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The effectiveness of different flap-raising techniques for mastectomy in reducing the rate of complications: a network meta-analysis

Saburi Oyewale[1*], Azeezat Ariwoola[2] and Idris Oyewale[3]

Abstract

Background Seroma has been associated with some energy devices used in raising flaps during modified radical mastectomy. Perhaps, its occurrence might be reduced by determining the most effective technique for raising the flap. Hence, the wide array of energy devices available for mastectomy warrants a network meta-analysis for comparison to determine the most suitable for rseducing complications.

Methods Searches were conducted on Google Scholar and PubMed for randomized controlled trials that compared the various energy devices (argon-cautery, diathermy, plasma blade, LigaSure, and harmonic scalpel) to traditional scalpel/scissors in mastectomy procedures. This review was registered with a PROSPERO number: CRD42023456510. The primary outcome was seroma formation, while the secondary outcomes included flap necrosis, drain effluent, and blood loss.

Results Thirty-three studies were used for this network meta-analysis. Using sharp dissections (scissors or scalpel) for raising flaps in mastectomy reduced seroma formation [Odds ratio (OR): 0.375 (Credible interval (CrI): 0.244, 0.575)], Argon cautery decreased blood loss [Mean difference (MD): -304 (CrI: -698, 90.5)] but harmonic scalpel reduced the rate of flap necrosis [OR: 0.379 (CrI: 0.177, 0.791)] and the volume of drain effluent [MD: -383 (CrI: -704, -62.9)].

Conclusion Using scissors or scalpels for mastectomy was associated with a reduction in the rate of seroma. In addition, the volume of drain effluent was reduced using a Harmonic scalpel compared to other energy devices. Aside from a reduction in flap necrosis rate, blood loss, and the volume of drain effluent; energy devices for raising flaps in mastectomy were not entirely superior to scalpels or scissors.

Keywords Mastectomy, Seroma, Blood loss, Flap-raising

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Introduction

Seroma formation stands as the most prevalent complication following mastectomy [1], often leading to heightened wound complications, delays in administering adjuvant chemotherapy, and increased frequency of hospital visits [2]. The use of diathermy in flap-raising during mastectomy has been linked to the occurrence of seroma and wound complications [3], while also contributing to elevated cytokine concentrations in drain effluent [4]. Conversely, employing pressure and energy, an electrosurgery bipolar unit can effectively seal vessels by denaturing protein in collagen and elastin fibres [5]. However, the efficacy of alternative dissection techniques, during mastectomy, involving vessel sealing systems compared to electrocautery or sharp dissections (scalpel and/or scissors) remains uncertain due to conflicting and inconclusive findings across studies [6, 7]. Furthermore, the adoption of electrothermal bipolar devices and Harmonic scalpels has been hindered by their associated high setup and maintenance costs [7].

The use of diathermy carries the risk of inadvertent damage of adjacent tissue due to the lateral spread of energy [3], potentially leading to incomplete closure of lymphatics. Consequently, this can result in an increased volume of drain effluent and potentially increase the occurrence of seroma formation after mastectomy. Thus, the routine utilization of certain energy devices for flap elevation during mastectomy may predispose some patients to seroma development.

The sluggish uptake of advanced surgical devices in some low-income countries might be due to the importation of the majority of surgical instruments from abroad [8]. Additionally, challenges such as the absence of comprehensive training manuals and subpar maintenance further impede their widespread adoption [8, 9]. Consequently, surgeons in certain low-income countries have found sharp dissection (scalpel/scissors) to be an appealing alternative technique for flap-raising during mastectomy.

While traditional systematic reviews and pairwise meta-analyses have yielded valuable insights into the relative effectiveness of individual flap-raising techniques, the multiplicity of treatment options necessitates a network meta-analysis. Such an analysis facilitates both head-to-head and indirect comparisons, offering a comprehensive overview of the available evidence and providing an opportunity to rank and compare the efficacy of various flap-raising techniques during mastectomy. Therefore, we aim to provide valuable insights that might contribute to refining clinical practices for treating breast cancer patients.

