

# BMJ Open Effectiveness of silver and iodine dressings on wound healing: a systematic review and meta-analysis

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## ABSTRACT

**Objective** To evaluate the effects of silver and iodine dressings on healing time, healing rate, exudate amount, pain and anti-infective efficacy.

**Design** Systematic review and meta-analysis.

**Data sources** Databases including PubMed, Cochrane Library, Embase, Web of Science and CINAHL were surveyed up to May 2024.

**Eligibility criteria** Randomised controlled trials comparing silver and iodine dressings on wound healing in humans.

**Data extraction and synthesis** Evidence certainty was evaluated using the Grading of Recommendations, Assessment, Development, and Evaluation approach. Data extraction was done independently by two reviewers, with the risk of bias assessed using the Cochrane tool. Narrative synthesis was performed to evaluate the effects of silver and iodine dressings on healing time, healing rate, pain, exudate amount and anti-infective efficacy. Meta-analysis using Review Manager V.5.4 calculated standardised mean differences for healing time and relative risks for rate to quantify the impacts of the treatments.

**Results** 17 studies (18 articles) were included. The meta-analysis indicated that silver dressings significantly reduced healing time compared with iodine dressings (SMD=-0.95, 95% CI -1.62 to -0.28,  $I^2=92%$ ,  $p=0.005$ , moderate-quality evidence), with no significant difference in enhancing healing rate (RR=1.29, 95% CI 0.90 to 1.85,  $I^2=91%$ ,  $p=0.16$ , low-quality evidence). Based on low-quality evidence, for exudate amount (3/17), 66.7% (2/3) of the studies favoured silver dressings over iodine in reducing exudate volume. For pain (7/17), 57.1% (4/7) of the studies reported no significant difference between silver and iodine dressings, while 42.9% (3/7) studies indicated superior pain relief with silver dressings. For anti-infective efficacy (11/13), 54.5% (6/11) of the studies showed equivalence between silver and iodine dressings, while 36.4% (4/11) suggested greater antibacterial efficacy for silver.

**Conclusion** Silver dressings, demonstrating a comparable healing rate to iodine dressings, significantly reduce healing time, suggesting their potential as a superior adjunct in wound care.

**PROSPERO registration number** CRD42020199602.

## INTRODUCTION

The wound is one of the most common clinical problems. Wounds that continue to occur

## STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ The strength of the systematic review lies in its rigorous methodology, adhering to Cochrane and Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines, ensuring a high standard of scientific integrity and replicability.
- ⇒ The search inclusivity of non-English literature, guided by rigorous strategies, showcases a pioneering commitment to global comprehensiveness, likely enriching the evidence base with diverse perspectives.
- ⇒ Independent use of the Cochrane risk-of-bias tool and Grading of Recommendations, Assessment, Development, and Evaluation for evidence certainty, coupled with a dual extraction process, reflects an innovative dedication to methodological rigour and data integrity.
- ⇒ Despite the methodological rigour, the acknowledged heterogeneity across studies might limit the generalisability of findings, suggesting a need for innovative approaches to synthesise diverse data effectively.

in all health settings place a financial burden on healthcare systems while increasing patient stress and reducing the quality of life.<sup>1-3</sup> Wound dressings play an important role in wound management, including protecting the surrounding healthy skin, supporting autolytic debridement, absorbing exudate, accelerating the rate of epithelialisation and lowering microorganism density.<sup>4</sup> Numerous options for wound dressings are commercially available, varying according to dressing material (eg, film, hydrocolloid, hydrogel and foam) or antimicrobial agents (eg, silver and iodine).<sup>5-7</sup> Among them, silver and iodine dressings are more common in the clinical practice of wound care due to their ease of use, low cost and ability to deal with excess exudates, prevent bacteria from entering and promote wound healing.<sup>8-11</sup>

Both silver and iodine dressings can effectively promote wound healing. According to checklists for wound healing assessments,<sup>12 13</sup>

the effectiveness of wound healing is usually assessed by healing time, healing rate, exudate amount, pain or anti-infective efficacy.<sup>14</sup> Iodine dressing has been established as an effective agent with a broad antimicrobial spectrum, low microbial resistance, low cytotoxicity and good tolerability.<sup>15</sup> Compared with hydrocellular foam dressing and petrolatum gauze, iodine dressing required less time to complete epithelialisation ( $p=0.0003$ ,  $p=0.0205$ ).<sup>16</sup> Silver dressing is recognised as a safe and effective topical antimicrobial agent that is highly cost-effective<sup>17</sup> and can be used against a broad spectrum of common wound pathogens.<sup>18</sup> A meta-analysis of eight randomised controlled trials (RCTs) showed that compared with other dressings (eg, brine dressing, activated carbon cloth, sterile polyacrylate wound pad, alginate dressing and hydropolymer adhesive dressing), silver dressings significantly increased the rate of healing,<sup>19</sup> reduced pain-related symptoms and decreased wound exudates ( $p<0.001$ ).<sup>20</sup> However, this meta-analysis did not include studies comparing iodine and silver dressings for wound treatment.

There is an urgent need for rigorous and empirical research to evaluate the effectiveness of silver/iodine dressings in wound management. There are a few RCTs comparing the wound-healing effects of two dressings, but the results are controversial. For instance, Singh and Apte<sup>21</sup> found that compared with povidone dressing, silver foam significantly shortened the wound healing time ( $p=0.0058$ ), which is in contrast to that of Homann *et al.*<sup>22</sup> We systematically searched PubMed, Cochrane Library, Embase, Web of Science and CINAHL databases using key terms such as ‘wounds’, ‘silver’ and ‘iodine’ to ensure comprehensive coverage of relevant research areas. Additionally, we checked the PROSPERO database, an international registry for systematic reviews. Then we confirm that no ongoing or published systematic reviews on comparative studies of silver and iodine dressings have been registered so far. Therefore, the aim of this study was to compare and analyse the effects of iodine and silver dressings on wound healing and provide an evidence-based basis for the clinical practice of wound management.

