Systematic Review / Meta-analysis

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Comparison between novel zipper device and conventional methods for skin closure: a systematic review and meta-analysis

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Introduction: The zipper device is a wound closure device that can be directly applied over the intact skin on either side of the wound edges and does not need anchoring into the skin or subcutaneous plane. The noninvasive nature of the zipper device makes it less time-consuming and less painful, but its effectiveness and related complications need to be studied.

Methods: Prospective registration of the protocol followed in this study was done. Electronic databases were searched for relevant articles, and their screening was completed, followed by data extraction and analysis. The odds ratio, mean difference, or standardised mean difference were used as an effect measure per the nature of the variables. Surgical site infection, wound dehiscence, skin closure time, scar score, and patient satisfaction were compared in this study.

Results: A total of 10 studies were identified, out of which eight compared zippers with sutures and two compared zippers with stapler devices. Compared to the suture, the zipper device took 4.9 min less to close the incision, and the scar scale outcome reported after one month was inferior, while other results were not significant. Staples showed a lower patient satisfaction level and no difference in complications.

Conclusion: The zipper device is a less technically demanding and less time-consuming method of skin closure, with no significant difference in the complication rate compared to conventional methods. The zipper device is an effective measure to use in settings with less expertise or at health institutions after assessing the cost at the local level.

Keywords: Skin closure, stapler, suture, zipper device

Introduction

Skin closure after surgery is an equally important aspect that determines the patient's outcome. The history of the use of foreign materials to suture dates back to 150 AD, when Galen of Pergamon used catgut as suture material[1]. Several newer methods, including synthetic sutures, staples, adhesive agents, and zipper devices, are currently in use. It is said that a surgical scar is the signature of a surgeon, but according to the needs of patients in today's world, surgeons prefer methods that deliver aesthetic closure. Rapid closure and a good cosmesis outcome with fewer complications are the priorities while treating skin wounds[2].

The zipper device is a novel, nontraumatic, and noninvasive wound closure device that is a hydrocolloid adhesive-based device that is designed to replace other conventional methods (sutures and staples) of skin closure[3]. Unlike conventional suturing methods, the zipper device is directly applied over the intact skin on either side of the wound edges and does not need anchoring into the skin or subcutaneous plane. The noninvasive nature of the zipper device makes it less time-consuming and less painful while placing and removing it, but its effectiveness and related complications need to be studied. Cheng-Xin Xie conducted a meta-analysis in 2020 (that included both randomised and non-randomised studies) to compare zipper devices with sutures and showed various advantages of the zipper devices[4]. But various randomised controlled trials have been published since then, so this study was conducted to give an updated view.

HIGHLIGHTS

- Zipper device does not need anchoring into the skin or subcutaneous plane.
- It is a less time-consuming method of skin closure.
- It has no significant difference in the complication rate compared to conventional methods.
- Zipper device is an effective measure to use in settings with lesser expertise or at health institutions.

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This systematic review and meta-analysis of randomized controlled trials aims to compare the outcomes of the zipper device with conventional methods (suture and staple) in terms of surgical site infection, wound dehiscence, skin closure time, scar score, and patient satisfaction.

Materials and methods

This study is in line with the PRISMA guidelines, Supplemental Digital Content 1, http://links.lww.com/MS9/A366[4] and the AMSTAR guidelines, Supplemental Digital Content 2, http://links.lww.com/MS9/A367[5].

Protocol registration

The prospective registration of the protocol used in this study was registered in the International Prospective Register of Systematic Reviews and in the Registry of Systematic Reviews/Meta-Analyses.

Search strategy

Relevant studies were searched in four electronic databases (PubMed, PubMed Central, Embase, and Scopus) with search terms like ("zipline device"), (zipper), ("surgical zipper"), ("wound closure strip"), (suture), (staple), ("skin closure") in combination with appropriate Boolean operators. No filters were applied during the search. Details of the search and the results of the search are available in Supplementary File 1, Supplemental Digital Content 3, http://links.lww.com/MS9/A368.

Inclusion criteria and exclusion criteria

Randomised controlled trials, published in the English language, that compared the outcomes of zipper devices to conventional skin closure methods (suture or staple) were included in this study. Other non-randomised trials, cohort studies, cross-sectional studies, case-control studies, commentaries, and editorials were excluded from the study.

Study selection

Results obtained from the search of the electronic databases were imported to Covidence[6] for screening. Two independent reviewers were involved in the first stage of screening (title and abstract screening), and a third reviewer resolved any conflict that arose during the screening phase. In the second stage of the screening (full-text screening), the roles of the reviewers were exchanged.

Data curation

Studies selected for qualitative synthesis were moved to the data extraction phase. Data were extracted using a template, under headings of study details, population, intervention, and comparator, made in Word. The author's list, the country in which the trial was done, the study period, the demographic profile, baseline characteristics of the population, the intervention, the comparator, and outcomes such as surgical site infection, wound dehiscence, skin closure time, and scar score were extracted. The data were refined, and analysis was carried out.