Table 1 Shows PubMed search strategies

#	SEARCHES
#1	Ultrasonic OR Ultracision OR Ultra*
#2	Diathermy OR Electrocautery OR Monopolar Diathermy
#3	Sharp dissection OR Scalpel OR Dissection with Scissors
#4	Argon-coagulators OR Argon*
#5	Pulsed-electron avalanche knife (PEAK) OR PlasmaBlade
#6	electrothermal bipolar vessel sealing device OR LigaSure OR Liga*
#7	Mastectomy OR Modified radical Mastectomy OR Breast surgery
#8	((((((Ultrasonic OR Ultracision OR Ultra*) AND (Diathermy OR Electrocautery OR Monopolar Diathermy)) AND (Sharp dissection OR Scalpel OR Dissection with Scissors)) AND (Argon-coagulators OR Argon*)) OR (Pulsed-electron avalanche knife (PEAK) OR PlasmaBlade)) OR (electrothermal bipolar vessel sealing device OR LigaSure OR Liga*)) AND (Mastectomy OR Modified radical Mastectomy OR Breast surgery)

Methodology

We aim to compare the outcomes with the use of energy devices and sharp dissection during flap raising in mastectomy for breast cancer using a meta-analysis. This review was prospectively registered on the PROSPERO registry (CRD42023456510).

Search strategy Relevant studies were searched from databases like Google Scholar and PubMed. This was done by S.O and A.A. The search terms were 'seroma', 'diathermy', 'sharp dissection', 'harmonic scalpel', 'plasma blade', 'LigaSure', and 'argon coagulator'. The Pubmed search terms used in the literature search were presented in Table 1. The last search was conducted on the 30th of December 2023.

Inclusion and exclusion criteria This review exclusively focuses on Randomized Controlled Trials (RCTs), to prevent selection bias, for women undergoing modified radical mastectomy for breast cancers. Different energy devices and sharp dissection methods during flap-raising for mastectomy were compared.

The inclusion criteria were: (i) women who had modified radical mastectomy (mastectomy plus axillary dissection) in which energy devices were compared; (ii) studies published in the English language. Exclusion criteria were: (i) conference abstract; (ii) case reports; (iii) case series; (iv) axillary dissection alone; and (v) mastectomy with breast reconstruction.

Data extraction Data extraction was done by SO (Saburi Oyewale) and IO (Idris Oyewale). The two reviewers independently screened the titles and abstracts of retrieved studies using the Rayyan software [10]. All disagreements were resolved by referring to AA (Ariwoola Azeezat). Eligible studies for network meta-analysis must be RCTs comparing outcomes of different surgical devices for flap raising in modified radical mastectomy, with full-text availability for review. The study characteristics (e.g.,

design, sample size), surgical device details, and outcome data were derived from the included studies.

Study outcomes The primary outcome of interest was the effectiveness of various surgical devices in reducing seroma formation following modified radical mastectomy. Secondary outcomes were the total blood loss, rate of flap necrosis, and total drain effluent volume.

Assessment of methodological quality

The methodological quality was assessed using the Risk of Bias tool [11]. this was done by AA and IO. The Robvis tool was used to generate the summary and traffic plots [12].

Statistical analysis

The Meta-insight software was used for the statistical analysis. The random effect model was used to analyse both the primary and secondary outcomes. Network diagrams were constructed to depict connections between surgical devices based on direct comparisons identified in included studies, aiding visualization of both direct and indirect evidence.

For binary data, an odds ratio (OR) was calculated which was statistically significant ($p<0.05$) if the 95% confidence interval did not include the value 1. For continuous data, the mean difference (MD) was calculated and was statistically significant if it did not include the value 0. The diathermy was used as a common reference for all the devices that were utilised for raising flaps.