## METHODS

This systematic review and meta-analysis was performed according to the Cochrane Handbook for Systematic Reviews of Interventions<sup>23</sup> and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines.<sup>24</sup> The protocol for this systematic review and meta-analysis was registered with PROSPERO (CRD42020199602).

### Eligibility criteria

Inclusion criteria were as follows: (1) participants were humans with wounds, and no further restrictions were placed on basic information such as the age and gender of the patients or the type of wound; (2) the study included articles in both English and non-English languages that

reported RCTs comparing the effects of silver and iodine dressings on wound treatment; (3) studies included, but were not limited to, the following outcome measures: healing time, healing rate, exudate amount, pain management and anti-infective efficacy. Exclusion criteria were as follows: (1) single-arm clinical trials, case series, reports, conference abstracts or comments on other studies and (2) studies with unknown target outcomes of interest.

### Search strategy

We executed a thorough search across PubMed, Cochrane Library, Embase, Web of Science and CINAHL via the Central South University Library, capturing records from their inception to the present. Further access to the library’s resources can be obtained through the Central South University Library (<https://lib.csu.edu.cn/>).

Employing MeSH terms and free-text keywords, enhanced by Boolean operators, our search encompassed topics such as ‘Wounds and Injuries’, ‘Wound Infection’, ‘Wound Healing’, ‘Surgical Wound Infection’, ‘Surgical Wound Dehiscence’, ‘Surgical Wound’, ‘stab wounds’, ‘penetrating wounds’, ‘gunshot wounds’ and ‘Multiple Trauma’, alongside broader terms ‘wound\*’, ‘injur\*’, ‘trauma\*’, ‘silver\*’ and ‘iodin\*’. The use of wildcard (\*) increased search sensitivity by capturing various word forms and derivatives.<sup>25</sup> Full-text searches were performed where possible, with the exception of Web of Science. Furthermore, to encompass grey literature and unpublished research, we used subject-specific terminology and free-text keywords on the Data Archiving and Networked Services platform (<https://easy.dans.knaw.nl/ui/datasets/id/easy-dataset:200362/tab/2>) and the ProQuest Dissertations & Theses database (<https://about.proquest.com/en/dissertations/>). This comprehensive approach was initiated in December 2018 and updated in May 2024. The complete search strategy is provided in the online supplemental material 1.

### Study selection

The results of the systematic searches were imported into the EndNote V.20 (Clarivate Analytics, Pennsylvania, USA) reference manager and duplicate references were removed using both the software and manual checks. Two investigators (YJ and WD) independently screened the titles and abstracts based on the inclusion and exclusion criteria. Where there were disagreements, full-text articles were then downloaded for eligibility assessment. Where necessary, a third investigator (JG) intervened to resolve disputes. A consensus was reached for all included studies.

### Quality assessment

Two investigators (YJ and WD) independently assessed each included study using the Cochrane tool to assess the risk of bias.<sup>26</sup> This tool addresses six specific domains: sequence generation, allocation concealment, blinding, incomplete outcome data, selective outcome reporting and other biases. Similarly, investigators assessed the

certainty of the evidence independently and in duplicate, using the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) approach. The certainty of the evidence ranges from very low to high. The RCTs were initially considered high-quality evidence and were downgraded based on prespecified criteria. It depends on risk of bias, inconsistency, indirectness, imprecision and other considerations such as publication bias. Risk of bias, assessed with the Cochrane tool, led to a downgrade if high-risk studies were judged to influence the pooled effects. Inconsistency, evaluated with  $I^2$  estimates, resulted in a downgrade when  $I^2$  was 60% or higher, indicating substantial heterogeneity. Indirectness was downgraded when factors related to participants, interventions or outcomes affected the generalisability of the findings. Imprecision was downgraded if the 95% CI included half or less of the minimal important difference for continuous outcomes, or included a relative risk RR of 1 for dichotomous outcomes, or when the study included fewer than 400 participants, indicating an insufficient sample size. Publication bias, indicated by funnel plot asymmetry, led to a downgrade in evidence certainty due to potential selective reporting or missing studies. Disagreements were resolved by consensus or by consulting a third investigator. A summary of findings was created using the GRADEpro Guideline Development Tool (<https://www.grade.org/>).

### Data extraction

The study data were compiled and entered into a purpose-built database using a framework adapted from the data collection checklist of Effective Practice & Organization of Care.<sup>25</sup> It provides helpful guidance for reviewers on the types of relevant information extracted from primary studies.<sup>27</sup> Author details, year of publication, country and sample size were extracted as characteristics of each study; the information was combined to synthesise the findings. The type of dressing was extracted as characteristics of the intervention. The effectiveness of iodine versus silver dressings was assessed for healing time, healing rate, reduction in exudate amount, pain and anti-infective efficacy. If the results of a single study were reported in more than one publication, the data from these publications were combined into one study entry. Again, two reviewers (YJ and WD) independently extracted the primary data and resolved discrepancies through mutual consensus or by consulting a third reviewer (JG). The data extraction process was critically appraised to ensure the accuracy and relevance of the extracted data.