Data synthesis

Dichotomous variables were studied with odds ratios, and continuous variables were studied with standardized mean differences. The effect model, random or fixed effect, was chosen as per heterogeneity. Heterogeneity was assessed by the I^2 test. The fixed-effect model was chosen if the heterogeneity was up to 30%, and beyond this, the random effect model was used. The data obtained were expressed with a 95% CI, and Forest plots are used to give visual feedback on the analyses.

Risk-of-bias assessment

The ROB tool was used to carry out the risk-of-bias assessment. Two reviewers independently made the assessments, and any disparity that was seen was solved through peer review from a third reviewer. The assessment of bias is shown in Fig. 1.

Sensitivity analysis and publication bias

Sensitivity analysis will be carried out for the results obtained by excluding each study at a time for every outcome. Publication bias will be assessed through funnel plots for the meta-analyses that have at least ten studies.

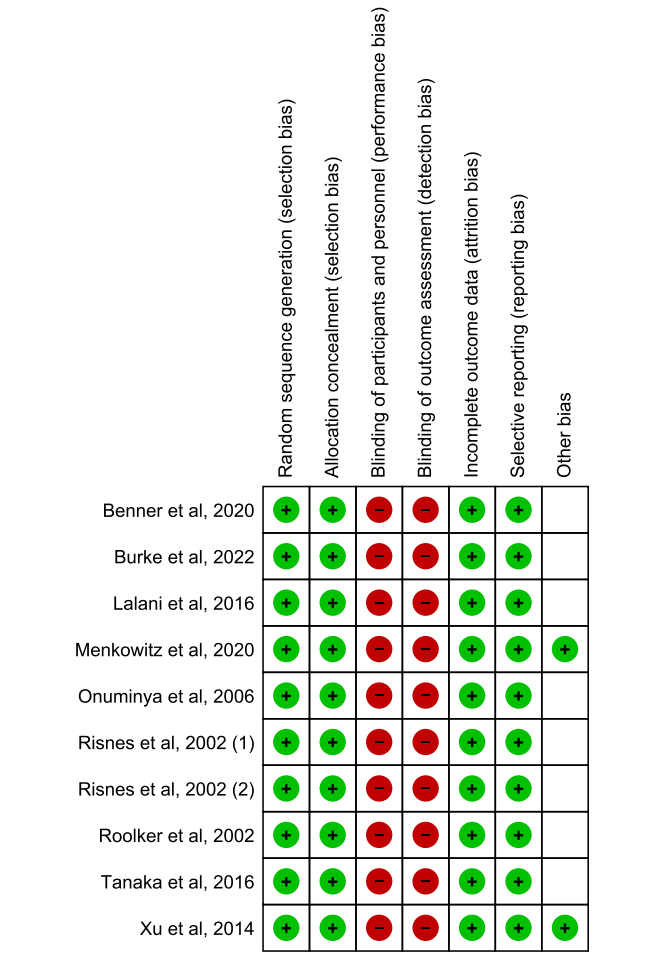

Figure 1. Risk-of-bias assessment.

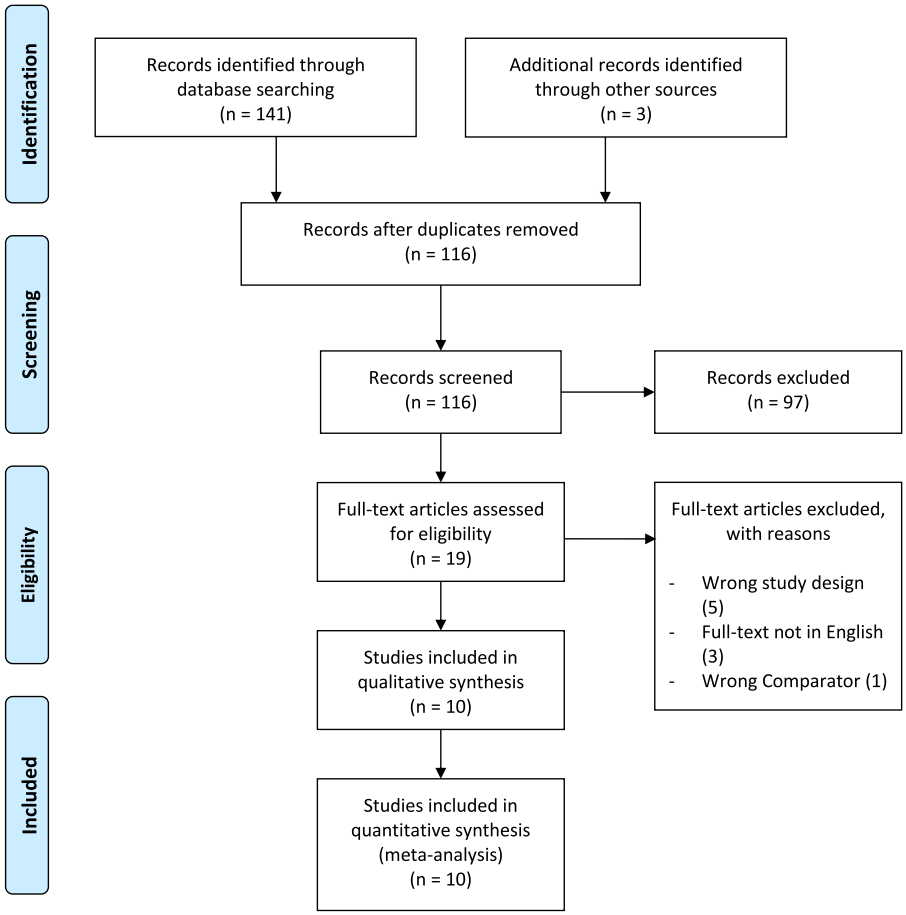

Figure 2. PRISMA flow chart.