The probability of ranking a device for flap raising for each outcome of interest was ranked using the P-score derived from the surface under cumulative ranking areas for all outcomes. If the probability of ranking is below 90%, it was not considered high enough to be correctly ranked for the outcome of interest.

Result

The literature searches were conducted on PubMed and Google Scholar databases. After excluding duplicate articles, a full-text review was conducted on 3,788 articles [see Fig. 1, 13]. This network meta-analysis incorporated 33 studies [14–46] involving 2,562 patients. The studies were published between 1996 and 2023 and they were all randomised control trials. Most of the studies were conducted on subjects in Asia. The energy device most described was diathermy ($n=32$). Seventeen studies compared harmonic scalpel to diathermy. A summary table of the included studies and comparisons is presented in Table 2.

The risk of bias was assessed with the ROB 2 tool. There were seven studies [15, 24, 30, 32–34, 40] with a high risk of bias. The summary plot and traffic plots give a general overview of the bias risk of the included studies. [See Fig. 2A and B]

Seromas were reported in 25 studies [14, 19–28, 31–34, 36–39, 41–46] comprised of 2017 patients. The highest number of direct comparisons were between diathermy and harmonic scalpel. The lowest incidence of seroma was found in sharp dissection OR: 0.375 (CrI: 0.244, 0.575) (P score=82.9). [see Fig. 3A and B and Table 3A, 3B].

In analyses of the volume of blood loss, 17 randomised controlled trials [15, 16, 18, 20–22, 24, 25, 27–30, 32, 35–37, 46], involving 1237 patients were incorporated. Diathermy vs. harmonic scalpel was the highest number of direct comparisons. Diathermy was associated with the highest volume of blood loss in 60.7% of all comparisons. [see Fig. 3C] This contrasted with the argon cautery which had the lowest volume of blood loss in 90.9% of all the comparisons.

Flap necroses were reported in 9 studies involving 852 patients and 3 pairwise comparisons [27, 28, 32, 36, 37, 39, 40, 42, 46]. Using a Harmonic scalpel for raising the flap during mastectomy was associated with a low incidence of flap necrosis [OR: 0.379 (CrI: 0.177, 0.791)] ($P=87.2$) [see Fig. 3D].

Nineteen studies were used to analyse the volume of drain output comprising 1183 individuals [14, 19–26, 28, 31, 32, 34, 36, 37, 40–42, 46]. The Harmonic scalpel was associated with low-volume drain output after mastectomy [MD: -383 (CrI: -704, -62.9)]. It was 86.3% of all comparisons [see Fig. 3E].

Discussion

This study shows that using scalpels and scissors for flap-raising during mastectomy is associated with a lower occurrence of seroma. Furthermore, the utilization of Argon cautery is linked to decreased intraoperative blood loss. Additionally, using a harmonic scalpel reduces flap necrosis and drainage volume in the postoperative period.

The finding of this review is in line with the result of a network meta-analysis on the use of energy devices for axillary dissection in breast cancer surgery, in which the use of a harmonic scalpel was associated with a decreased occurrence of seroma in patients undergoing axillary dissection [47]. However, scalpel or scissors were not incorporated into that network meta-analysis. The minimal effect of scissors/scalpel on seroma drainage effluent might be due to its non-charring effect on fat tissues and lymphatic vessels [38]. Harmonic scalpels might not be completely effective for sealing lymphatic vessels because of the thin walls and the reduced quantity of denatured protein coagulum when a harmonic scalpel works. Therefore, some experts have suggested using sutures to ligate axillary fats to reduce prolonged lymphatic drainage [48].