### Statistical analysis

Data were analysed using Review Manager V.5.4 software. All data were double entered into the database to minimise errors. Acknowledging the methodological heterogeneity in outcome assessment across studies, we selected a random effects model to accommodate variability. For dichotomous data, we calculated the RR, with an  $RR > 1$  suggesting superior healing rate with silver dressings. For

continuous outcomes, we used the standardised mean difference, which is deemed significant when the 95% CI does not encompass zero, indicating a non-chance effect of the intervention. Heterogeneity was methodically assessed with the  $\chi^2$  test and  $I^2$  statistic, where an  $I^2 > 50\%$  signals substantial variability. Considering the variability in clinical and methodological approaches among the studies included, we established a priori criteria for conducting a meta-analysis. We determined that a minimum of three studies was required to ensure the statistical robustness and clinical interpretability of the pooled effect sizes.<sup>28</sup> Studies that reported outcomes not amenable to standardisation or lacked adequate data for effect size calculation were consequently excluded from the meta-analysis. The asymmetry of the funnel plot was assessed for the presence of publication bias.

### Patient and public involvement

Patients and/or the public were not involved in the design, conduct, reporting or dissemination plans of this research.

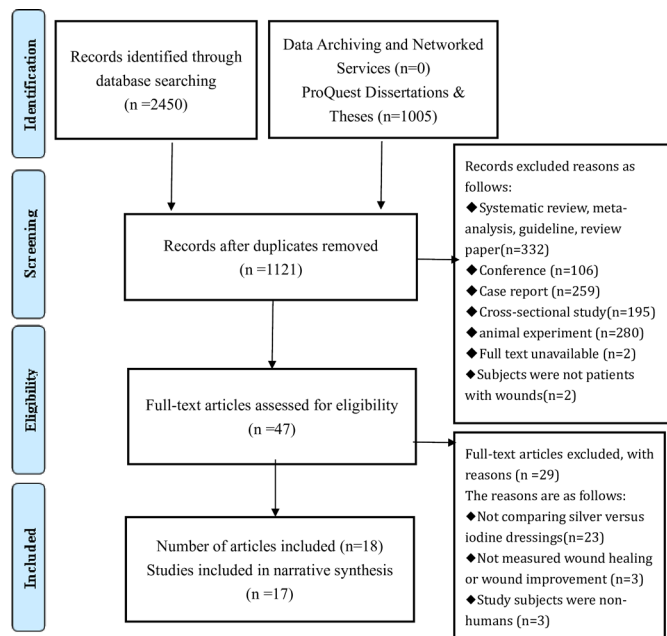
## RESULTS

### Study inclusion

The database search yielded 2450 studies, with an additional 1005 records obtained from the Data Archiving and Networked Services platform and the ProQuest Dissertations & Theses database. After removing duplicates and screening at the title and abstract level, a total of 47 full-text articles were reviewed for eligibility. On thorough examination of the full texts, 29 articles were excluded. The online supplemental material 2 contains a list of excluded studies along with the reasons for their exclusion. Ultimately, 18 articles met the inclusion criteria, of which 2 studies<sup>29 30</sup> were found to be duplicates of the same study (see [figure 1](#)).

### Characteristics of included studies

Detailed features of the included studies are reported in online supplemental table 1. 17 studies were included, encompassing 3374 subjects from various geographical backgrounds, including India (n=5),<sup>21 31-34</sup> the USA (n=3),<sup>35-37</sup> Germany (n=2),<sup>22 38</sup> Korea (n=1),<sup>39</sup> Australia (n=1),<sup>29</sup> China (n=1),<sup>40</sup> Egypt (n=1),<sup>41</sup> Bahrain (n=1)<sup>42</sup> and Turkey (n=1).<sup>43</sup> Additionally, one study was a collaborative effort across Germany, France and Great Britain.<sup>44</sup> The total sample size of the intervention groups (silver dressing) was 1709, while the total sample size of the control groups (iodine dressing) was 1541. The number of participants in each study ranged from 11 to 1089. Study participants were presented with a diverse range of wound types, with burn wounds (n=5)<sup>22 31 36 38 39</sup> being the most common and diabetic foot ulcers (n=4)<sup>32 33 41 42</sup> closely following. Other observed wound types included surgical and traumatic wounds (n=2),<sup>43 44</sup> chronic pressure ulcers (n=1),<sup>35</sup> leg ulcers (n=1),<sup>29</sup> cutaneous abscesses (n=1),<sup>37</sup>



**Figure 1** Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram.

infected wounds (n=1),<sup>21</sup> needle stick injuries (n=1)<sup>34</sup> and pemphigus vulgaris (n=1).<sup>40</sup>

**Intervention characteristics and measured outcomes**

The primary outcomes measured by the included studies (intervention group vs comparison group after intervention) are shown in online supplemental table 2. The silver dressing group consisted of various formulations: silver sulfadiazine cream (n=7),<sup>22 31 34-36 38 40</sup> nanocrystalline silver dressings (n=4),<sup>29 32 33 42</sup> silver-containing hydrofibre dressings (n=3),<sup>37 43 44</sup> silver foam dressing (n=2),<sup>21 39</sup> and SilvrSTAT Gel dressing (n=1).<sup>41</sup> Conversely, the iodine dressing group was primarily represented by povidone-iodine gauze (n=13),<sup>21 31-36 39-44</sup> polyvinylpyrrolidone-iodine (n=2),<sup>22 38</sup> cadexomer iodine (n=1)<sup>29</sup> and iodoform (n=1).<sup>37</sup> The time period from baseline to final assessment ranged from 48 hours to 27 months. Healing time was assessed by time to complete wound healing.<sup>21 22 29 31 39 44</sup> Healing rate was assessed by either determining the percentage change in total wound surface area between two measurements and

