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Efficacy of Versajet hydrosurgery system in chronic wounds: A systematic review

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Abstract

Studies demonstrating the effectiveness of hydrosurgery for chronic wounds are extremely limited. This systematic review aimed to evaluate the efficacy of hydrosurgery compared with conventional debridement in chronic wounds, skin ulcers, and non-acute wounds. This PROSPERO-registered review was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement. A systematic search was performed in PubMed, Scopus, and Cochrane Library databases. Abstracts of all studies were screened independently by two reviewers. The bias of prospective randomised controlled studies was assessed using the Cochrane Collaboration's tool for assessing the risk of bias and RevMan 5.4 software, whereas the bias of retrospective comparative studies was evaluated using the Risk of Bias Assessment Tool for Non-randomised Studies. Two prospective randomised controlled trials, two retrospective comparative studies, and three prospective non-comparative studies were included. Hydrosurgery enabled rapid debridement. The Versajet Hydrosurgery System saved 8.87 minutes compared with the conventional methods. Similarly, the debridement quality was high with this system. The debridement number needed to achieve adequate wound beds was fewer in the hydrosurgery group than in the conventional group. These superiorities lead to subsequent success and cost-effectiveness. As there were only two prospective randomised controlled studies, and much information was missing, the risk of bias was unclear. This review confirmed that hydrosurgery is useful for the debridement of chronic wounds, considering the procedural speed and quality.

KEYWORDS

chronic wound, debridement, hydrosurgery, systematic review, Versajet

1 | INTRODUCTION

Debridement is the most important technique in wound management.[1-3] Particularly in chronic wounds with contaminations, bacterial loads, infected granulation tissues, and necrotic tissues, debridement is a premise of wound healing. Many techniques of debridement are often used, including autolytic,[4] enzymatic,[5] surgical

(scalpels, scissors, or electrocautery), high-pressure irrigation,[6] and ultrasonic[7,8] debridement.

The Versajet Hydrosurgery System (Smith and Nephew, Hull, UK, hereinafter shortened to hydrosurgery)[9] utilises a high-pressure parallel water jet that promotes the Venturi effect. It enables a surgeon to distinguish, excise, and evacuate non-viable tissues, bacteria, and contaminants tangentially from the wound surface. It can preserve more viable tissue than conventional surgical debridement and lead to less operative bleeding than conventional surgery.[10,11] Moreover, this technique can easily be performed to debride small spaces, such as the finger web space, which is difficult with conventional methods.[12] The usefulness of hydrosurgery in treating burn wounds has been widely reported, and a systematic review already confirmed its usefulness.[13,14] In this review, hydrosurgery allows for immediate skin grafting, high graft take rates, and faster healing in burn wounds.[15,16] Legemate et al showed that hydrosurgery-treated patients underwent few surgical procedures and had a low mean volume of blood transfusion compared with conventional debridement.[17]

However, studies demonstrating its effectiveness in chronic wounds are extremely limited compared with that in burns. Moreover, no systematic review of the usefulness of hydrosurgery for chronic wounds has been performed. Therefore, the purpose of this systematic review was to evaluate the efficacy of hydrosurgery compared with conventional debridement in chronic wounds, skin ulcers, and non-acute wounds by exploring all available evidence.

Key Messages

- debridement is the most important procedure in the treatment of chronic wounds
- hydrosurgical debridement with the Versajet Hydrosurgery System provides a high-pressure jet stream of saline to cut debris and keep the surgical field clean
- this is the first systematic review evaluating the efficacy of hydrosurgery in chronic wounds
- hydrosurgery is useful for the debridement of chronic wounds regarding the speed and quality of the procedure

2 | MATERIALS AND METHODS

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[18] The protocol of this review was submitted to PROSPERO, the international prospective registry of systematic reviews (University of York, UK)[19] on 12 June 2020 and registered on 11 July 2020 as CRD42020191743.

2.1 | Eligibility criteria

Several eligibility criteria were applied in this review. The inclusion criteria were as follows:

1. English full-text articles, including adults/children with chronic wounds, ulcers, and non-acute wounds.

2. Intervention with the Versajet or Versajet II Hydrosurgery System.

3. Relevant clinical outcomes and information on effectiveness, safety, and healthcare cost.

4. Prospective randomised controlled studies, retrospective comparative studies, and prospective non-comparative studies.