Results

This study of 10 randomized controlled trials involved a total of 1119 patients. Out of 10, 8 studies compared the outcome of zipper devices with sutures, while 2 studies compared zipper devices with staples. The search of databases yielded 141 studies, and an additional 3 studies were added from other sources. After the removal of duplicates, 116 studies were screened. After the screening, 10 studies were identified as matching the inclusion and exclusion criteria of this study. Details are shown in Fig. 2.

Qualitative synthesis

This study included ten randomized controlled trials. Details of the included study in the Population, Intervention, Comparator, and Outcome (PICO) format are shown in Table 1.

Quantitative synthesis

Zipper device versus suture

Incision closure time: Incision closure time outcome was reported by 5 of the included studies, and pooling of the data using a random effect model showed that the zipper device took 298.33 sec less on average to close the incision (MD: – 298.33; 95% CI: (– 485.54) to (– 111.11); $n = 407$; $I^2 = 100\%$; $P = 0.002$) (Fig. 3). On excluding one study (Lalani *et al*., 2016), it was shown that the zipper device took 342.95 sec less on average, and the result was statistically significant (Figure A, Supplementary File 2, Supplemental Digital Content 4, http://links.lww.com/MS9/A369).

Wound infection: Pooling the data from 5 trials reporting wound infection outcomes by making use of the random effect model showed no significant difference between zipper device and suture [odds ratio (OR): 0.56; 95% CI: 0.22–1.40; $n = 1022$; $I^2 = 54\%$, $P = 0.21$) (Fig. 4). On re-running the analysis by using the fixed-effect model, it yielded statistically significant data showing that the zipper group had 0.56 lesser odds of developing a wound infection (Figure B, Supplementary File 2, Supplemental Digital Content 4, http://links.lww.com/MS9/A369).

Wound dehiscence: Three studies reported the wound dehiscence outcome, and pooling of the data using a random effect model showed no statistically significant difference between the two groups (Fig. 5). Sensitivity analysis done by excluding each study at a time and re-running the test using the fixed-effect model showed no difference.

Blister formation and accidental removal: Pooling of the data on blister formation reported by two of the included studies using the fixed-effect model showed no significant difference. Three studies reported the accidental removal outcome, and its analysis using the fixed-effect model showed no significant difference between the two groups. Forest plots are available as Figures C

Table 1

Details of the included studies.