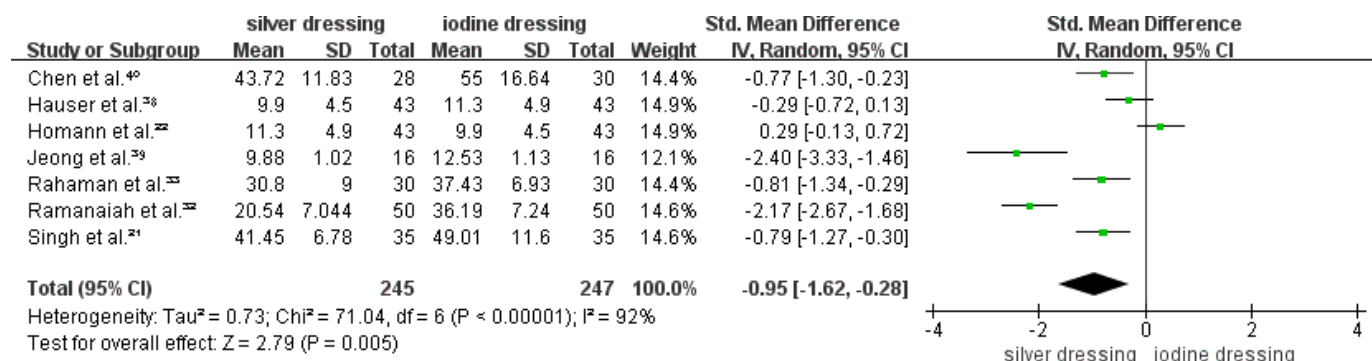
dividing by the number of days between wound measurements<sup>21 29 31-33 36 41 44</sup> or by observing the change in surface area of cellulitis and abscess at the first follow-up visit (48–72 hours).<sup>37</sup> The amount of exudate was assessed by professional assessment by the investigator (categorised as none, minimal, moderate or heavy) in one study<sup>36 44</sup> or by measuring the time taken for exudate reduction in another study.<sup>21</sup> Pain was assessed using various scales including a 10-point Numeric Rating Scale,<sup>39 40</sup> a 5-point scale for itching point scale, for sensation during dressing changes,<sup>22 36</sup> a Visual Analog Scale<sup>44</sup> or the Wong-Baker Faces Pain Rating Scale.<sup>37</sup> The assessment of anti-infective efficacy included a 7-point scale,<sup>22</sup> reduction of infected wounds,<sup>31 44</sup> leucocyte counts, Gram stain bacterial growth<sup>29</sup> and the mean days to negative cultures<sup>21</sup> or reduced bacterial loads.<sup>33 35</sup> Alternatively, a ratio of infected punctate sites over infection duration was compared with observed sites over the study duration.<sup>34</sup>

**Healing time**

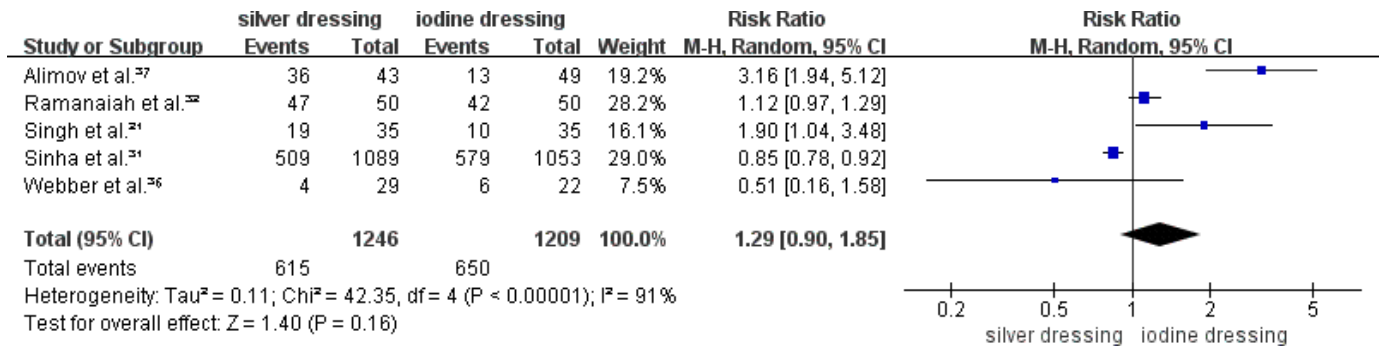
9 (9/17, 52.9%) out of 17 studies reported on healing time.<sup>21 22 31-33 38-40 44</sup> Among these, two (2/9, 22.2%) studies did not find a significant difference between silver and iodine dressings,<sup>39 44</sup> while four (4/9, 44.4%) studies favoured silver dressings<sup>21 32 33 40</sup> and three (3/9, 33.3%) studies favoured iodine dressings.<sup>22 31 38</sup> Healing time varied from 8 to 71.64 days. Given the omission of SD values in two studies,<sup>31 44</sup> our meta-analysis was predicated on seven studies (7/9, 77.8%), which indicated a statistically significant reduction in healing time with silver dressings compared with iodine treatments (n=7) (SMD=-0.95, 95% CI -1.62 to -0.28, I<sup>2</sup>=92%, p=0.005) (figure 2). This implied that silver dressings may offer superior efficacy in accelerating wound healing. The funnel plot was largely symmetrical and there was no apparent publication bias (online supplemental figure 1).

**Healing rate**

10 (10/17, 58.8%) out of 17 studies reported on healing rate.<sup>21 29 31-33 36 37 41 42 44</sup> Among these, three (3/10, 30%) studies reported no significant differences between silver and iodine dressings,<sup>33 36 44</sup> while six (6/10, 60%) studies indicated superior performance of silver dressings.<sup>21 29 32 37 41 42</sup> One study (1/10, 10%) favoured iodine



**Figure 2** Forest plot of the effect of silver and iodine dressings on wound healing time.



**Figure 3** Forest plot of the effect of silver and iodine dressings on wound healing rate.

dressings.<sup>31</sup> Due to the inconsistency in data formats and the inability to standardise to a uniform percentage format, we were constrained to a meta-analysis of only five (5/10, 50%) studies. The pooled RR from the random effects model was 1.29 (RR=1.29, 95% CI 0.90 to 1.85), indicating a non-significant trend towards higher healing rate with silver dressings, although this did not reach statistical significance (Z=1.40, I<sup>2</sup>=91%, p=0.16) (figure 3). The symmetrical distribution of points in the funnel plot suggests no evident publication bias, yet conclusions are tentative due to the small sample size (online supplemental figure 2).