In contrast, the exclusion criteria were as follows:

1. Non-English literature.

2. Animal, ex vivo, or in vitro study.

3. Combination therapy with hydrosurgery debridement.

4. Case series, narrative review, expert opinion, or letters.

5. Duplicate trials, publications, and results.

2.2 | Search strategy

A systematic search was performed in PubMed, Scopus, and Cochrane Library databases from 1 January 2000 to 10 August 2020. The search terms for articles from the database were "hydrosurgery," "hydrodebridement," "hyderscalpels," "water jet surgery," and "Versajet." We did not search these terms with "chronic wounds" or "ulcers." We removed the studies regarding burns or acute wounds manually to determine the type of wound.

2.3 | Study selection

All abstracts of studies retrieved from the database using the search strategy were screened independently by two reviewers who read and selected potentially eligible studies. The full text of these articles was collected, examined, and selected in accordance with the inclusion criteria.

The following data were extracted from the studies: methods, participant profiles, types of intervention implemented for the study and control groups, and outcomes. Any disagreements between reviewers over the eligibility of particular studies were resolved by a third reviewer, who determined the inclusion of such studies. When a publication included relevant data from previous studies, the latest study was analysed.

2.4 | Risk of bias in individual studies

The level of evidence was determined according to the method of the Oxford Centre for Evidence-Based Medicine.[20]

The bias of prospective randomised controlled studies was assessed using the Cochrane Collaboration's tool for assessing the risk of bias[21] and RevMan 5.4 software (ver.5.4, The Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark).[22] The bias of retrospective comparative studies was evaluated using the Risk of Bias Assessment Tool for Non-Randomised Studies.[23] Quality of prospective non-comparative studies was evaluated using the three-domain tool (selection, ascertainment, and reporting) for evaluating the methodological quality of case reports and case series[24] proposed by the Evidence-Based Practice Center, Mayo Clinic. We sent an e-mail to all authors asking for the detailed methods of the studies that were not described in the manuscript. Only one author responded; however, no answers were available regarding the detailed methods of the study. Bias was assessed by two of the authors independently. A third opinion was asked in case of disagreement between the authors, and a consensus was subsequently achieved.

2.5 | Statistical analysis

A meta-analysis was performed using RevMan software (ver.5.4, The Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark).[22] A random-effect model for outcomes was used. A *P*-value of .05 was used to determine statistical significance.

3 | RESULTS

3.1 | Included studies

After excluding duplicates, 497 studies were extracted from the three databases, and 22 studies were identified after screening (by the evaluation of the titles and abstracts). Seven studies met the criteria of this review after the full-text screening.

There were two prospective randomised controlled studies,[23,24] two retrospective comparative studies,[25,26] and three prospective non-comparative studies.[27-29] The PRISMA flow diagram is shown in Figure 1, and the study design and level of evidence of each study are shown in Table 1.

The numbers of patients, wound types, and techniques compared are shown in Table 2. Study outcomes are shown in Table 3. The forest plot results of the time for the debridement procedure in the two prospective randomised controlled studies are shown in Figure 2.

3.2 | Review of the effectiveness of hydrosurgery debridement

3.2.1 | Procedure time

Procedure time using hydrosurgery was reported in five studies, including two prospective randomised controlled studies.[23-27,29] The mean procedure time using hydrosurgery in these studies ranged between 5.8 and 12 minutes. The procedure time was significantly shorter with hydrosurgery than with the conventional methods in two prospective randomised controlled studies. The median areas of the devitalised areas of hydrosurgery/the control in the two studies were 5.3/3.7 cm [223] and 5.2/6.2 cm[2,24] and no significant difference was observed between the two groups in both studies.

The results of the forest plot are shown in Figure 2. The mean difference in procedure time between the techniques was −8.87 minutes, and the procedure time was shorter using hydrosurgery than using the conventional methods. There was moderate heterogeneity.

