prevention” AND “randomized clinical trial” NOT “mesh” NOT “prophylactic mesh reinforcement”.

Study selection, data extraction and quality assessment

The title and abstract of the studies were analyzed to determine their eligibility. This analysis was performed by 3 independent reviewers. After this first review, the full text of considered studies was evaluated, and only clinical trials were included. The methodological quality of the studies was evaluated using the Scottish Intercollegiate Guidelines Network (SIGN) guidelines, and the risk of methodological bias of the studies was assessed using the Cochrane Collaboration tool (20). The following aspects were analyzed: random sequence generation; allocation concealment; blinding of patients, staff, or assessors; blinding of researchers; incomplete outcome data; selective reporting of results; and other sources of bias. The evaluation of the methodological quality and risk of bias was performed by 3 independent reviewers, and the studies were identified as having a low or high risk of bias. Any disagreement regarding the selection of a study was resolved by consensus.

Only controlled and randomized clinical trials that met the following inclusion criteria were included: patients older than 15 years, elective or emergency surgery, midline laparotomy only, high, or low risk of IH, regardless of the cavity characteristics during the intraoperative period (clean, clean-contaminated, contaminated, or dirty), and modification of the typical abdominal wall closure technique. The primary objective of the review was to determine the incidence of IH, as defined in each study. The secondary objective was to determine the incidence of acute postoperative evisceration (wound dehiscence), and the third was to determine the presence of complications associated with each type of closure: surgical site infection, hematoma, and seroma. There was no language restriction, and only results from published studies were included.

A table was created that synthesized the included articles that were identified in the search. The table included the following information: study characteristics (author, year of publication and number of patients included), inclusion/exclusion criteria, details of the technique modification and control group, outcomes, IH diagnostic method and follow-up time.

Statistical analysis

A meta-analysis was performed in which the results of the analyzed studies were grouped. A sensitivity analysis was performed to reduce the risk of bias of the primary objective reported in the studies; additionally, a subgroup analysis was performed to evaluate the incidence of acute evisceration and complications. The odds ratio (OR) and its 95% confidence interval (CI) were calculated with a random effects model, and the effect was considered statistically significant if the 95% confidence interval did not include 1. The I^2 statistic was calculated to evaluate heterogeneity. The bias analysis was reported using funnel plots and the Egger's test was used to assess publication bias. These analyses were performed using Review Manager software (RevMan version 5.3), and a p-value less than 0.05 was considered statistically significant.

Results

A total of 552 articles were identified as potentially eligible in the different databases. After duplicate articles were removed, the title and abstract were reviewed, studies that did not meet the inclusion criteria were removed, 25 articles were chosen. After the full text was read, 16 articles were excluded: 8 because they compared different types of suture material; 2 because they included different types of incisions in addition to midline incisions; 4 because they were protocols of ongoing studies; and 2 because they were protocols of published studies (Figure 1). In total, 9 clinical trials met the inclusion criteria (1, 16-18, 21-26). Their risk of bias was analyzed and is reported in Figures 2 and 3.

A total of 2,612 patients were included in the 9 analyzed clinical trials, and the study and patient characteristics are shown in Table 1. The modifications of the abdominal wall closure technique differed among the studies: Niggebrugge et al. (continuous double-loop closure, CDLC), Marwah et al. (closure after rectus sheath relaxation incisions), Milbourn et al. (small bites), Agarwal et al. (reinforced tension line, RTL), Khorgami et al. (retention sutures), Deerenberg et al. (small bites), Dhamnaskar et al. (Smead-Jones technique), Peponis et al. (interrupted fascial closure) and Lozada et al. (RTL). Figure 4 shows these techniques.

The general inclusion criteria were as follows: undergoing midline laparotomy, emergency, or scheduled surgery; patients older than 15 years; and modification of the laparotomy closure technique. The individual inclusion criteria were diverse and included emergency or scheduled surgery, generalized peritonitis, incision longer than 10 cm, malnutrition, emergency surgery or contaminated surgery, use of steroids, hemodynamic instability, hemoglobin <10 mg/dL, prediction of postoperative abdominal distension (ascites or ileus), bilirubin >3, diabetes, rectal cancer surgery or a score >6 on the Rotterdam scale. Table 1.

The control group: in six studies were standardized to large-bite closure at 1 cm from the wound edge with 1-cm advancements (1,16,18, 21, 23, 25). Two studies do not clearly describe the procedure used for the control group, but both used nonabsorbable or slowly absorbable no. 1 suture, and most used continuous suturing (22,26) Only one study used interrupted fascial closure in the control group (24). Table 1.

Outcome measurement

The main outcome evaluated was the incidence of IH. The follow-up duration was not uniform and ranged from 6 months to 3 years. Only studies that had a minimum follow-up of one year were included in the analysis of the primary outcome, thus five articles were included in the global quantitative analysis of this outcome, and the risk of bias was evaluated (1,16,18,23,25). The meta-analysis showed a statistically significant reduction in IH in patients who underwent modified closure compared to patients who underwent conventional closure (OR 0.39, 95% CI 0.26-0.57) (Figure 5a). The funnel plot showed high asymmetry, with an I^2 of 24% and a p-value of 0.26, which indicates a low risk of bias (Figure 5b).