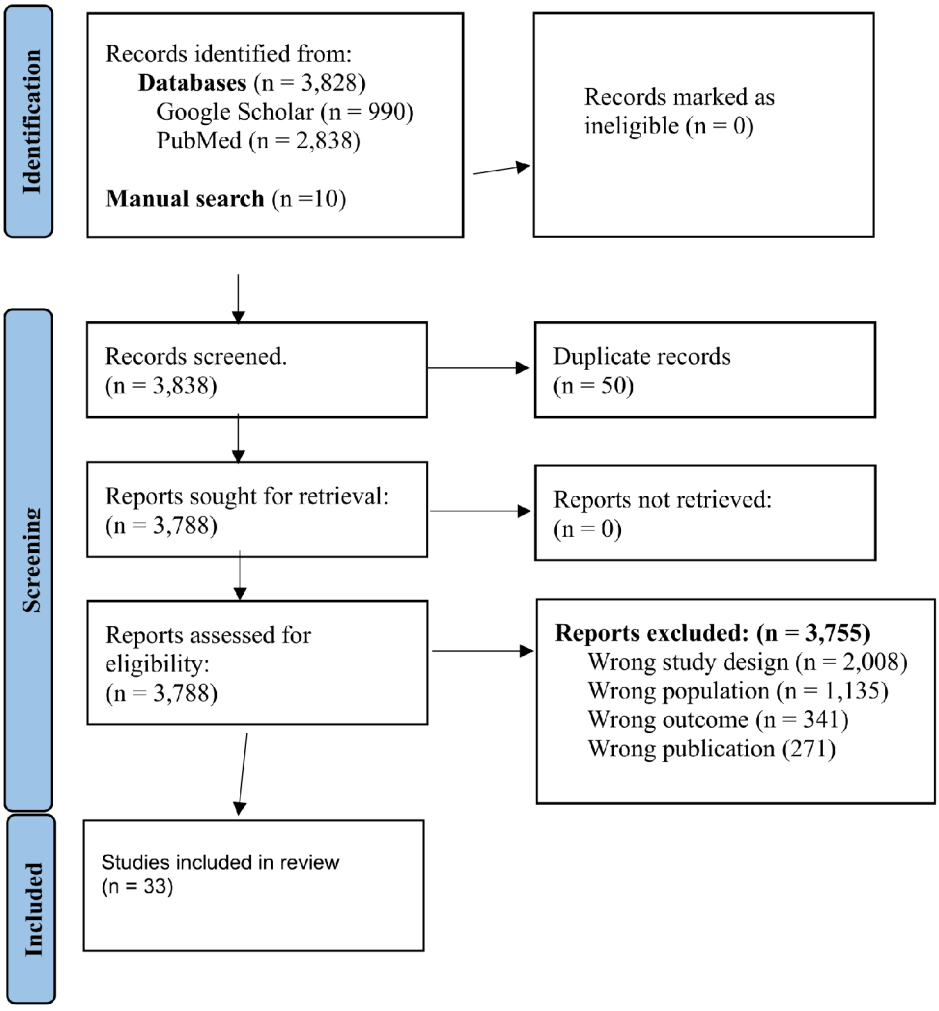

Fig. 1 Shows the PRISMA flow diagram

Table 2 Shows the characteristics of the included studies

Comparison	Number of studies	Number of Patients	Publication years	Study location
Scalpel vs. Diathermy	8	665	1998–2023	North America: 1 Europe: 1 Asia: 6
Harmonic scalpel vs. Diathermy	17	1335	2002–2023	Asia: 13 Europe: 3 Africa: 1
Plasma blade vs. Diathermy	1	50	2020	Asia: 1
Argon cautery vs. Diathermy	1	50	1996	Europe: 1
Ligasure vs. Diathermy	5	402	2021–2023	Africa: 1 Asia: 4
Scalpel vs. LigaSure	1	60	2023	Asia: 1

In this review, there was a reduced volume of drain effluent with a Harmonic scalpel for dissection during mastectomy. In addition, the use of argon cautery for raising the flap in mastectomy was in the second rank. LigaSure performed poorly in reducing the volume of drainage. This might be due to associated systemic response or lateral thermal spread in LigaSure when in use, especially for lymph node dissection [49]. There was a difference in the criteria for the removal of the drain in all of the studies. However, the majority removed the drain when the effluent was <30 ml/day. This might

Fig. 2A shows the traffic plot for the studies incorporated in the network meta-analysis

contribute to the limitations of ranking the volume of drain effluents.