Granick et al's retrospective comparative study reported no statistical difference in total debridement time between the two methods.[25]

3.2.2 | Quality of debridement

The number of debridements needed to adequately prepare the wound bed for closure or secondary healing was evaluated in five studies, including one retrospective comparative study.[25-29] More than 70% of the cases in which hydrosurgery was used achieved adequate debridement in one session. The number of debridements was significantly fewer in the hydrosurgery group (median,

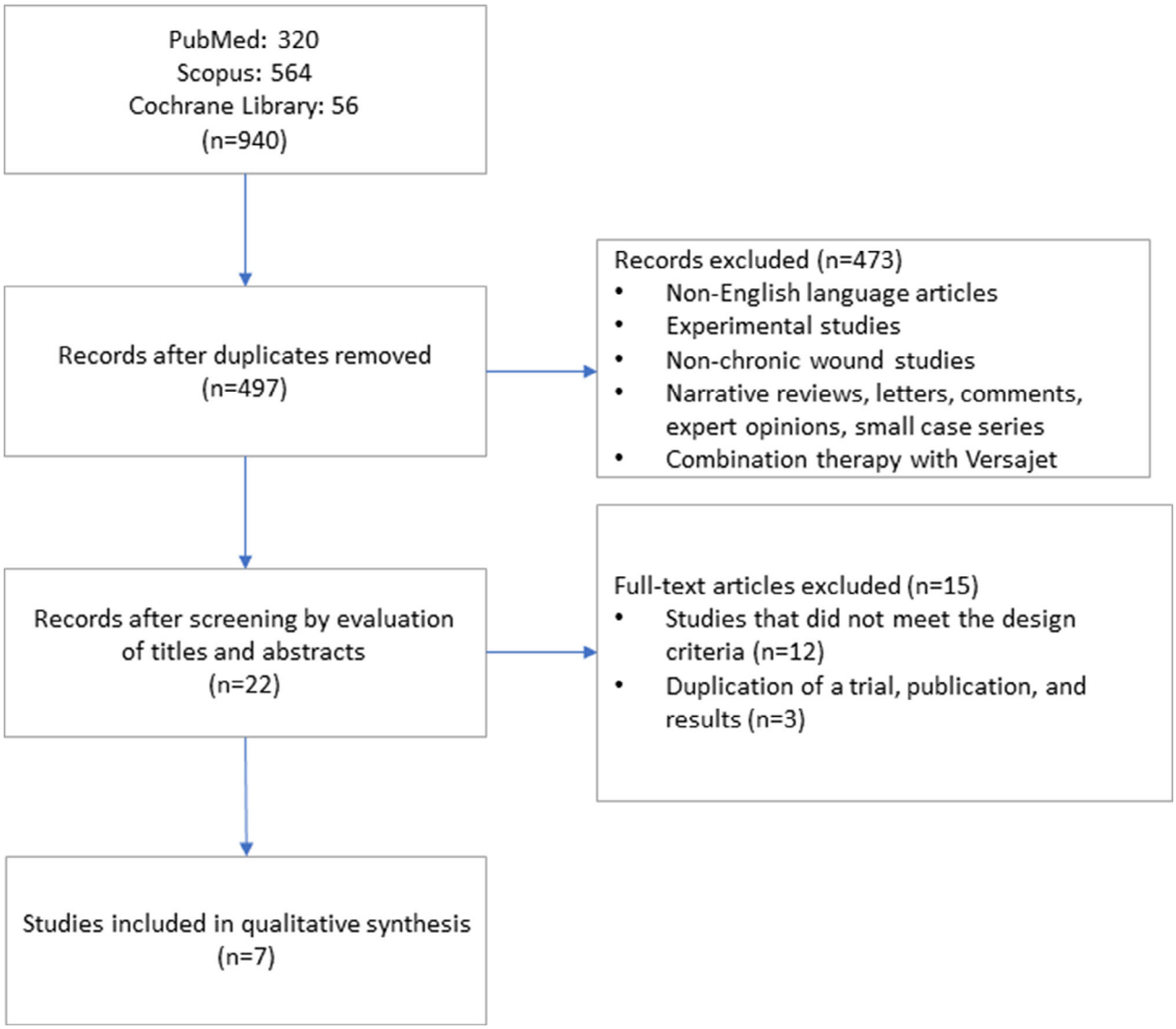

FIGURE 1 The preferred reporting items for systematic reviews and meta-analyses flow diagram adopted for the final selection of studies included in the review

one session) than in the conventional method group, according to Granick et al.[25]

3.2.3 | Wound closure

The period of wound closure was evaluated in five studies.[23,24,26,28,29] No statistical difference in the period of wound closure was observed between hydrosurgery and conventional methods in two prospective randomised controlled studies.[23,24]

Pain associated with hydrosurgery debridement.