The secondary outcomes were the presence of wound dehiscence and complications associated with the closure type. Regarding wound dehiscence, 9 articles were included in the quantitative analysis. The global meta-analysis showed a statistically significant difference in the reduction of the incidence of evisceration with the use of a modified closure technique compared with conventional closure (OR 0.46, 95% CI 0.23-0.92) (Figure 6a). The funnel plot showed low asymmetry, with an I^2 of 47% and a p-value of 0.06, which indicates a high risk of bias (Figure 6b).

Regarding complications associated with the closure type, there was not sufficient data to compare the presence of seroma, hematoma and pain or quality of life (Table 2). One study did not report this complication. Only the presence of surgical site infection could be compared; the meta-analysis showed that there was no significant difference between patients who underwent modified closure compared to patients who underwent conventional closure (OR 0.83, 95% CI 0.66-1.05) (Figure 7a). The funnel plot showed high asymmetry, with an I^2 of 0% and a p-value of 0.48, which indicates a low risk of bias (Figure 7b).

Discussion

The present study showed that modification of the closure technique for midline laparotomy significantly decreases the incidence of IH compared to conventional closure. This significant effect was identified for 3 techniques: small bites, RTL, and retention sutures. The use of retention sutures showed a decrease in the occurrence of IH; however, the retention sutures were removed at 3 or 4 weeks, and after the 4th day, greater pain was reported for this group than for the control group; other studies have used this type of closure with contradictory results, and it has been suggested that it should only be used in high-risk patients (27).

The small bites technique is currently the one with the most scientific evidence of its effectiveness for reducing the incidence of IH. The EHS recommends its use in low-risk patients, and efforts are being made to make its use widespread (28-30). In both studies in which the small bites technique was used (1,23), it was applied in patients with different degrees of IH risk, the follow-up time was 1 year, and no benefit was found for reducing the incidence of postoperative evisceration; however, it should be noted that the incidence of this complication was very low, and thus, the usefulness of the technique cannot be objectively determined. The RTL technique was used in 2 studies (18,26) that demonstrated its usefulness for reducing the incidence of IH; it was performed in high-risk patients, in 1 study the follow-up time was 3 years, and both studies found that its usefulness for reducing the incidence of postoperative evisceration was good.

The meta-analysis also showed that modification of the closure technique is safe and does not increase the risk of surgical site infection; however, this relationship could not be confirmed for other complications.

The limitations of this meta-analysis include the great variety of techniques used for closure of the abdominal wall, which makes it difficult to recommend a single technique. There was low heterogeneity regarding the presence of IH, but the analysis of the presence of evisceration and/or eventration showed very high heterogeneity resulting from the variability in the closure techniques used and the selection of study subjects, as previously stated.

A great variety of techniques were used to modify the conventional closure technique, and the suture length/wound length ratio (SL/WL) and compliance with the Jenkins rule were only reported for the small bites and RTL techniques; hence, adherence to the appropriate closure method in the control groups was not clear. Only the RTL and retention suture techniques showed efficacy for reducing both complications – IH and evisceration – but the use of retention sutures had the disadvantage of associated postoperative pain.

Another limitation in the final analysis was the duration of follow-up for reporting the incidence of IH, as the range was very wide, six months (1), one year (22-23) or three years (18). The selection of participants also differed for all the studies, and there was no standardization of high or low risk, similar studies examining the use of other closure techniques, such as mesh.

In most of the studies, only clinical follow-up was used to determine the presence of IH, and only 2 studies reported the use of ultrasound and computed tomography. Hence, the use of imaging techniques could increase the number of patients diagnosed with subclinical IH and provide a more accurate estimate of the effect of these interventions on decreasing this complication.

When the overall outcome of IH was analyzed, the group that underwent a modified closure technique had an IH incidence of 9.5%, compared to 20% in the patients who underwent conventional closure. Both rates are like the results reported with the use of mesh. Currently, there are ongoing studies comparing the use of these modified closure techniques with the use of mesh, and in the future, these studies may provide objective support for the use of one technique over another.

Another important issue is definition of the criteria used to determine which patients should be considered high-risk. The studies included in this meta-analysis had highly varied inclusion criteria and considered different factors when determining this risk. Only one study used a validated scale, (although this validation was for wound dehiscence a not for IH) (18) to define high and low risk. However, there is still no consensus in the literature on any useful scale for predicting which patients should be considered high or low risk.

Conclusions

This meta-analysis showed that modification of the closure technique for midline laparotomy significantly decreases the occurrence of IH compared to conventional closure.

The results showed that only the small bites, RTL and retention suture techniques decrease the presence of IH, and that only RTL and retention suture techniques decrease the incidence of postsurgical evisceration, but retention suture technique present greater postoperative pain when compared with the usual technique and in other non-randomized studies and not included in this meta-analysis present controversial results.

Due to the great variety of techniques used and the differences in the inclusion criteria for the control group, a technique of choice cannot be established. At this time, different studies are being conducted to compare the effectiveness of these techniques with the use of meshes, which should lead to an objective recommendation.

Abbreviations

IH Incisional Hernia

CTM closure technique modification

OR Odds ratio

CI confidence interval

EHS European Hernia Society

RTL Reinforced Tension Line

Declarations

Ethics approval and consent to participate

This review was approved by the local commitee for clinical research and ethics committee: Number registration: CI/HRAEB/029/2020

Registration: This study was prospectively registered in the PROSPERO database under registration number CRD42021231107.