Large breast mass and body mass index are risk factors for blood loss during mastectomy [50]. In our review, Argon cautery reduced the volume of intra-operative blood loss. Therefore, we suggest that argon cautery be utilised in patients with a higher risk of blood loss and those aversive to blood transfusion, for whatever reason. Moreover, Harmonic scalpel has been associated with a higher cost of treatment [26] and prolonged operation time [22].

This study is limited by the non-evaluation of publication bias and the relatively small sample sizes included in the network meta-analysis. Additionally, the bulk of the studies included in this network meta-analysis (NMA), especially those comparing scalpel/scissors with other energy devices, were done in low- and middle-income countries (LMICs). Since Asian women have smaller breasts compared with women of Caucasian ancestry; [51] hence, this might make it difficult to generalize the findings from this study. Lastly, there is a need for future studies to compare the effects of different energy devices on wound healing and scar formation in mastectomy.

Conclusion

The research indicates that using a scalpel and/or scissors during mastectomy lowers the risk of seroma formation. Similarly, the Harmonic scalpel reduced postoperative drain output and flap necrosis while Argon cautery reduced intra-operative blood loss during mastectomy. Furthermore, there should be caution among breast surgeons when considering the adoption of newly developed energy devices, as their superiority over established techniques may not be evident. There is a need for future multi-center studies to compare the cost-effectiveness of the various energy devices in reducing complications during mastectomy.

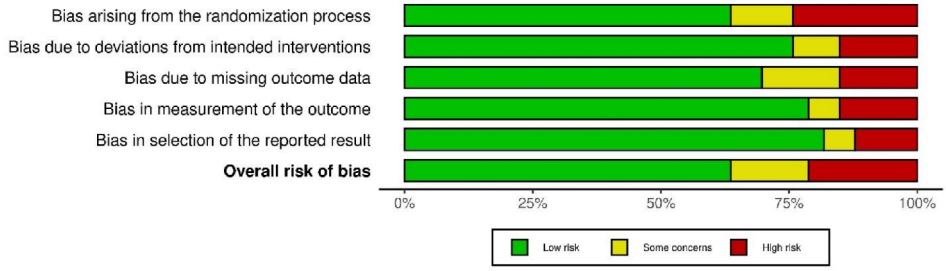

Fig. 2B Shows the summary plot for the studies incorporated in the network meta-analysis