Pain during the procedure was evaluated in two studies using the visual analogue scale.[26,28] Pain associated with hydrosurgery debridement was reportedly mild to moderate, and it was tolerable by the patients.

3.2.4 | Bacterial count

A bacterial analysis was performed in three studies.[24,26,29] In all studies, the bacterial load was reduced after hydrosurgery debridement; however, there was no difference compared with the conventional methods in a prospective randomised controlled study.[23,24]

3.2.5 | Cost

Cost analysis was performed in three studies.[23-25] Two studies showed potential cost savings using hydrosurgery[23,25]; however, one study reported no difference between the methods.[24]

3.2.6 | Other potential benefits of hydrosurgery

Less saline use[23] and blood loss[24] were reported during the debridement procedure using hydrosurgery.

3.2.7 | Safety outcome

Several adverse events were reported; however, no device-related serious adverse event was observed.[25-31]

TABLE 1 Study designs and levels of evidence

Study	Study design	Level of evidence[a]
Caputo, W. J., et al. (2008)	Prospective randomised controlled study	1b
Liu, J., et al. (2015)	Prospective randomised controlled study	1b
Granick, M.S., et al. (2006)	Retrospective comparative study	3b
Mosti, G. and Mattaliano, V. (2006)	Retrospective comparative study	3b
Ferrer-Sola, M., et al. (2017)	Prospective case series	4
Hong, C. C., et al. (2014)	Prospective consecutive case series	4
Matsumine. H., et al (2020)	Prospective consecutive case series	4

[a]According to the levels of evidence of the Oxford Centre for Evidence-Based Medicine.

3.3 | Risk of bias within studies

Figure 3 illustrates the risk of bias in the two prospective randomised controlled studies. The protocol for Caputo et al's study[25] was obtained from Clinical Trials.gov[32] (NCT00521027). The risk of bias in the two retrospective comparative studies is shown in Figure 4, and the results of the methodological quality case series evaluation are shown in Figure 5.

As there were only two prospective randomised controlled studies out of the seven selected studies and much information was missing, the overall risk of bias was unclear. The major risks of bias involved an unclear study protocol and poor description of the inclusion/exclusion criteria, which led to possible selection and detection biases. The method of outcome was not mentioned or appropriately described.

4 | DISCUSSION

As the number of patients with chronic wounds continues to increase,[33,34] it has become critical to improve these patients' outcomes. In particular, the increase in the incidence of diabetic foot ulcers is significant, and proper management of ulcers and avoidance of major amputations are essential for patients.[35]

Wound bed preparation is the first step in the treatment of chronic wounds.[36,37] In recent years, this treatment concept has become widely known as "TIME".[36,38] As the first step in this process, the "T" stands for the assessment and debridement of nonviable or foreign materials (including host necrotic

TABLE 2 Patients, wound types, and compared techniques

Study	Number of patients (hydrosurgery/control)	Wound type	Compared technique
Caputo, W. J., et al. (2008)	22/19	Lower extremity ulcers: DFU 22 (53.7%), VLU 18(43.9%)	Conventional debridement
Liu, J., et al. (2015)	21/19	Pressure ulcers 19 (47.5%), dehisced incisions 6 (15%), DFU 6 (15%)	Conventional debridement
Granick, M. S., et al. (2006)	20/14	DFU, VLU, others	Conventional debridement
Mosti, G. and Mattaliano, V. (2006)	142/327	Difficult-to-heal leg ulcer; arterial wound, venous wound, vasculitis, diabetes mellitus	Moist dressing
Hong, C. C., et al. (2014)	15	DFU	NA
Ferrer-Sola, M., et al. (2017)	39 (53 wounds)	Arterial leg ulcer 21 (39.7%), pressure sores 12 (23%), DFU 8, (15.1%), VLU 5 (9.4%)	NA
Matsumine. H., et al (2020)	7	Pressure injury in trunk	NA

Abbreviations: DFU, diabetic foot ulcer; NA, not applicable; VLU, venous leg ulcer.