Consent for publication

According to the study publication

Availability of data and material

The database is available for review

Competing interests

The authors declare that they have competing interests

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Authors' contributions

LHEE, HBJP: Protocol/project Development, Data collection or management, Manuscript writing/editing, data analysis. **HUD, MGM, MGJC, ZVLA**, **OME, VRJR and JHAE:** Protocol/project Development, Data collection or management. All authors have read and approved the manuscript.

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Tables

Table 1. Summary of findings for included studies on the IH prevention by modification of the abdominal wall closure technique.

Study, year	Inclusion and exclusion criteria	Description of the modification of closure technique and used closure in the control group	Outcome measurements	Diagnosis of IH (Clinical/Radiological)	Follow-up (months)
Niggebrugge 1999	Older than 15 years undergoing an elective or emergency surgery. Excluded: patients who had a laparotomy in the previous 3 months.	The CDLC technique consists of a running suture that forms outer and inner loops in one plane. Stress on the outer loop produces tension in the inner loop that approximates the wound edges. It passes through all layers of the abdominal wall at 2 cm from the wound edges, and again through anterior fascia, muscle, and posterior fascia at 1 cm from the wound edges. Adjacent loops were close together in the two groups (1 cm). Closure of the peritoneum was not advocated (Figure 4). The closure in the control group: technique was a continuous mass-closure technique that encompasses all layers of the abdominal wall apart from the skin. The margins between suture and wound edge were at least 1 cm.	IH, Wound Infection, Pain, haematoma, wound dehiscence, Ileus and Relaparotomy.	Clinical	1
Marwah 2005	Generalized peritonitis who underwent emergency laparotomy through midline incisions.	A longitudinal incision was then made through each anterior rectus sheath about 6 to 7 cm lateral to the incision line, which relaxed the rectus sheath flap and exposed the anterior surface of the rectus muscle. The fascial edges	IH, Wound dehiscence, Wound Infection, Pain, and Ileus.	Clinical	6

		of the linea alba were thereafter sutured in the midline with continuous nonabsorbable polypropylene (Figure 4). Control group: the laparotomy wound closure consisted of a single layer of continuous suturing of fascial edges of the linea alba with nonabsorbable polypropylene in the midline. The skin and subcutaneous tissue were approximated with interrupted nonabsorbable sutures.			
Millbourn 2009	Patients older than 18 years who underwent emergent or planned surgery. Excluded: Patients with a previous midline incision, a previous abdominal incision crossing the midline, or a preexisting ventral hernia such as an umbilical or epigastric.	The short stitch group, surgeons were urged to place stitches 5 to 8 mm from the wound edge and to include only the aponeurosis in the stitches. In this group, 2-0 polydioxanone suture on a needle with a half-circle, tapered point and a diameter of 20 mm was used (PDS II suture and MH-1 needle: Ethicon GmbH) (Figure 4). The long stitch length, the previous standard technique for wound closure at the department was used and stitches were placed at least 10 mm from the wound edge. For the long stitch group, a 1-0 polydioxanone suture on a needle with a half-circle, tapered point and a diameter of 41	IH, Wound dehiscence, Wound Infection.	Clinical	12

		mm was used (PDS II suture and TP-1 needle; Ethicon GmbH).			
Agarwal 2011	Patients older than 18 years who underwent emergent surgery.	RTL (reinforced tensión line). The rectus sheath is cleared about 1.5 cm laterally linea alba. The longitudinal suture (polydioxanone) is inserted using a 65-mm 1/2 needle parallel to the linea alba, starting at the lower end of the incision, as a continuous suture on both sides, after first clearing the fat about 2 cm from it. The ends are held by haemostats inferiorly. Then the continuous suture (again polydioxanone) is placed using again a 65-mm 1/2 needle, taking care that the points are introduced laterally to the longitudinal suture. This suture is tied and knotted, the subcutaneous sutures and skin sutures are used to close the wound (Figure 4). Control group: A simple suture loop polydioxanone (PDS) was used as suture material and a 65-mm 1/2 needle was used in all patients who underwent abdominal closure by simple closure.	Wound dehiscence Intra-abdominal pressure	Clinical	1
Khorgami 2013	Inclusion criteria: 10-cm surgical incision minimum, and having 2 of the following preoperative risks factors: poor nutritional status (clinical cachexia	Retention sutures were added using a #1 nylon string every 10 cm and contained 5 cm of the skin, subcutaneous tissue, rectus muscle, and	IH, Wound Infection, Pain, haematoma, wound dehiscence, Ileus and Relaparotomy.	Clinical Ultrasonography	3-15

	or hypoalbuminemia); emergent surgery; intra-abdominal infection; uncured extensive-stage malignancy; use of corticosteroids in the last 12 mo (>10 mg/d prednisolone or equivalent for ≥3 mo); uremia; hemodynamic instability (BP ≤ 90 mm Hg); hemoglobin 3 mg/dL); diabetes mellitus; and age >60 y. Patients younger than 18 y and those with an incision length of < 10 cm were excluded.	abdominal fascia (except peritoneum) on each side. The first retention suture was placed 5 cm above the lower end of the incision and repeated every 10 cm toward the upper part of the incision (Figure 4). Control group: the fascia was sutured continuously using a running looped #1 nylon string located 1 cm from the edge of the linea alba with 1-cm intervals. The running suture was locked intermittently every 5 cm to divide the long continuous suture into multiple smaller sections. Subcutaneous tissue was not sutured, and skin was closed using interrupted suture of 3-0 nylon.			
Deerenberg 2015	Patients aged 18 years or older, elective abdominal surgery. Excluded patients with a history of incisional hernia or fascial dehiscence after midline laparotomy, those who had undergone abdominal surgery through a midline incision within the past 3 months, those who were pregnant, or those who had participated in another intervention trial.	The suture technique was applied with tissue bites of 5 mm and intersuture spacing of 5 mm. In all cases the stitch incorporated the aponeurosis only and incorporation of fat or muscle tissue was avoided (Figure 4). Group control: The conventional large tissue bites or mass closure technique was applied with tissue bites of at least 1 cm and intersuture spacing of 1 cm with USP 1 double loop PDS Plus II (Ethicon) with a 48 mm needle.	IH, Wound Infection, Pain, haematoma, wound dehiscence, Ileus and Relaparotomy, cardiac events, length of hospital stay, and health-related quality of life	Clinical Ultrasonography CT abdominal	12