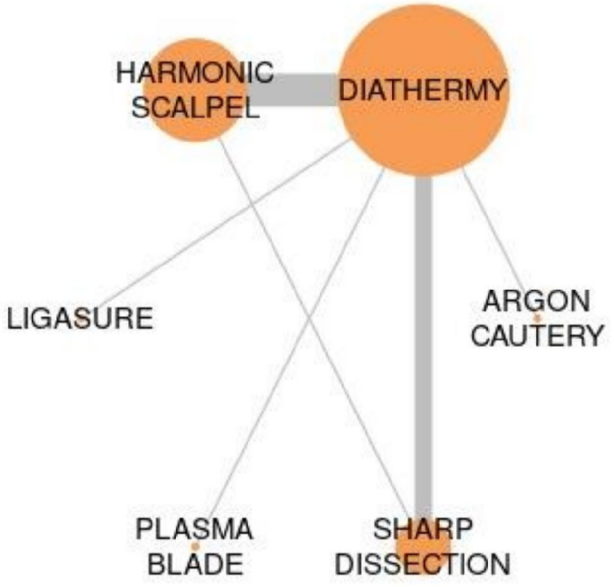

Fig. 3A Shows the network of comparison of seroma

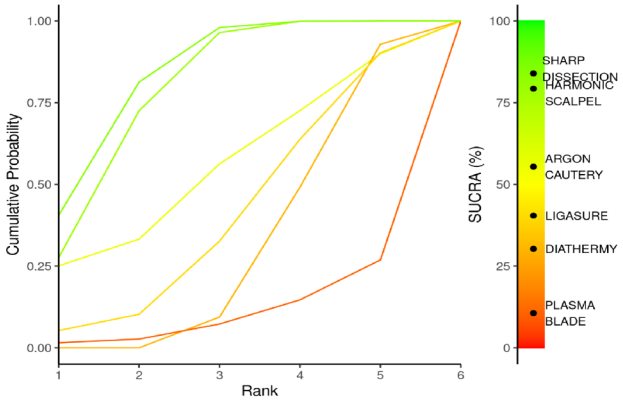

Fig. 3B Shows the SUCRA (Surface under the cumulative ranking curve) for seroma. Sharp dissection had the highest P-score at 83.9%

Table 3A Shows the studies contributing data to the volume of drain effluent

Study	Indication for removal of drain	Level of Axillary Dissection
Aheer 2023	Effluent < 30 ml/day for 2 days	Level 3
Anandaravi 2017	Effluent < 30 ml/day for 1 day	Not available
Boonsripitayanon 2020	Not available	Not available
Din 2023	Effluent < 30 ml/day for 1 day	Level 2
Deo 2002	Effluent < 30 ml/day for 1 day	Level 3
Damani 2013	Effluent < 30 ml/day for 1 day	Not available
Faisal 2018	Effluent < 30 ml/day for 2 days	Levels 2 and 3
Galatius 2003	5th postoperative day	Level 2
Khan 2014	Effluent < 30 ml/day for 1 day	Level 3
Kerin 1996	Not available	Level 3
Kozomara 2009	Effluent < 30 ml/day for 1 day	Not available
Mittal 2017	Effluent < 30 ml/day for 1 day	Not available
Ozdogan 2008	Effluent < 30 ml/day for 1 day	Level 3
Park 2022	Effluent < 50 ml/day for 1 day	Not available
Rohaizak 2012	Effluent < 30 ml/day for 1 day	Not available
Shahid 2021	Effluent < 30 ml/day for 1 day	Level 3
Sharma 2019	Effluent < 30 ml/day for 2 days	Not available
Sharma 2018	Effluent < 30 ml/day for 1 day	Level 3
Yilmaz 2011	Effluent < 50 ml/day for 1 day	Level 2

Table 3B Shows the ranking of the energy devices for each of the outcomes with the P score in parentheses where a P-value of 1.00 is the highest and P-value of 0.00 is the lowest. The bolded value for Argon cautery indicate that is the best technique for reducing blood loss

	Seroma	Volume of drain	Blood loss	Flap necrosis
Rank 1	Sharp dissection (*P* = 83.9)	Harmonic scalpel (*P* = 86.3)	Argon cautery (P = **90.9**)	Harmonic scalpel (*P* = 84.4)
Rank 2	Harmonic scalpel (*P* = 79.3)	Argon cautery (*P* = 62.1)	Harmonic scalpel (*P* = 55.1)	Sharp dissection (*P* = 61.8)
Rank 3	Argon cautery (*P* = 55.4)	Diathermy (*P* = 48.8)	Plasma blade (*P* = 38.7)	Diathermy (*P* = 3.7)
Rank 4	LigaSure (*P* = 40.4)	Plasma blade (*P* = 43.5)	LigaSure (*P* = 33.1)	-
Rank 5	Diathermy (*P* = 30.3)	Sharp dissection (*P* = 34.7)	Diathermy (*P* = 31.9)	-
Rank 6	Plasma blade (*P* = 10.6)	LigaSure (*P* = 24.5)	-	-