Study details	Population (*N*)	Intervention (T)	Comparison (C)	Outcome
Benner *et al.*, 2020[3] Country: USA Wound site: Knee for total knee arthroplasty	*N* = 25 (T = 25, C = 25) Male T = 13/25, C = 13/25 Female T = 12/25, C = 12/25 Value(mean): Age: T = 66.4, C = 66.4	Zipper device	Staple	Pain Score (on scale of 10, 0 being the best and 10 being the worst): At discharge (Mean ± SD): T = 1.8 ± 2.0; C = 2.4 ± 2.6 On 2 weeks (Mean ± SD): T = 1.4 ± 1.7; C = 2.0 ± 1.8 During removal (Mean ± SD): T = 0.7 ± 1.1; C = 1.6 ± 1.2 Scar rating appearance rating (on scale of 10, 0 being the best and 10 being the worst): At 8 weeks Patient-reported (Mean ± SD): T = 1.3 ± 0.5; C = 2.7 ± 2.4 Orthopaedic surgeon reported (Mean ± SD): T = 1.8 ± 1.2; C = 3.3 ± 1.0 Independent plastic surgeon reported (Mean ± SD): T = 3.7 ± 2.0; C = 4.8 ± 1.8 Complications Superficial skin peeling: T = 1/25; C = 0/25
Menkowitz *et al.*, 2020[7] Country: USA Wound site: Knee for total knee arthroplasty	*N* = 41 (T = 21, C = 20) Male T = 7/21, C = 9/20 Female T = 14/21, C = 11/20 Value (mean ± SD): Age: T = 66.3 ± 7.41, C = 64.7 ± 6.78 BMI: T = 32.1 ± 5.46, C = 35.8 ± 9.36 Skin type (Fitzpatrick scale): T = 2.90 ± 1.25, C = 3.24 ± 1.37	Zipper device	Staple	At 6 weeks (T = 21, C = 16) Patient and Observer Scar Assessment Scale (1-Normal to 10-Very Different), Patient scale (Mean ± SD): T = 2.25 ± 1.52, C = 3.40 ± 1.96 Surgeon scale (Mean ± SD): T = 1.10 ± 0.31, C = 2.29 ± 1.10 Patient Satisfaction (1-minimal scar to 5-significant scars): T = 1.45 ± 0.76, C = 1.94 ± 0.97 Complications Blister formation: T = 1/21, C = 0/20 Serous Drainage: T = 1/21, C = 0/20
Burke *et al.*, 2022[8] Country: USA Wound site: Lower limb including knee for primary orthopedic procedures	*N* = 21 (T = 11, C = 10) Male T = 4/11, C = 4/10 Female T = 7/11, C = 6/10 Value (mean ± SD): Age: T = 34.6 ± 16.7, C = 40.9 ± 10.6 BMI: T = 30.6 ± 7.9, C = 30.7 ± 6.6 Length of incision (in cm): T = 8.1 ± 2.78, C = 9.78 ± 4.87 Smokers: T = 1/11, C = 3/10 Diabetes: T = 1/11, C = 0	Zipper device	Suture (running 3-0 Prolene suture)	Time to close (sec) (Mean ± SD): T = 123.27 ± 124.23, C = 266.31 ± 193.59 Surgeon satisfaction (Mean ± SD): T = 8.0 ± 1.55, C = 7.11 ± 3.62 (on a 10-point scale) Stony Brook Scar Evaluation Scale (0: worst, 5: best): At 2 weeks: T = 3.45 ± 1.21, C = 2.8 ± 0.92 At 3 months: T = 3.0 ± 0.89, C = 2.85 ± 1.20 Patient satisfaction (on scale of 10, 0 being the worst and 10 being the best): At 2 weeks: T = 8.64 ± 1.80, C = 8.33 ± 1.66 At 3 months: T = 8.82 ± 1.47, C = 8.11 ± 1.95 Complications Blister formation: T = 2/11, C = 0/10 Unit cost (USD): T = 80, C = 15
Lalani *et al.*, 2016[9] Country: USA Wound site: Thorax for Cardiac implantable electronic device implantation	*N* = 40 (T = 21, C = 19) Male T = 13/21, C = 12/19 Female T = 8/21, C = 7/19 Value (mean ± SD): Age: T = 71 ± 14, C = 70 ± 15 BMI: T = 27 ± 5.08, C = 27 ± 4.31 Race White, non-Hispanic: T = 18/21, C = 16/19 White, Hispanic: T = 1/21, C = 1/19 Black: T = 1/21, C = 1/19 Asian: T = 1/21, C = 1/19 Fitzpatrick skin scale I—Always burns, never tans: T = 2/21, C = 0 II—Usually burns, tans with difficulty: T = 1/	Zipper device	Suture (Monocryl or Vicryl 4-0 suture)	Wound closure time (sec) (Mean ± SD): T = 78 ± 6.6, C = 216 ± 21.5 Unit cost (USD): T = 60, C = 5 At 2 weeks Patient incision pain: T = 0.67, C = 0.68 (0 = No pain, 10 = worst pain) Patient satisfaction with closure: T = 1.48, C = 1.63 (1 = most favourable, 5 = least favourable) Patient comfort: T = 1.67, C = 2.05 (1 = most favourable, 5 = least favourable) Surgeon WES: T = 5.81, C = 5.79 (score of 6 is considered optimal, while a score of ≤5 suboptimal) At 3 months Patient satisfaction with scar: T = 1.32, C = 1.22 (1 = most favourable, 5 = least favourable) Patient scar rating: T = 0.87, C = 1.04 (0 = best expected scar, 10 = worst scar) Patient incision pain: T = 0.27, C = 0.27 (0 = No pain, 10 = worst pain)