Dhamnaskar 2016	Emergency midline laparotomy, age group of 18 to 70 years were included whose surgeries could be classified as contaminated or infected/dirty. Presence or suspicion of the abdominal compartment syndrome was excluded. Patients having previous midline laparotomy scars were excluded. Children and pregnant women were also excluded.	Smead-Jones closure technique of far-near and near-far suturing was interrupted. But we proposed continuous far-near and near-far suturing technique as modified Smead-Jones technique, which was used for midline fascial closure in the study group. In this technique suturing was done with points 'A' and 'D' being 1.5 cm away from the edge of the fascia and points 'B' and 'C' being 0.5 cm away from the fascial edge. The distance between two successive continuous sutures was not more than 1 cm. There was one 2 x 1 x 1 x 1 surgical knot at each end of laparotomy wound (Figure 4). In the controlled arm, midline closure was done with interrupted sutures 1.5 cm away from the cut margin/edge of fascia tied every time with 2 x 1 x 1 x 1 surgical square knots. Again, distance between two consecutive sutures was not more than 1 cm.	Wound dehiscence and wound infection	Clinical	1
Peponis 2018	Adult patients undergoing midline laparotomy for gastrointestinal emergencies were considered eligible for inclusion. Excluded patients who underwent elective operations, laparotomies due to trauma, were pregnant, did not	Interrupted closure was also performed with no. 0 nonlooped, slowly absorbable polydioxanone, sutures in a simple interrupted fashion. Again, sutures were placed at 10 mm from the fascial edge after	IH, Wound Infection, wound dehiscence, and mortality.	Clinical Ultrasonography CT Abdominal	24

	have their fascia closed, were not expected to survive for more than 2 days given their baseline comorbid status, had a primary ventral hernia with or without mesh in place, had undergone any abdominal operation within the last 30 days, or were unable to communicate in English.	advancing 10 mm (Figure 4). Patients in the continuous group had their fascia closed with no. 0 nonlooped, slowly absorbable polydioxanone sutures (Ethicon, Inc, Somerville, NJ). The ratio of suture length to incision length was kept at 4:1. A tapered needle was used, and the fascia was closed from both the superior and inferior edge of the wound simultaneously, with the sutures being placed at approximately 10 mm from the fascial edge and 10 mm advancement. The fascia was eventually closed in the middle of the incision, where the two sutures were knotted together with at least four-square knots or eight throws.			
Lozada 2021	Patients older than 18 years, emergency or scheduled, regardless of their underlying diagnosis, who were considered high risk, and who completed 3-year follow-up were included. All patients with a score of≥6 on the Rotterdam risk model were defined as high risk. Excluded were pregnant women, those who underwent any other protocol of wall closure, those for whom it was decided to manage the open abdomen	Two longitudinal and parallel suture lines were placed, each along the fascial aponeurotic edge. Suturing was started with a PDS Plus II suture number 1 needle of 48 mm in length at one end of the wound where the stitch ran longitudinally and parallel to the aponeurotic edge. The needle entered and exited at intervals of 1 cm and was kept 0.5–0.8 cm from the edge of the aponeurosis. Upon reaching the opposite angle of	IH, Wound Infection, Pain, haematoma, wound dehiscence, and seroma.	Clinical CT abdominal	36

at the end of the surgery, those with incomplete data who could not be classified on the Rotterdam scale, those who had a history of previous midline laparotomy, those who did not attend their postoperative check-ups, and patients reoperated through the same wound for a situation different from the IH and therefore did not complete the 3-year follow-up.	the wound, another suture with the same characteristics was used, repeating the process on the opposite aponeurotic edge. The ends of the two sutures were knotted at the angles. In this way, the aponeurotic wound was left with two suture lines reinforcing its edges. The wound was closed as indicated in the control group, always taking care that the stitch included and anchored the two longitudinal strands of reinforcement. The rest of the wound was closed in a conventional manner. No drains were left in the wound (figure 4). Control group: At the end of the surgical procedure, the abdominal wall was closed in masse with PDS Plus II monoflament number 1 (Ethicon) with a 48 mm needle, starting the suture of one of the ends of the wound. It was continued with a simple continuous stitch, advancing each point 1 cm away from the other and one centimeter away from the edge of the aponeurosis, in the midpoint of the wound, with knotting, following the Jenkins 4:1 rule. At the opposite end of the wound, the

	closure was started in the same way, and the closure of the aponeurosis was continued until it was more than 1 cm away from the previous stitch. The stitches were knotted separately, and the rest of the wound was closed in a conventional manner. There were no drains left.

Table 2. Comparison of reports of outcomes in meta-analysis.