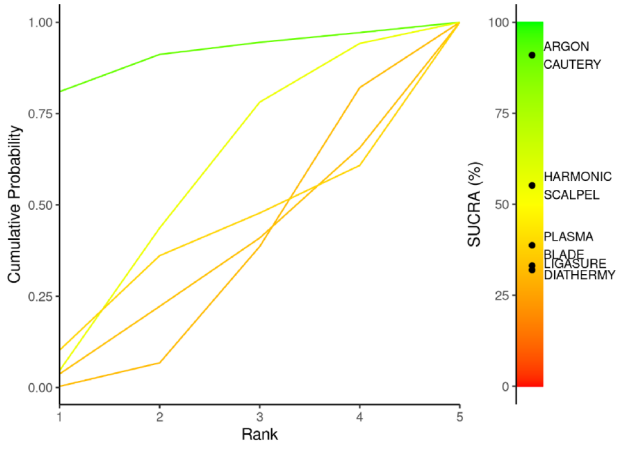

Fig. 3C Shows the SUCRA for the volume of blood loss. Argon cautery had the highest P-score at 90.9%

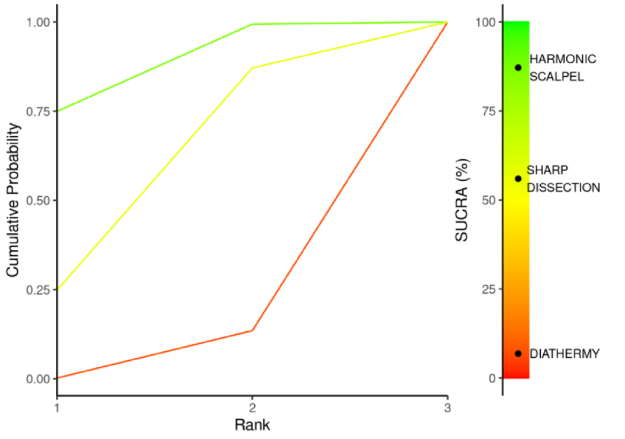

Fig. 3D shows the SUCRA for the occurrence of flap necrosis. Harmonic scalpel had the highest P-score at 84.4%

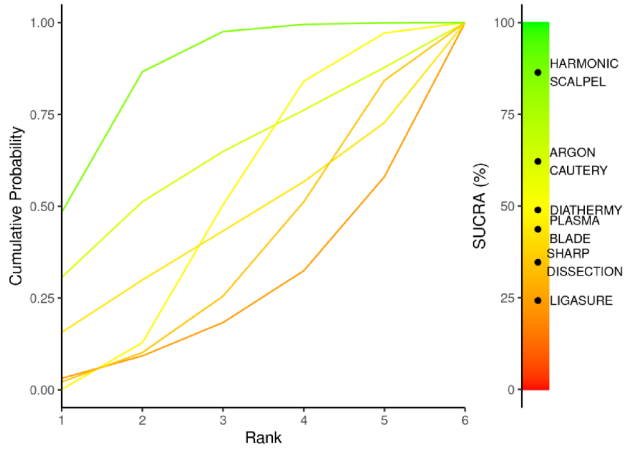

Fig. 3E Shows the SUCRA for the volume of the drain effluent after mastectomy. Harmonic scalpel had the highest P-score at 86.3%

Abbreviations

SO	Saburi Oyewale
AA	Azeezat Ariwoola
IO	Idris Oyewale
RCT	Randomised control trial
PRISMA	Preferred reporting items for systematic reviews and meta-analysis
RoB	Risk of bias
NMA	Network meta-analysis
LMIC	Low- and middle-income countries
SUCRA	Surface under the cumulative ranking curve
OR	Odds ratio

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12893-024-02723-6.

Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

Supplementary Material 5

Supplementary Material 6

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Author contributions
All authors reviewed the manuscripts.A.A - Preparation of ROBVIS plot, data extractionI.O - data extraction, assessment of quality of study, and data analysisS.O - data extraction, assessment of the quality of study, and data analysis.

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Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
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