	21, C = 1/19 III—Sometimes mild burn, gradually tans: T = 7/21, C = 6/19 IV—Rarely burns, tans with ease: T = 6/21, C = 7/19 V—Very rarely burns, tans very easily: T = 4/21, C = 3/19 VI—Never burns, tans very easily: T = 1/21, C = 2/19			Surgeon WES: T = 6, C = 6 (score of 6 is considered optimal, while a score of ≤5 suboptimal) Surgeon satisfaction with scar: T = 1.00, C = 1.06 (1 = most favourable, 5 = least favourable) Surgeon scar rating: T = 0.24, C = 0.41 (0 = best expected scar, 10 = worst scar) Scar cosmesis rated by an independent panel: T = 35.8, C = 40.6 (0 = normal skin, 100 = poor scar visual analogue scale)
Onuminya *et al.*, 2006[10] Country: Nigeria Wound site: Multiple sites	*N* = 100 (T = 50, C = 50) Male T = 38/50, C = 38/50 Female T = 12/50, C = 12/50 Age range: 10–50, Median age: 35	Zipper device	Suture (nylon suture)	Good scar: T = 43/50, C = 21/50 Bad scar: T = 7/50, C = 29/50 Accidental removal: T = 2/50, C = 0/50 Difficult removal: T = 0/50, C = 25/50 Painful removal: T = 0/50, C = 50/50 Dressing material required: T = less, C = more Complications Wound gape: T = 0/50, C = 15/50 Wound dehiscence: T = 0/50, C = 5/50 Wound infection: T = 2/50, C = 12/50
Risnes *et al.*, 2002 (1)[11] Country: Norway Wound site: Lower limb after saphenous vein	*N* = 168 (T = 78, C = 90) Male = 125/168 Female = 63/168 Age = 68.1 (39.4–81.5) years	Zipper device	Suture (Monocryl 3-0 or Ethilone 3-0)	At 6 weeks Scar scale (1–10, 10 being best): T = 9, C = 8.4 Complications Wound infection: T = 12/78, C = 21/90
Risnes *et al.*, 2002 (2)[12] Country: Norway Wound site: Thorax for open-heart surgery	*N* = 300 (T = 150/300, C = 150/300) Male = 204/300 Female = 96/300 Age = 64.6 (24.0–85.5) years	Zipper device	Suture (Monocryl 3-0)	At 6 weeks Scar scale (1–10, 10 being best) (mean ± SD): T = 8.9 ± 1.5, C = 8.2 ± 1.6 Complications Superficial wound infection: T = 8/150, C = 9/150 Deep wound infection: T = 2/150, C = 1/150 Total wound infection: T = 10/150, C = 10/150
Roolker *et al.*, 2002[13] Country: Netherlands Wound site: Knee, hip, and spinal regions for orthopedic procedures	*N* = 120 (T = 60/120, C = 60/120) Male T = 25/60, C = 35/60 Female T = 20/60, C = 40/60 Value (mean ± SD): Age: T = 44.9 ± 16.65, C = 49.1 ± 18.27 Length of wound (cm): T = 20.5 ± 9.55, C = 18.2 ± 6.98	Zipper device	Suture (PDS suture)	Scar result (6-point scale, 1 very good, 6 unsatisfactory) At 2 weeks (mean ± SD): T = 2.5 ± 0.83, C = 2.2 ± 0.54 At 6 weeks (mean ± SD): T = 2.0 ± 0.74, C = 2.0 ± 0.55 Wound closure (sec): T = 126 ± 46.8, C = 564 ± 174 Accidental removal: T = 1/120, C = 0/120 Complications Wound infection: T = 2/120, C = 0/120 Blister formation: T = 4/120, C = 0/120 Wound dehiscence: T = 5/120, C = 2/120 Unit cost (USD): T = 13, C = 8
Tanaka *et al.*, 2016[14] Country: Japan Wound site: Thorax for cardiac surgery	First operation group *N* = 136 (T = 71, C = 65) Male T = 38/71, C = 38/65 Female T = 33/71, C = 27/65 Value (mean ± SD): Body weight: T = 7.8 ± 6.8, C = 7.3 ± 5.6 Wound length (in mm): T = 102.8 ± 35.8, C = 95.1 ± 37.4 Down syndrome: T = 7/71, C = 6/65 Infant: T = 43/71, C = 38/65 Neonate: T = 12/71, C = 10/65	Zipper device	Suture (5-0 Prolene sutures)	Skin closure time (sec): T = 113.0 ± 9.1, C = 375.9 ± 60.2 First operation group (0 and 13, where a score of 0 reflects normal skin, 13 reflects the worst) At 3 months Vancouver Scar Scale (mean ± SD): T = 2.3 ± 1.7, C = 5.0 ± 2.3 (71, 65) Vancouver Scar Scale in patients with Trisomy 21 (mean ± SD): T = 3.2 ± 1.8, C = 6.3 ± 1.9 Vancouver Scar Scale in infants (mean ± SD): T = 2.7 ± 1.8, C = 5.3 ± 1.9 Reoperation group At 3 months Vancouver Scar Scale (mean ± SD): T = 4.2 ± 1.5, C = 5.8 ± 2.4 (42, 36) Vancouver Scar Scale in patients with Trisomy 21 (mean ± SD): T = 4.5 ± 0.9,

Table 1

(*Continued*)

Study details	Population (*N*)	Intervention (T)	Comparison (C)	Outcome
	Cardiopulmonary bypass: T = 58/71, C = 53/65 Reoperation operation group *N* = 78 (T = 42, C = 36) Male T = 20/42, C = 17/36 Female T = 22/42, C = 19/36 Value (mean ± SD): Body weight: T = 9.6 ± 7.0, C = 9.0 ± 5.9 Wound length (in mm): T = 113.3 ± 41.3, C = 109.1 ± 40.9 Down syndrome: T = 10/42, C = 6/36 Infant: T = 18/42, C = 15/36 Neonate: T = 2/42, C = 2/36			C = 6.8 ± 1.1 Vancouver Scar Scale in infants (mean ± SD): T = 4.2 ± 1.7, C = 6.1 ± 1.8 Complications Wound infection: T = 1/113, C = 2/101 Wound dehiscence: T = 2/113, C = 3/101 Skin discoloration: T = 1/113, C = 0/101 Epidermolysis: T = 1/113, C = 0/101 Pain among patients on removal: T = 8/113, C = 53/101 Accidental removal: T = 2/113, C = 0/101
Xu *et al*., 2014[15] Country: China Wound site: Spinal region for posterior spinal fusion surgery	*N* = 90 (T = 45, C = 45) Female T = 45/45, C = 45/45 Value (mean ± SD): Age (years): T = 13.2 ± 1.6, C = 13.5 ± 2.1 BMI (kg/m 2): T = 17.8 ± 3.5, C = 17.2 ± 4.2 Number of levels fused: T = 9.6 ± 1.6, C = 9.9 ± 1.2 Length of incision: T = 31.2 ± 3.2, C = 32.2 ± 2.2	Zipper device	Suture (4-0 Monocryl suture)	Time for Closure (sec): T = 45.3 ± 5.3, C = 540.5 ± 23.8 Hollander Incision Evaluation Score (mean ± SD): (6 best, 0 worst) In 7 days: T = 4.3 ± 1.3, C = 4.1 ± 1.0 In 2 weeks: T = 4.5 ± 1.2, C = 4.2 ± 1.1 In 6 months: T = 4.8 ± 0.8, C = 4.6 ± 1.1 In 1 year: T = 5.6 ± 0.3, C = 5.5 ± 0.4 Visual analogue scale (on scale of 10, 0 being the worst and 10 being the best): In 6 months: T = 7.2 ± 1.3, C = 7.3 ± 1.5 In 1 year: T = 7.7 ± 1.1, C = 7.4 ± 0.9 Complications Pain: T = 0/45, C = 2/45 Unit cost (USD): T = 60, C = 24