Estudio	IncisionalHernia (IH)	Wound infection	Seroma	Hematoma	Wound Dehiscence (WD)	NNT
Niggebrugge 1999	⊗	✓	⊗	✓	✓	WD 35
Marwah 2005	✓	✓	✓	✓	✓	WD 7 IH 8.3
Millbourn 2009	✓	✓	⊗	⊗	✓	WD 500 IH 7.9
Agarwal 2011	⊗	⊗	⊗	⊗	✓	WD 7.7
Khorgami 2013	✓	✓	⊗	⊗	✓	WD 48 IH 29.5
Deerenberg 2015	✓	✓	⊗	⊗	✓	WD 142.8 IH 14.28
Dhamnaskar 2016	⊗	✓	⊗	⊗	✓	WD 6.25
Peponis 2018	✓	✓	⊗	⊗	✓	WD 333 IH 11.24
Lozada 2021	✓	✓	✓	✓	⊗	WD 7.7 IH 5.4

NNT Number necessary to treat for all techniques.

Figures

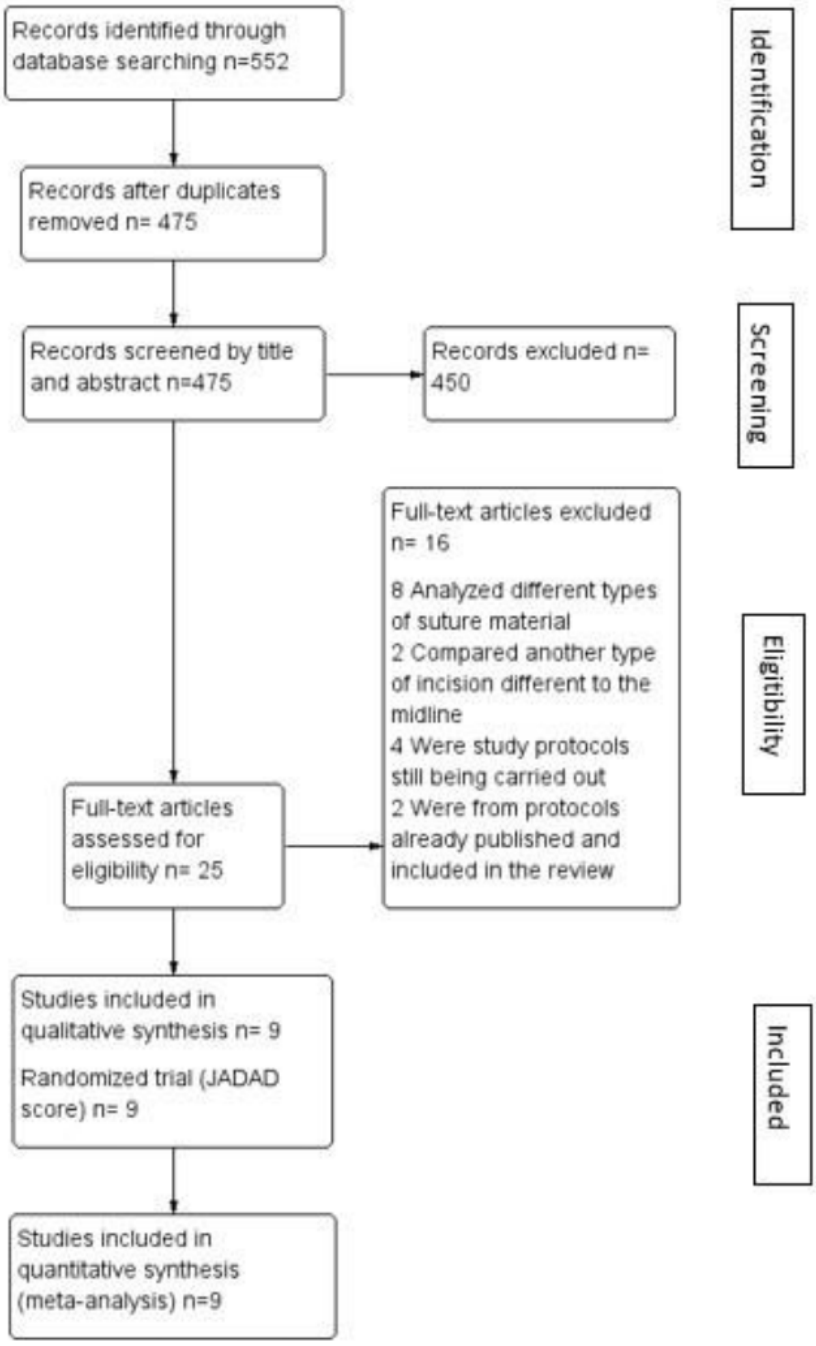

Figure 1

PRISMA digram for the review.