#### Exudate amount

3 (3/17, 17.6%) out of the 17 studies reported on the amount of exudate.<sup>21 36 44</sup> Among the studies, two demonstrated that silver dressings were superior in reducing exudate compared with iodine dressings,<sup>21 44</sup> while one indicated that wounds treated with iodine dressings were significantly drier.<sup>36</sup> However, this difference became non-significant when patients with complicating factors were excluded. Due to disparate expression patterns of exudation reduction across studies, a meta-analysis was not feasible, precluding the aggregation of these data into a pooled estimate.

#### Pain

7 (7/17, 41.2%) out of the 17 studies reported on the pain.<sup>22 36–40 44</sup> Among them, three studies (3/7, 42.9%) demonstrated that silver dressing was more effective than iodine dressing.<sup>37 40 44</sup> Conversely, four (4/7, 57.1%) studies found no significant differences in pain management scores between the silver and iodine dressing groups.<sup>22 36 38 39</sup> Due to the heterogeneity in pain scoring criteria across studies, a meta-analysis was not feasible.

#### Anti-infective efficacy

11 (11/17, 64.7%) out of the 17 studies reported on the anti-infective efficacy.<sup>21 22 29 31 33–35 38 40 43 44</sup> Among these, four studies (4/11, 36.4%) reported superior anti-infective outcomes with silver dressings.<sup>21 29 35 43</sup> Conversely, six studies (6/11, 54.5%) found no significant difference in anti-infective efficacy between the dressing groups.<sup>22 33 34 38 40 44</sup> And only one study (1/11, 9.1%) suggested that wounds dressed with iodine

exhibited greater resistance to infection.<sup>31</sup> The diversity in methodologies for assessing antimicrobial properties, including bacterial load reduction, sterility duration, infection ratios and efficacy grading, precluded a meta-analysis.

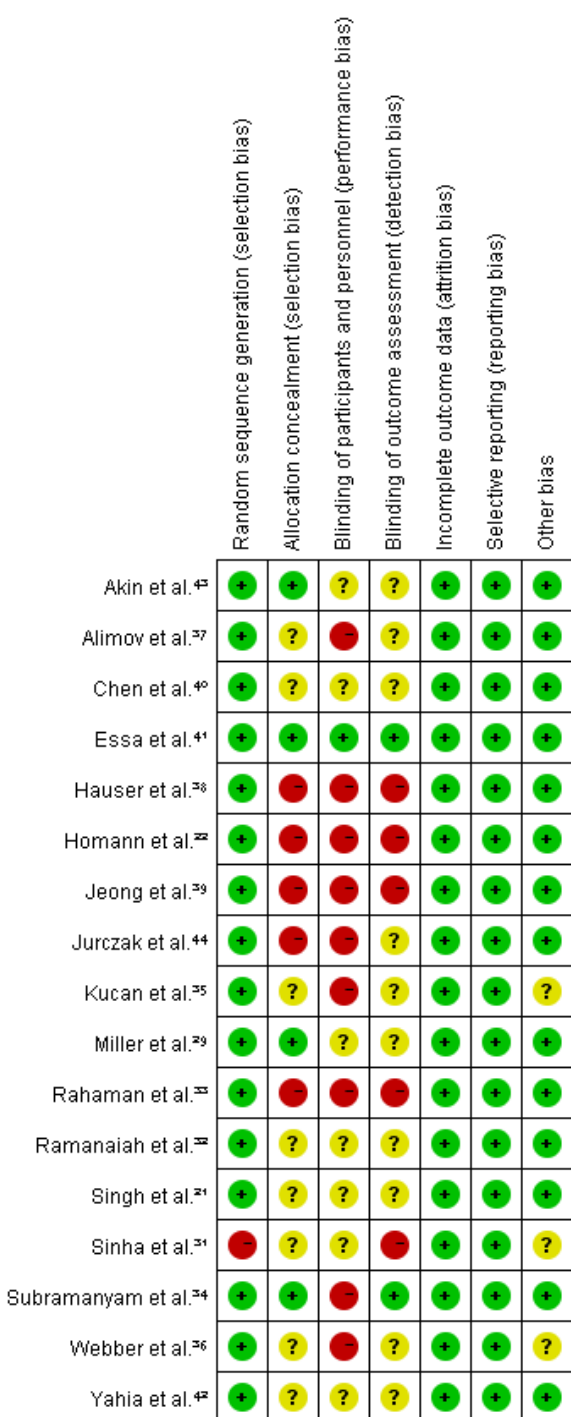
#### Methodological quality

The risk-of-bias assessment across the included studies is detailed in figure 4. A single study<sup>31</sup> exhibited a high risk of bias in the randomisation sequence due to selective grouping practices. The remaining studies were characterised by low risk of bias in this domain. Allocation concealment was not employed in five studies,<sup>22 33 38 39 44</sup> leading to a high risk of bias in these instances. Only one study<sup>41</sup> explicitly reported the use of blinding for investigators and participants, thus being classified as low risk of bias; the remaining 16 studies were categorised as having high or unclear risk of bias due to the absence of blinding or lack of reporting on this aspect. Furthermore, five studies presented a high risk of bias due to the absence of blinding for outcome assessors.<sup>22 31 33 38 39</sup> All studies maintained a low risk of bias regarding incomplete and selective outcome reporting, as there were no missing data that could potentially influence the study outcomes.