Study or Subgroup	Zipper device Mean	SD	Total	Suture Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Burke et al, 2022	123.27	124.23	11	266.31	193.59	10	18.4%	-143.04 [-283.70, -2.38]
Lalani et al, 2016	78	6.6	21	216	21.5	19	20.5%	-138.00 [-148.07, -127.93]
Roolker et al, 2002	126	46.8	60	564	174	60	20.2%	-438.00 [-483.59, -392.41]
Tanaka et al, 2016	113	9.1	71	375.9	60.2	65	20.5%	-262.90 [-277.69, -248.11]
Xu et al, 2014	45.3	5.3	45	540.5	23.8	45	20.5%	-495.20 [-502.32, -488.08]
Total (95% CI)			**208**			**199**	**100.0%**	**-298.33 [-485.54, -111.11]**

Heterogeneity: Tau² = 44544.70; Chi² = 3435.79, df = 4 (P < 0.00001); I² = 100%
Test for overall effect: Z = 3.12 (P = 0.002)

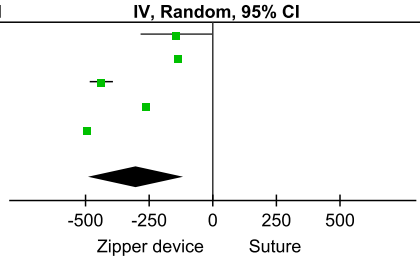

Figure 3. Forest plot for incision closure time outcome.

Study or Subgroup	Zipper Events	Total	Suture Events	Total	Weight	Odds Ratio M-H, Random, 95% CI
Onuminya et al, 2006	2	50	15	50	19.4%	0.10 [0.02, 0.45]
Risnes et al, 2002 (1)	12	78	21	90	32.4%	0.60 [0.27, 1.31]
Risnes et al, 2002 (2)	10	150	10	150	30.0%	1.00 [0.40, 2.48]
Roolker et al, 2002	2	120	0	120	7.5%	5.08 [0.24, 107.03]
Tanaka et al, 2016	1	113	2	101	10.8%	0.44 [0.04, 4.95]
Total (95% CI)		**511**		**511**	**100.0%**	**0.56 [0.22, 1.40]**
Total events	27		48			

Heterogeneity: Tau² = 0.52; Chi² = 8.62, df = 4 (P = 0.07); I² = 54%
Test for overall effect: Z = 1.25 (P = 0.21)

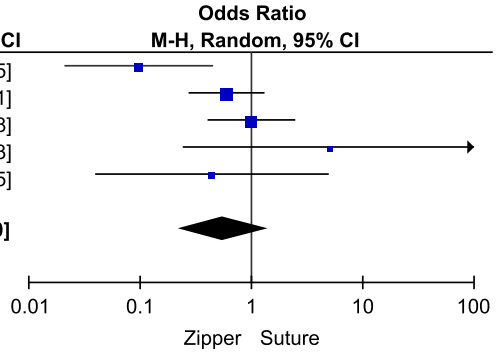

Figure 4. Forest plot for incision wound infection outcome.

Study or Subgroup	Zipper Events	Total	Suture Events	Total	Weight	Odds Ratio M-H, Random, 95% CI
Onuminya et al, 2006	0	50	5	50	23.0%	0.08 [0.00, 1.52]
Roolker et al, 2002	5	120	2	120	39.7%	2.57 [0.49, 13.49]
Tanaka et al, 2016	2	113	3	101	37.3%	0.59 [0.10, 3.60]
Total (95% CI)		**283**		**271**	**100.0%**	**0.67 [0.11, 3.96]**
Total events	7		10			

Heterogeneity: Tau² = 1.34; Chi² = 4.48, df = 2 (P = 0.11); I² = 55%
Test for overall effect: Z = 0.44 (P = 0.66)

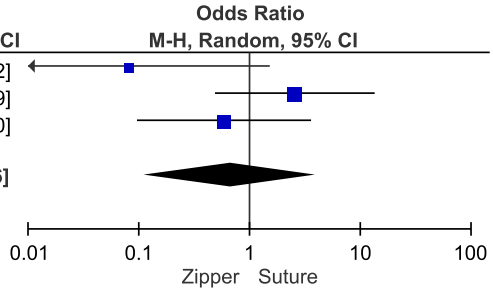

Figure 5. Forest plot for incision wound dehiscence outcome.