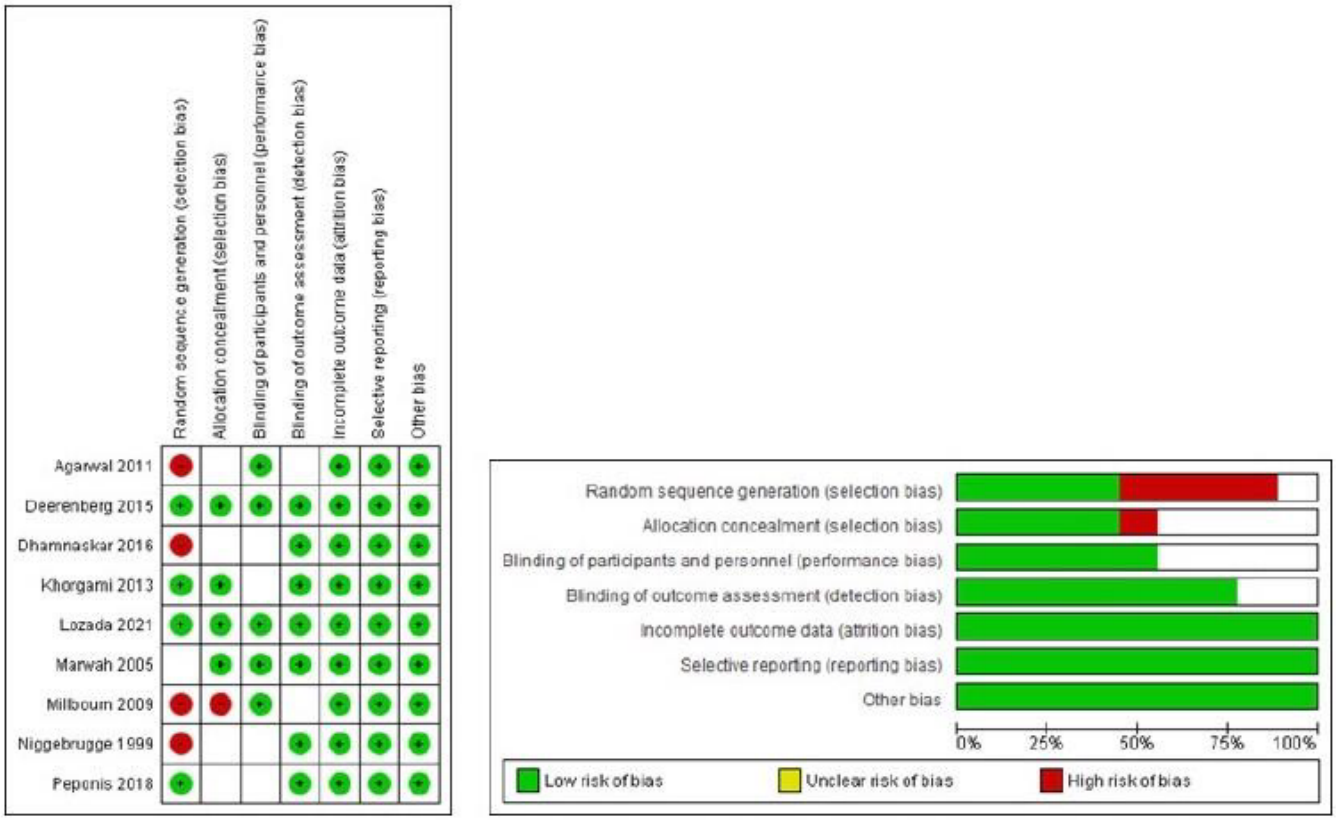

Figure 2 and 3. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

Figure 2

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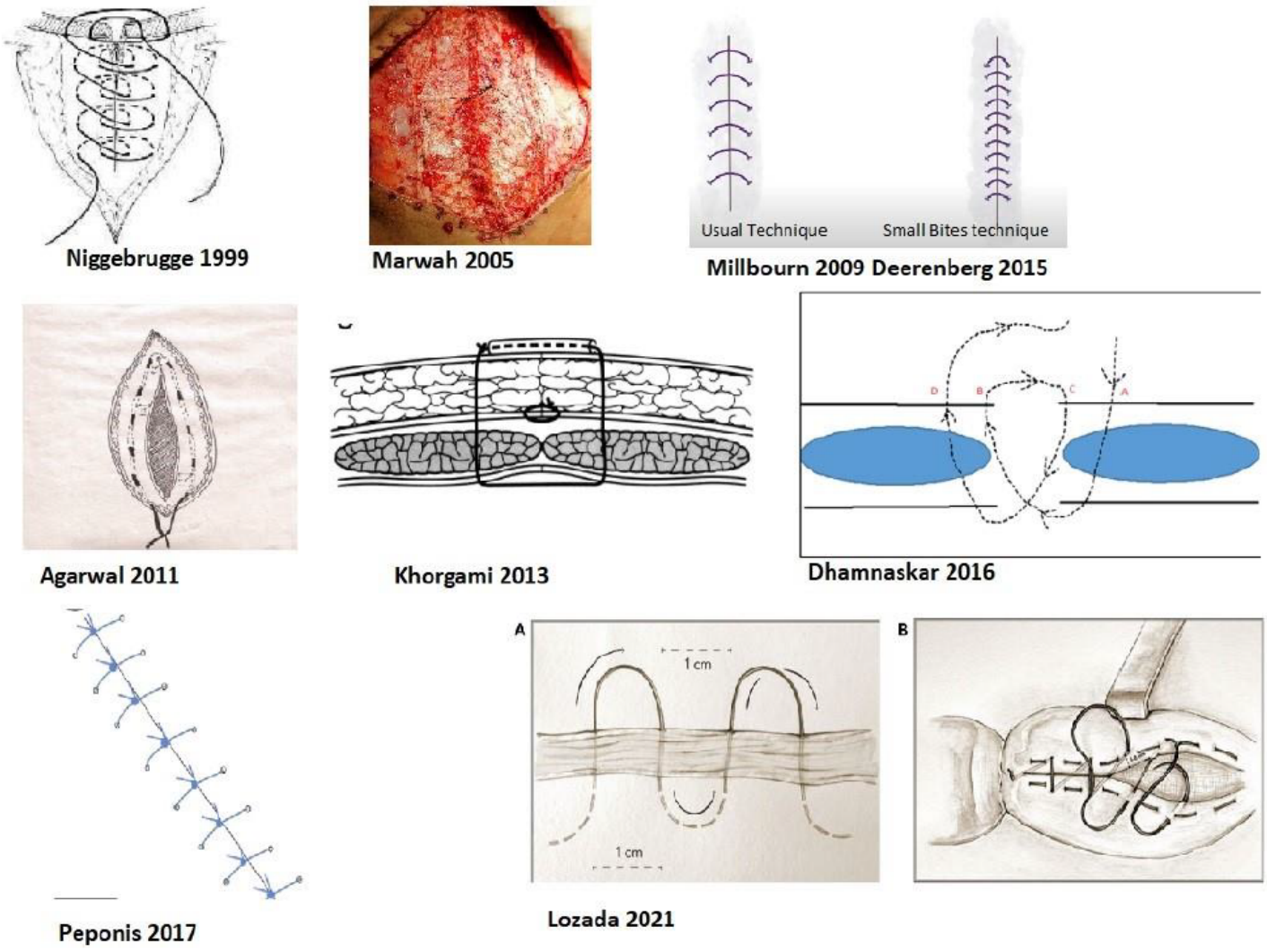