According to the GRADE evaluation, the evidence for healing time was rated as moderate certainty, downgraded one level due to serious inconsistency. The evidence for healing rate was rated as low certainty, downgraded two levels due to serious inconsistency and serious imprecision. Furthermore, the evidence for exudate amount, pain and anti-infective efficacy was rated as low certainty, each downgraded two levels due to serious risk of bias and serious imprecision (see table 1).

## DISCUSSION

This review systematically summarised the available evidence on the clinical effects of silver and iodine dressings. It was found that silver dressings are superior to iodine dressings in terms of shortening healing time. Therefore, silver dressings may be an ideal adjuvant material for more effective wound healing compared with iodine dressings.



**Figure 4** Risk of bias among the included randomised controlled trials according to the Cochrane risk-of-bias tool.

Our meta-analysis showed that silver dressings have an advantage over iodine dressings in reducing healing time. Singh and Apte<sup>21</sup> found that silver dressings resulted in a statistically significant increase in wound capillary proliferation when compared with iodine dressings ( $p < 0.05$ ). This scientific finding validates the results of this study. Silver ions in the dressing promote Vascular Endothelial Growth Factor production, stimulate angiogenesis and improve periwound blood flow. In addition, silver ions can

also stimulate fibroblasts to differentiate into myofibroblasts, which effectively stimulate wound contraction and accelerate skin remodelling, further promoting wound healing and shortening healing time.<sup>45 46</sup> Two studies showed no significant difference in healing time between the two dressings, but healing time in the silver dressing group was shorter than that in the iodine dressing group. Therefore, compared with iodine dressings, silver dressings are more capable of reducing wound healing time and promoting wound healing.

Healing rate is a crucial indicator used to evaluate the effectiveness of wound recovery. Our meta-analysis did not identify significant statistical differences in healing rate between the two dressings. This finding does not align with a previous meta-analysis, which found that silver dressings were more effective than non-silver dressings in reducing the size of chronic non-healing wounds.<sup>20</sup> Additionally, other research has suggested that silver dressings could be particularly beneficial in the initial stages of wound healing, especially within the first 2 weeks of treatment ( $p < 0.05$ ).<sup>33 44</sup> This implies that silver dressings may offer significant advantages during specific crucial early phases of wound healing, even if an overall statistical superiority in healing rate is not conclusively proven. To summarise, silver dressings may have an advantage over iodine dressings in enhancing healing rate, which needs more studies.

In addition, our study found that silver dressing also showed positive and effective application effects in reducing exudate amount and relieving pain compared with iodine dressing. Chaganti *et al*<sup>47</sup> showed that dressings, such as Hydrofiber Ag<sup>44</sup> and silver foam dressings,<sup>21</sup> have unique liquid handling properties and the ability to absorb exudates, which is similar to the results of this study. In addition, Homann *et al*<sup>22</sup> found that nearly 50% of the patients in the iodine dressing group reported unpleasant sensations, such as pain during the application of the excipients, much more than in the silver dressing group. The possible reason is that the silver dressing forms a soft adhesive gel after absorbing a large amount of wound fluid, perfectly fitting the wound and reducing the patient's discomfort and pain.<sup>37</sup>

In terms of anti-infective efficacy, our study found that 54.5% (6/11) of the studies supported that there was no significant difference in anti-infective efficacy between the two dressings, which may be related to the use of antibiotics, changing dressings daily and other factors. The other two studies showed that the anti-infective efficacy of silver dressings was better than that of iodine dressings, probably because the subjects in these two studies had a clinical infection or severe colonisation of the wound.<sup>21 29</sup> Silver, through reliability, is fast and effective at killing critical colonisation, that is, Ag<sup>+</sup> binding to DNA, enzymes and proteins in the cell wall of bacterial cells.<sup>48</sup> Once Ag<sup>+</sup> is attached to these sites, it alters their structure, leading to structural and functional changes in bacterial cells, regulating the ever-present inflammatory response promoting healing and producing long-term clinical

**Table 1** Summary of findings

Outcomes	Effect size (95% CI)	Participants (n)	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Quality assessment
Healing time	SMD -0.95, (-1.62 to -0.28)	2814 (9 RCTs)	Not serious	Serious ( $I^2=92\% > 60\%$ )	Not serious	Not serious	Not serious	Moderate*
Healing rate	RR 1.29 (0.90 to 1.85)	3001 (10 RCTs)	Not serious	Serious ( $I^2=91\% > 60\%$ )	Not serious	Serious (CI overlaps with no effect)	Not serious	Low†
Exudate amount	N/A	188 (3 RCTs)	Serious (2/3: selection bias)	None	Not serious	Serious (fewer than 400 participants)	None	Low†
Pain	N/A	378 (7 RCTs)	Serious (4/7: selection bias; 6/7: performance bias)	None	Not serious	Serious (fewer than 400 participants)	None	Low†
Anti-infective efficacy	N/A	2904 (11 RCTs)	Serious (5/11: performance bias)	None	Not serious	Serious‡	None	Low†

The outcomes of interest are healing time, healing rate, exudate amount, pain and anti-infective efficacy.  
 \*Moderate certainty: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.  
 †Low certainty: the true effect may be substantially different from the estimate of the effect.  
 ‡On analysis of 11 studies by 2 investigators, and consultation with a third, the notable inconsistencies in the anti-infective efficacy results suggest serious imprecision in the research area.  
 RCT, randomised controlled trial; SDM, standardised mean difference.



effects.<sup>49</sup> However, high concentrations (>10%) of iodine ions can induce tissue necrosis, and low concentrations can induce cell apoptosis, limiting the antibacterial effect of iodine dressings.<sup>50</sup>

This is the first systematic review and meta-analysis to generalise and summarise the effects of silver and iodine dressings on promoting wound healing, reinforcing the rigour of this review by including RCTs, using a comprehensive and exhaustive search, a systematic approach to identifying trials and extracting data and using systematic tools to assess bias and overall quality of evidence. In addition, the inclusion of outcome measures such as healing time, healing rate and exudate amount in this study highlights the potential clinical applicability of the findings.