TABLE 3 Study outcomes

Study	Procedure time (hydrosurgery/control)	Number of procedures (hydrosurgery/control)	Wound closure (hydrosurgery/control)	Pain (hydrosurgery/control)
Caputo, W.J., et al. (2008)	Mean 10.8 min/17.7 min $P = .008$		Median 71 days/74 days NS	
Liu, J., et al. (2015)	Mean 7.3 min/16.3 min $P < .001$		Stable wound closure at 28 days after the first excision; 9(42.9%)/7 (26.8%) $P = .77$	
Granick, M.S., et al. (2006)	Debridement time NS $P = .522$	Median 1/2 $P < .001$		
Mosti, G. et al. (2006)	5.8 ± 3.6 min	1:108 2:27 3:7	82%/88%	Acceptable with Versajet VAS score: 4.3/5.3
Hong, C. C., et al. (2014)	Mean 9.5 min	1:13 2:2		
Ferrer-Sola, M., et al. (2017)		1:39 2:10 3:4	More than 80% granulation tissue in 1 week with hydrosurgery	Mild to moderate VAS score <5
Matsumine. H., et al (2020)	Mean 12 ± 3.1 min	1:7	Complete closure with fasciocutaneous flap or skin graft in all cases	
Caputo, W. J., et al. (2008)		Potential cost saving because of the shorter procedure time with hydrosurgery	Less saline use with hydrosurgery	Non-device-related AE 1/0 Non-device-related SAE 5/3
Liu, J., et al. (2015)	Reduction in bacterial count with hydrosurgery NS	Surgical procedure cost, total cost within the study period NS	Less intraoperative blood loss with hydrosurgery $P = .03$	No health and safety issue
Granick, M. S., et al. (2006)		Cost of surgical debridement $3900(1.14 procedures)/$6700(2 procedures)		No health and safety issue
Mosti, G. et al. (2006)	Reduced bacteria load with hydrosurgery			2 cases with hydrosurgery, CLI and new necrosis occurred
Hong, C. C., et al. (2014)				2 cases of graft loss and infection
Ferrer-Sola, M., et al. (2017)				None
Matsumine. H., et al (2020)	Positive wound swab before 6/7 after 0/7			None

Abbreviation: NS, not significant.

tissues, adherent dressing materials, multiple organism-related biofilms or sloughs, exudates, and debris) on the surface of the wound. After "T," "I"; controlling inflammation and infection, "M"; restoration of moisture balance, and "E"; wound edge advancement are followed.