Figure 3

Representative images of each of the techniques analyzed.

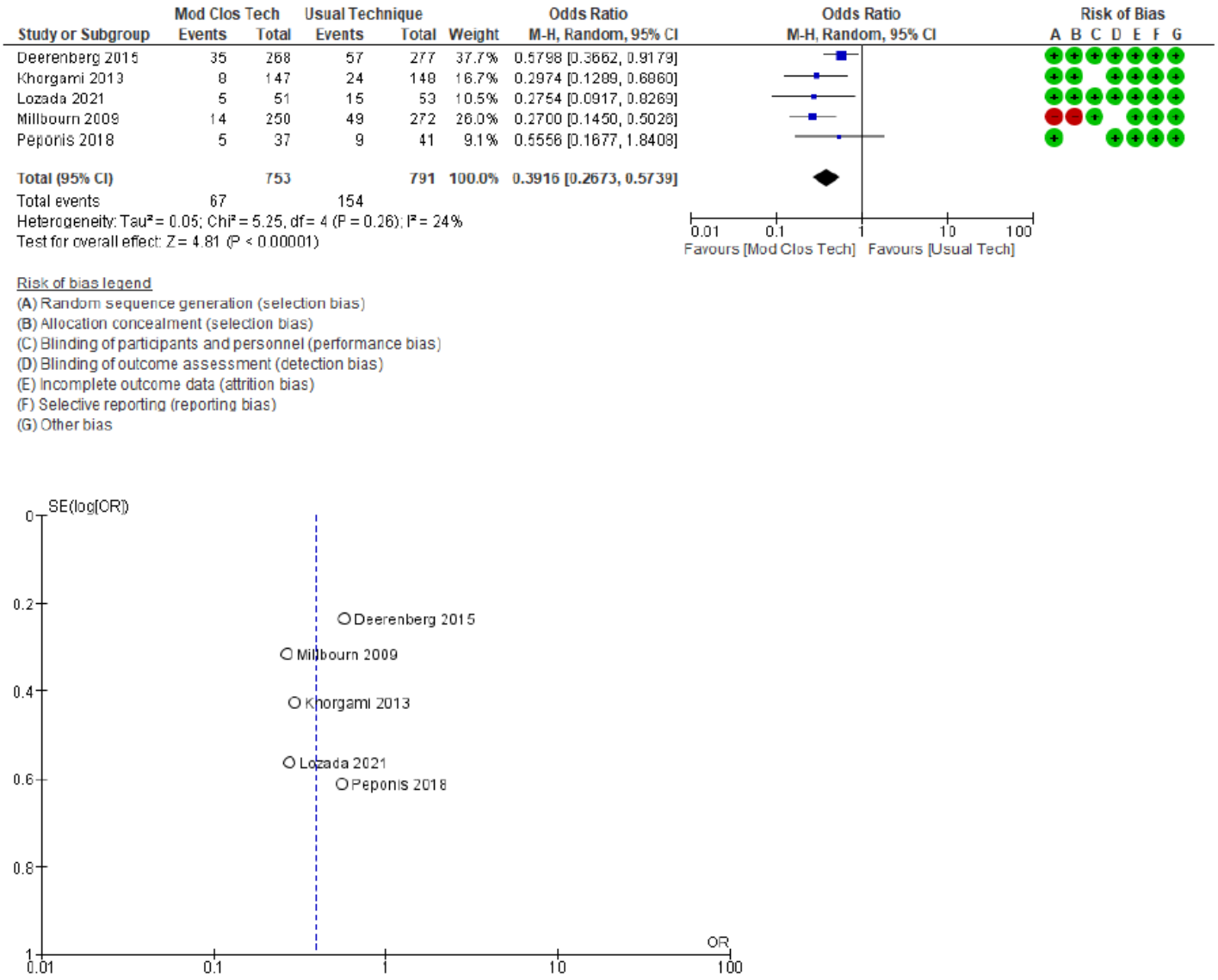

Figure 4

a. Forest plot of incisional hernia after modification closure technique of a midline laparotomy versus usual technique (studies with follow-up > 1 year). b. Funnel plot for risk of bias studies (Incisional Hernia follow-up > 1 year).