Our study is subject to limitations. Primarily, the evidence quality is limited by the moderate-to-low ratings of the reviewed studies, potentially weakening the strength of our conclusions. Furthermore, the varying adjuvant therapies used in the studies may have impacted wound healing processes, leading to differing outcomes. To address these constraints, future research should focus on using high-quality studies and standardised methodologies to provide a more accurate assessment of the effects of silver dressings on wound healing processes.

In terms of clinical implications, we have observed that silver dressings, acting as an antimicrobial agent, can shorten healing time in most wound treatments. Therefore, when affordable, silver dressings are recommended as a priority. Regarding research implications, more rigorous trials should be conducted to compare the effectiveness of the two dressings. First, considering the potential impact of healthcare system differences on wound care, studies from various geographical areas, including high-income, middle-income and low-income countries, should be encouraged. Second, given the limited number of studies focusing on outcomes like exudate reduction and pain when comparing silver and iodine dressings, additional research is required. Third, future studies should provide more detailed data on wound infections to reach definitive conclusions about the anti-infective efficacy of silver and iodine dressings.

## CONCLUSIONS

This systematic review and meta-analysis provides robust evidence that silver dressings markedly accelerate wound healing time compared with iodine dressings, without a corresponding impact on healing rate. The findings on silver dressings' effects on exudate amount, pain and anti-infective efficacy are inconsistent and derived from studies of variable quality. Despite these limitations, the collective research implies that silver dressings may be a viable clinical option for wound care, specifically in hastening the healing timeline. Nonetheless, the dearth and heterogeneity of existing studies necessitate further well-designed research to delineate unequivocal clinical protocols.

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## REFERENCES

- Harding KG, Morris HL, Patel GK. Science, medicine and the future: healing chronic wounds. *BMJ* 2002;324:160–3.
- Wilkins RG, Unverdorben M. Wound cleaning and wound healing: a concise review. *Adv Skin Wound Care* 2013;26:160–3.
- Chaby G, Senet P, Vaneau M, et al. Dressings for acute and chronic wounds. *Arch Dermatol* 2007;143:1297–304.
- Dhivya S, Padma VV, Santhini E. Wound dressings – a review. *BioMed* 2015;5:5.
- Broussard KC, Powers JG. Wound dressings: selecting the most appropriate type. *Am J Clin Dermatol* 2013;14:449–59.
- Greenhalgh DG. Topical antimicrobial agents for burn wounds. *Clin Plast Surg* 2009;36:597–606.
- Omar Sarheed A, Boateng J. Antimicrobial dressings for improving wound healing antimicrobial dressings for improving wound healing. In: *Wound healing - new insights into ancient challenges*. InTech, 2016.
- Sharma G, Lee SW, Atanacio O, et al. In search of the optimal wound dressing material following total hip and knee arthroplasty: a systematic review and meta-analysis. *Int Orthop* 2017;41:1295–305.