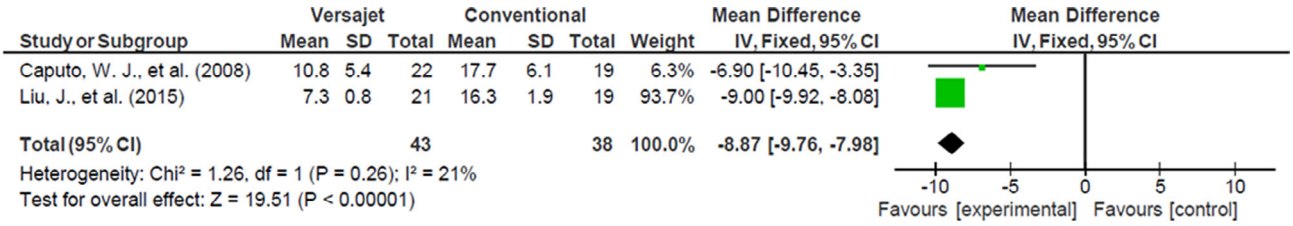

FIGURE 2 Forest plot of the debridement procedure time. CI, confidence interval

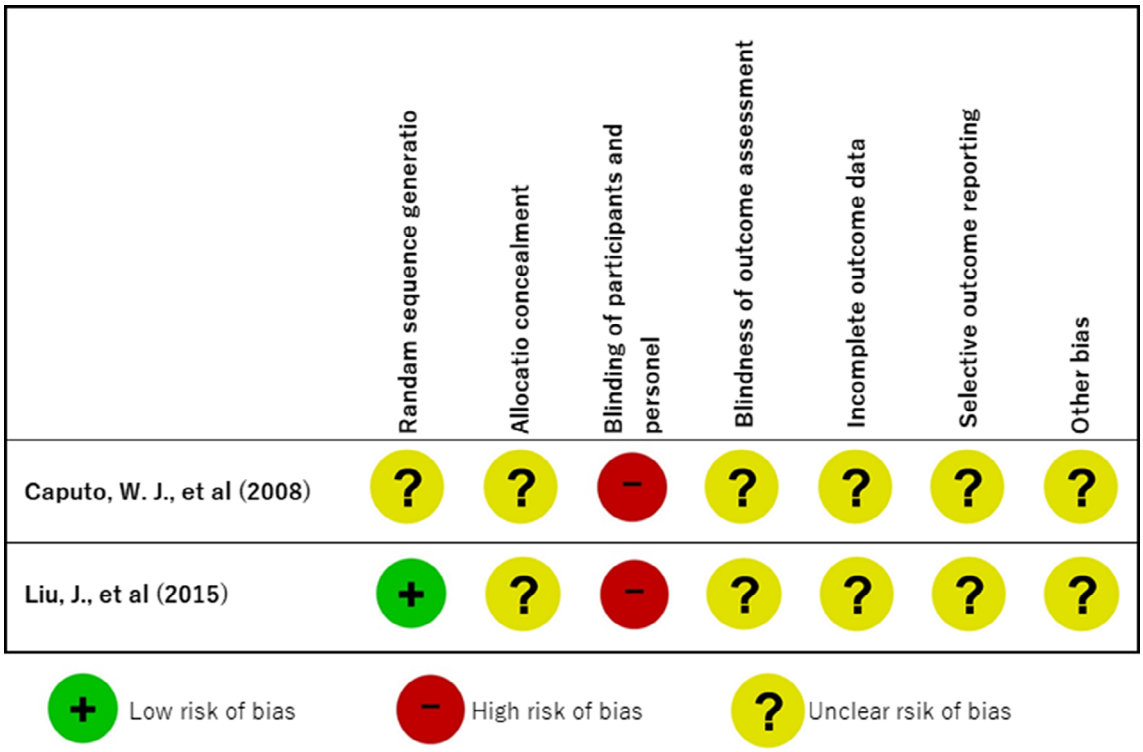

FIGURE 3 Risk of bias summary of the prospective randomised controlled studies

Hydrosurgery is a debridement device with several features. First, high-speed saline flows parallel to the wound surface, which allows for the removal of debris and other poor tissues. Second, the excised tissues, wound slough, and biofilms can be removed by the Venturi effect.[39] This material is suctioned into the handpiece, and this allows the wound surface to be cleaned and necrotic and infected tissues to be removed. Similarly, the debridement can be performed tangentially to the wounds, which is extremely useful for wound surfaces in chronic ulcers. Furthermore, the depth of one slice of debridement by hydrosurgery is much thinner than that by scissors or scalpels,[40] allowing more accurate debridement to be performed and more viable tissues be salvaged.

There are only two systematic reviews of hydrosurgery in burn wounds,[13,14] and it reported no significant difference in efficacy between hydrosurgery and conventional methods. However, this review reported that there is evidence for immediate skin implantation after debridement, high skin engraftment, and faster healing, and there is fair and limited evidence concerning its cost-effectiveness.

There are several points in our review that confirm the effectiveness of hydrosurgery in chronic wounds, and they are discussed in the following paragraphs.

First, hydrosurgery enables rapid debridement. Although a relatively small area was debrided, the procedure time was reduced to 7–9 minutes using hydrosurgery. Hard tissues, such as third-degree burn wounds, are considered difficult to debride by hydrosurgery.[31,41] The hard eschar usually needs to be initially removed separately with scissors or scalpel debridement, followed by hydrosurgery. However, in chronic wounds, these hard, necrotic tissues are rarely present or already removed, and the wound bed is often soft and contains