Study or Subgroup	Zipper Mean	SD	Total	Suture Mean	SD	Total	Weight	Std. Mean Difference IV, Fixed, 95% CI
Burke et al, 2022	3	0.89	11	2.85	1.2	10	5.2%	0.14 [-0.72, 0.99]
Risnes et al, 2002 (2)	8.9	1.5	150	8.2	1.6	150	72.6%	0.45 [0.22, 0.68]
Xu et al, 2014	4.8	0.8	45	4.6	1.1	45	22.2%	0.21 [-0.21, 0.62]
Total (95% CI)			**206**			**205**	**100.0%**	**0.38 [0.18, 0.58]**

Heterogeneity: Chi² = 1.34, df = 2 (P = 0.51); I² = 0%
Test for overall effect: Z = 3.81 (P = 0.0001)

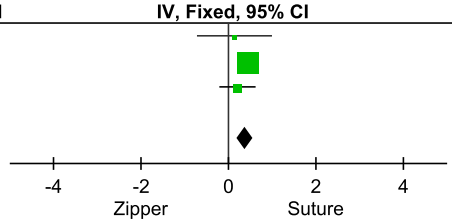

Figure 6. Forest plot for incision scar scale after 1-month outcome.

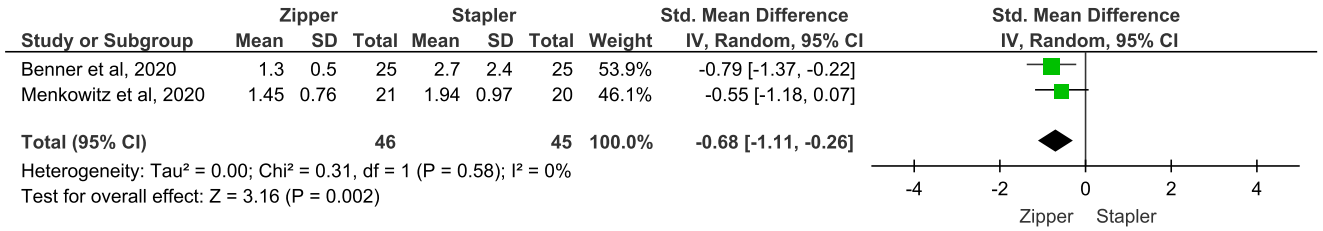

Figure 7. Forest plot for incision patient satisfaction outcome.

and D, Supplementary File 2, Supplemental Digital Content 4, http://links.lww.com/MS9/A369. Re-running the analysis using the random effect model and sensitivity analysis also showed no difference.

Scar scale at 2 weeks and after 1 month: Scar scale outcomes reported by surgeons at two weeks were pooled using the fixed-effect model, and it showed no significant difference between the two groups (Figure E, Supplementary File 2, Supplemental Digital Content 4, http://links.lww.com/MS9/A369), but when data on scar scale outcomes reported after 1 month (1–3 months timeframe) was pooled using the fixed-effect model, the result favoured the suture group (SMD: 0.38; 95% CI: (018)–(0.58); $n = 411$; $I^2 = 0\%$; $P = 0.0001$) (Fig. 6). Sensitivity analysis did not show great differences in this result.

Patient satisfaction: Pooling of the data using the fixed-effect model showed no significant difference in patient satisfaction outcomes. The forest plot is available in Figure F, Supplementary File 2, Supplemental Digital Content 4, http://links.lww.com/MS9/A369.

Zipper device versus stapler

Patient satisfaction: Patient satisfaction outcome favoured the zipper group significantly when the data were pooled using the fixed-effect model (SMD: – 0.68; 95% CI: (– 1.11) to (– 0.26); $n = 91$; $I^2 = 0\%$; $P = 0.002$) (Fig. 7).

Overall complications: Pooling of the data using the fixed-effect model showed no significant difference in the overall complication outcome. The forest plot is available in Figure G, Supplementary File 2, Supplemental Digital Content 4, http://links.lww.com/MS9/A369.

Discussion

The main concern that lingers regarding newer techniques of skin closure, when compared to conventional sutures and staples, remains their effectiveness, time taken for skin closure, cosmesis, complications, and any additional benefits they provide. Likewise, when the zipper device is studied, similar questions arise. In this systematic review and meta-analysis, the results of zipper devices were compared with sutures and staples separately.