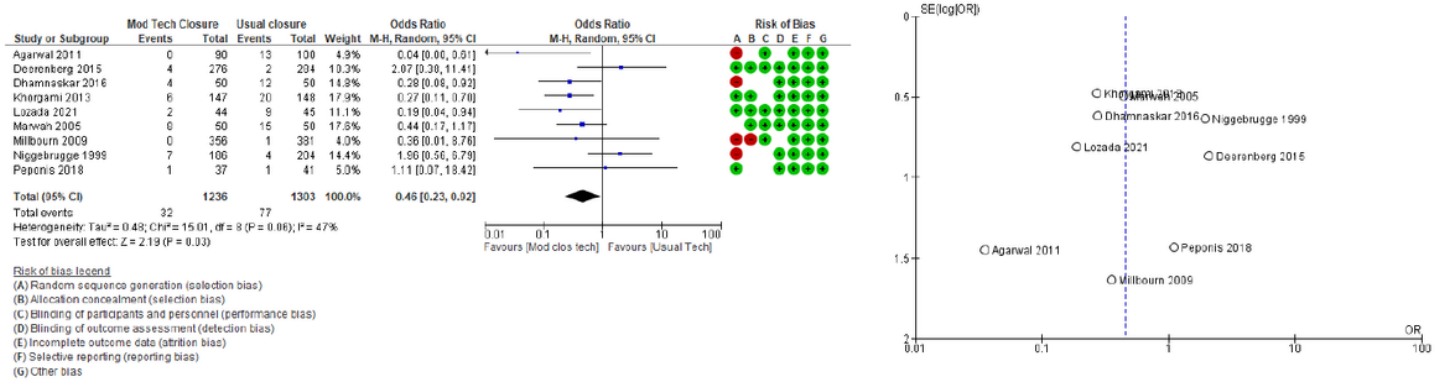

Figure 5

a. Forest plot of wound dehiscence after modification of closure technique of a midline laparotomy versus usual technique. b. Funnel plot for risk of bias studies (wound dehiscence).

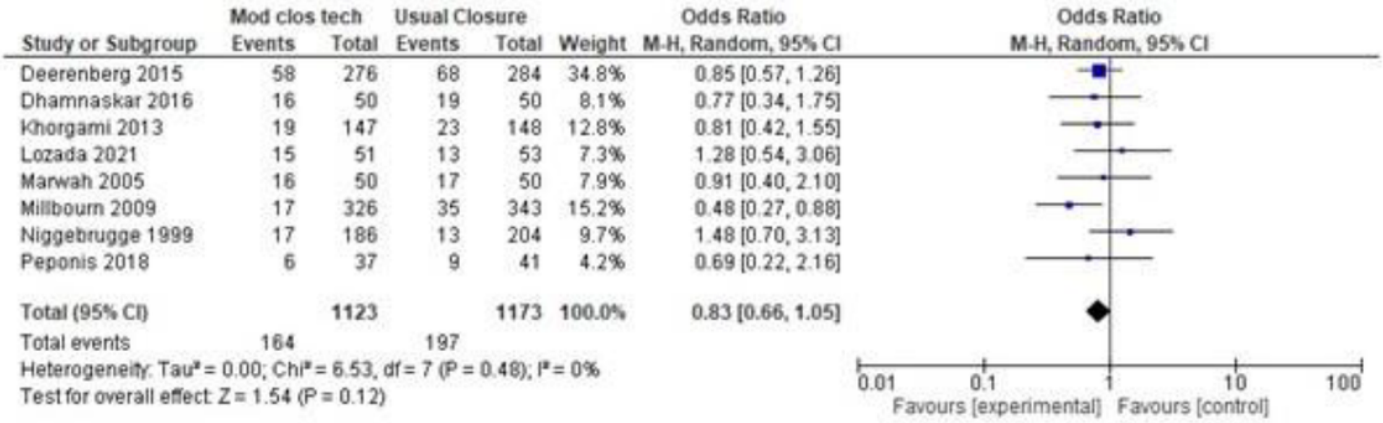

Figure 7a Forest plot of wound infection after modification closure technique of a midline laparotomy versus usual technique.

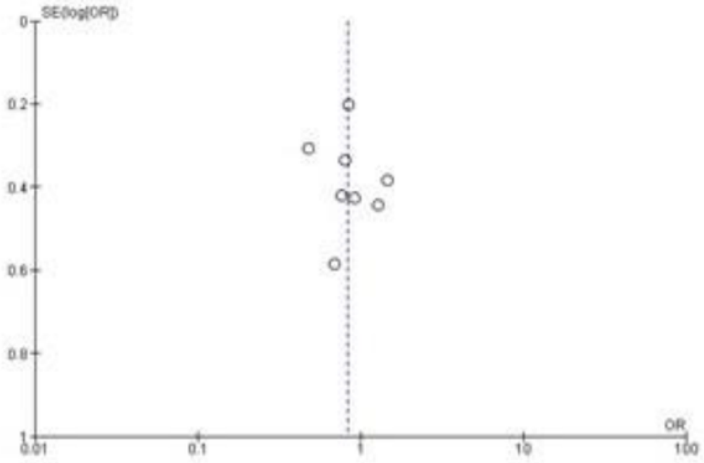

Figure 7b Funnel plot for risk of bias studies (wound infection)

Figure 6

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