- 9 Fumal I, Braham C, Paquet P, *et al.* The beneficial toxicity paradox of antimicrobials in leg ulcer healing impaired by a polymicrobial flora: a proof-of-concept study. *Dermatology (Basel)* 2002;204:70–4.
- 10 Lansdown ABG, Williams A, Chandler S, *et al.* Silver absorption and antibacterial efficacy of silver dressings. *J Wound Care* 2005;14:155–60.
- 11 Cho Lee A-R, Leem H, Lee J, *et al.* Reversal of silver sulfadiazine-impaired wound healing by epidermal growth factor. *Biomaterials* 2005;26:4670–6.
- 12 Hess CT. Clinical and documentation management checklist. *Adv Skin Wound Care* 2010;23:288.
- 13 Thomas Hess C. Checklist for factors affecting wound healing. *Adv Skin Wound Care* 2011;24:192.
- 14 Rowan MP, Cancio LC, Elster EA, *et al.* Burn wound healing and treatment: review and advancements. *Crit Care* 2015;19:243.
- 15 Bigliardi PL, Alsagoff SAL, El-Kafrawi HY, *et al.* Povidone iodine in wound healing: a review of current concepts and practices. *Int J Surg* 2017;44:260–8.
- 16 Pak CS, Park DH, Oh TS, *et al.* Comparison of the efficacy and safety of povidone-iodine foam dressing (Betafoam), hydrocellular foam dressing (Allevyn), and petrolatum gauze for split-thickness skin graft donor site dressing. *Int Wound J* 2019;16:379–86.
- 17 Dissemond J, Böttrich JG, Braunwarth H, *et al.* Evidence for silver in wound care – meta-analysis of clinical studies from 2000–2015. *J D D G* 2017;15:524–35.
- 18 Mimura ECM, Favoreto JPM, Favero ME, *et al.* Silver serum levels in burned patients treated with silver sulfadiazine and its toxicity on inflammatory cells. *Burns* 2020;46:1120–7.
- 19 Choi YM, Campbell K, Levek C, *et al.* Antibiotic ointment versus a silver-based dressing for children with extremity burns: a randomized controlled study. *J Pediatr Surg* 2019;54:1391–6.
- 20 Lo S-F, Chang C-J, Hu W-Y, *et al.* The effectiveness of silver-releasing dressings in the management of non-healing chronic wounds: a meta-analysis. *J Clin Nurs* 2009;18:716–28.
- 21 Singh S, Apte A. Comparative study of silver foam dressing over povidone iodone dressing in infected wounds. *J E M D S* 2014;3:6233–42.
- 22 Homann H-H, Rosbach O, Moll W, *et al.* A liposome hydrogel with polyvinyl-pyrrolidone iodine in the local treatment of partial-thickness burn wounds. *Ann Plast Surg* 2007;59:423–7.
- 23 Higgins JPT, Thomas J, Chandler J. *Cochrane handbook for systematic reviews of interventions version 6.* 2019.
- 24 Moher D, Liberati A, Tetzlaff J, *et al.* Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med* 2009;6:e1000097.
- 25 Carter MJ, Tingley-Kelley K, Warriner RA. Silver treatments and silver-impregnated dressings for the healing of leg wounds and ulcers: a systematic review and meta-analysis. *J Am Acad Dermatol* 2010;63:668–79.
- 26 Higgins JPT, Altman DG, Gotzsche PC, *et al.* The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ* 2011;343:d5928.
- 27 Cochrane effective practice and organisation of care (EPOC). 2021. Available: <https://epoc.cochrane.org/>
- 28 Higgins JTJC. *Cochrane handbook for systematic reviews of interventions version 6.1 version 6.3.* 2022.
- 29 Miller CN, Newall N, Kapp SE, *et al.* A randomized-controlled trial comparing cadexomer iodine and nanocrystalline silver on the healing of leg ulcers. *Wound Repair Regen* 2010;18:359–67.
- 30 Miller CN, Carville K, Newall N, *et al.* Assessing bacterial burden in wounds: comparing clinical observation and wound swabs. *Int Wound J* 2011;8:45–55.
- 31 Sinha R, Agarwal RK, Agarwal M. Povidone iodine plus neosporin in superficial burns--a continuing study. *Burns* 1997;23:626–8.
- 32 N V R, Saikrishna S, Chandrasekhar C, *et al.* A clinical study on efficacy of nanocrystalline silver dressing in diabetic foot ulcers. *J E B M H* 2015;2:8160–70.
- 33 Rahaman A, Manjunath A, Mookherjee Bhattacharya A. Efficacy in the management of chronic diabetic foot ulcers. *J Evol Med Dent Sci* 2017;6:1799–803.
- 34 Subramanyam KN, Mundargi AV, Potarlanka R, *et al.* No role for antiseptics in routine pin site care in Ilizarov fixators: a randomised prospective single blinded control study. *Injury* 2019;50:770–6.
- 35 Kucan JO, Robson MC, Hegggers JP, *et al.* Comparison of silver sulfadiazine, povidone-iodine and physiologic saline in the treatment of chronic pressure ulcers. *J Am Geriatr Soc* 1981;29:232–5.
- 36 Webber CE, Glanges E, Crenshaw CA. Treatment of second degree burns: nitrofurazone, povidone-iodine, and silver sulfadiazine. *JACEP* 1977;6:486–90.
- 37 Alimov V, Lovecchio F, Sinha M, *et al.* Use of a silver-containing hydrofiber dressing for filling abscess cavity following incision and drainage in the emergency department: a randomized controlled trial. *Adv Skin Wound Care* 2013;26:20–5.
- 38 Hauser J, Rosbach O, Langer S, *et al.* Lokale Behandlung von Grad-IIa-Verbrennungen. *Unfallchir* 2007;110:988–94.
- 39 Jeong CS, Kwak K, Hur J, *et al.* A pilot study to compare the efficacy and safety of Betafoam® and Allevyn® Ag in the management of acute partial thickness burns. *Burns Open* 2019;3:1–7.
- 40 Chen J, Zou Q, Hamblin MR, *et al.* A preliminary clinical trial comparing wet silver dressings versus wet-to-dry povidone-iodine dressings for wound healing in periphigus vulgaris patients. *Dermatol Ther* 2021;34:e14906.
- 41 Essa MS, Ahmad KS, Zayed ME, *et al.* Comparative study between silver nanoparticles dressing (SilverSTAT Gel) and conventional dressing in diabetic foot ulcer healing: a prospective randomized study. *Int J Low Extrem Wounds* 2023;22:48–55.
- 42 A. Yahia E, Sharkawey AEE, Bayoumi MM. Quantitative evaluation of diabetic foot wound healing using hydrogel composite nanosilver (AgNPs) - Based dressing vs. traditional dressing: a prospective randomized control study. *PJMHS* 2021;15:2043–7.
- 43 Akin T, Kendirci M, Akgün AE, *et al.* Applying a silver-containing dressing to the incision site and its effect on the development of surgical site infection after ostomy closure: a prospective randomized clinical pilot study. *Wound Manag Prev* 2022;68:34–43.
- 44 Jurczak F, Dugré T, Johnstone A, *et al.* Randomised clinical trial of Hydrofiber dressing with silver versus povidone-iodine gauze in the management of open surgical and traumatic wounds. *Int Wound J* 2007;4:66–76.
- 45 Bourdillon KA, Delury CP, Cullen BM. Biofilms and delayed healing - an in vitro evaluation of silver- and iodine-containing dressings and their effect on bacterial and human cells. *Int Wound J* 2017;14:1066–75.
- 46 Beukelman CJ, van den Berg AJJ, Hoekstra MJ, *et al.* Anti-inflammatory properties of a liposomal hydrogel with povidone-iodine (Repithel) for wound healing in vitro. *Burns* 2008;34:845–55.
- 47 Chaganti P, Gordon I, Chao JH, *et al.* A systematic review of foam dressings for partial thickness burns. *Am J Emerg Med* 2019;37:1184–90.
- 48 Nadworny PL, Wang J, Tredget EE, *et al.* Anti-inflammatory activity of nanocrystalline silver-derived solutions in porcine contact dermatitis. *J Inflamm* 2010;7:13.
- 49 Ovington LG. The truth about silver. *Ostomy Wound Manage* 2004;50:1S–10S.
- 50 Woo KY. Management of non-healable or maintenance wounds with topical povidone iodine. *Int Wound J* 2014;11:622–6.