Zipper device and suture

Incision closure time was found to be 298.33 sec (4.9 min) less on average with a zipper device when compared to a suture. This statistically significant result decreases the total operative time, which has its benefits. There is a positive association between the increasing time of the surgical procedure and the increased likelihood of having complications like surgical site infection, venous thromboembolism, bleeding, haematoma formation, and necrosis. A study has shown that the likelihood of developing complications increases by 1% for every 1-min, 4% for every 10-min, 14% for every 30-min, and 21% for every 60-min increase in operative time[16]. Also, it is beneficial for the operating surgeons at health camps and during minor surgeries as it is less time-consuming and technically less challenging compared to sutures. Wound infection was seen to be less in the zipper device group, but it was not statistically significant; however, on re-running the test with the fixed-effect model, the result was statistically significant. Three out of five studies included in the analysis showed a lower wound infection rate among zipper devices, while one study showed an equal incidence. This may be attributed to the invasive nature of the suture and bacterial adherence to suture materials[17]. Included studies reported blister formation and accidental removal for the zipper device group; however, on pooling, these data showed no significant difference between the two groups. Above all, how well the wound edges are approximated is of primary concern. When wound dehiscence was studied, the results showed no significant difference between the zipper and suture. The results of the sensitivity analysis were also consistent with this finding. This study also studied the scar score, which showed no difference in cosmesis at two weeks, but the outcome assessed at 1–3 months' timeframe showed a better cosmesis outcome in the suture group. Also, patient satisfaction outcomes did not show any significant difference between the two groups. Although atraumatic and better conditions of wound healing have been attributed to a lesser risk of keloid formation, which makes it of particular importance in black races, further study is needed regarding this matter[10].

Zipper device and staple

Due to the unavailability of data, only the analysis of patient satisfaction and overall complications was performed. The overall complication rate outcome showed no significant difference between the zipper device and staple group. However, the patient satisfaction outcome favoured the zipper device group. Our study showed more patient satisfaction with the zipper technique compared to staples. The zipper device is associated with less pain, less time for closure of the wound, a shorter waiting time for other patients in the emergency department, not being affected by different surgeons and different lengths of the wound, and the patients can also remove the closure device by themselves.

For the majority of the outcomes, this study showed statistically insignificant results. The main advantage of the newer zipper device over the suture was the lesser time taken by the zipper device, and the advantage of the suture over the zipper device was on the scar scale measured at one month. In the comparison

between the zipper devices and the stapler, patients were more satisfied with the zipper device. Compared to sutures and staplers, the surgical zipper has the further advantage of being its own dressing, allowing an uncomplicated wound inspection with its adhesive properties remaining for at least 10 days and its removal being painless. However, another important factor could not be studied, which is the cost due to the unavailability of the data. Three studies comparing zippers with sutures reported the cost, and all three studies showed a higher cost of zipper devices[8,9,13]. But in the event of an emergency in remote places, including wars and natural calamities, in areas with lesser expertise and where facilities for local anaesthesia are not readily available, the use of a zipper device can prove to be of great relief due to its ease of use. This device can also be of importance in military medicine, but further study is needed to assess the outcomes. Also, the use of zipper devices for skin closure can be done in hospital settings after an assessment of the cost factor at the local level. However, its use is limited to external wounds and cannot be used in cases of infected wounds, high-tension areas, oedematous wound edges, skin loss, animal bites, mucosal surfaces, mucocutaneous junctions, or patients with a risk of delayed wound healing[18].

This study could not study the cost factor extensively, and it also could not compare the zipper device with the stapler on varied outcomes due to the lack of studies. Further studies directed towards answering the question of cost-effectiveness are needed to have an assuring data. Another limitation of this study was its heterogeneity. Heterogeneity in this study is attributed to the skin closure method applied in different parts of the body in different specialties of surgery, to the different suture materials used among the included studies, and to the disparity in the time frames in which the outcomes were reported. Also, the majority of included studies had a shorter follow-up period to assess the scar score, and zipper devices were used on sites like the knee, spinal region, and sternal region where there is high mobility, high tension, and irregularities in the surface. This might have affected the performance of the zipper device.

Conclusion

The zipper device is a newer, technically less demanding, and less time-consuming method of skin closure, with no significant difference in the complication rate compared to sutures. Patient satisfaction outcomes also showed no difference with sutures, while patients were more satisfied with the zipper when compared to the stapler device. Zipper devices are as effective as sutures and can be used in settings with less expertise or at health institutions after assessing the cost at the local level.

Ethical approval

Not applicable.

Consent

Not applicable.

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This study didn't receive any kind of grants.

Author contribution

O.S., S.B., and N.T. contributed to the conceptualization of the study. S.K., N.B., and N.J. contributed to the screening of the studies. S.K., N.T., N.B., N.J., and S.P. were involved in the data curation phase. O.S. and S.B. did the formal analysis. O.S., S.K., N.T., S.B., and S.P. were involved in initial manuscript drafting. S.B. edited the manuscript intellectually. All the authors were involved in approving the final version of the manuscript.

Conflicts of interest disclosure

There are no conflicts of interest to disclose.

Research registration unique identifying number (UIN) (for case reports detailing a new surgical technique or new equipment/technology)

Not applicable.

Guarantor

Oshan Shrestha.

Data availability

Data analysed in the study are present within the manuscript.

Provenance and peer review

Not commissioned, externally peer-reviewed.

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