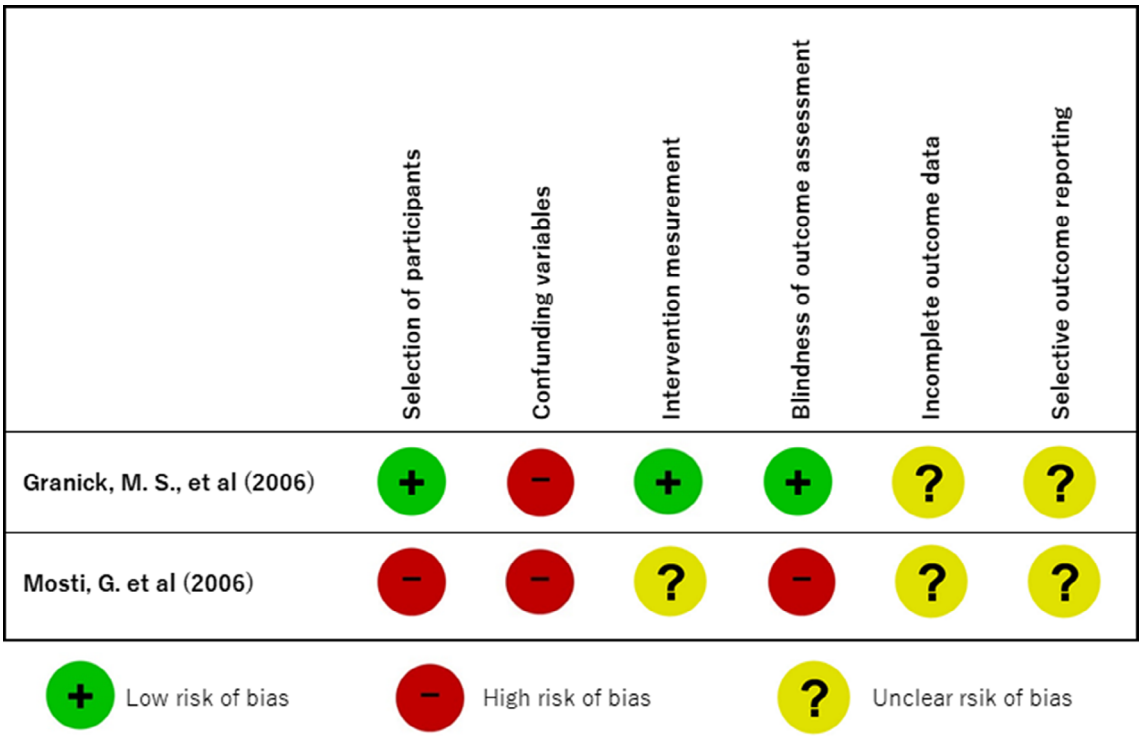

FIGURE 4 Risk of bias assessment tool for non-randomised studies

	Does the patient(s) represent(s) the whole experience of the investigator (centre)?	Was the exposure adequately ascertained?	Was the outcome adequately ascertained?	Is the cases described with sufficient details to allow other investigators to replicate the research?
Hong, C. C., et al (2014)	Yes	Yes	Yes	Yes
Ferrer-Sola, M., et al (2017)	Yes	Yes	Yes	Yes
Matsumine. H., et al (2020)	Yes	Yes	Yes	Yes

FIGURE 5 Methodological quality case series evaluation

infected granulation tissues. Therefore, there is no need to change the tools for debridement. In addition, a clean, bloodless surgical field is always available because of the high-speed water jet that cleanses the wound. As debridement can be performed using only one device, hydrosurgery, and the clean surgical fields are maintained during the surgery, surgeons can perform rapid debridement.

Moreover, the angled tip of the handpiece allows surgeons to perform debridement in small spaces or in pocket spaces that are difficult to debride by scissors or scalpels.[16,41]

The quality of the debridement is also incredibly high. In the case of chronic wounds, multiple sessions of conventional debridement are often needed to achieve proper wound bed preparation. However, using hydrosurgery, only a single debridement achieves adequate wound beds in most cases.[27-29,31] The reason for this seems to be that bacterial contamination of the wound can be efficiently removed and cleaned by the water jet.[28,31]

Moreover, the quality of the wound bed obtained with hydrosurgery creates a smoother, less-irregular wound surface, which allows immediate skin grafting.[42]

The rapid debridement and high-quality debridement are expected to be cost-effective and shorten patients' hospital stay.[27,28] Unfortunately, none of the literature in this study evaluated the overall cost to wound healing.

New necrosis after debridement and graft loss because of infection were reported[28,29]; however, they are common events after the debridement of chronic wounds. Therefore, there was no obvious device-related adverse event reported in the included studies.

Cost analysis was performed in three studies,[23-25] and only two studies[23,25] showed potential cost savings because of the shorter procedure time with hydrosurgery or fewer procedures of debridement. Therefore, the overall cost of the treatment has not been closely examined. For this reason, future research on adequate cost scrutiny, especially the general cost of treatment, is warranted.

To our knowledge, this is the second study reviewing the efficacy and safety of hydrosurgery and the first study reviewing the use of hydrosurgery for chronic wounds. The most important limitation of this review is the poor quality of the studies, which include relatively small sample sizes, unclear study designs, and a bias that cannot be ignored.

5 | CONCLUSIONS

Surgical debridement has an important role in the treatment of chronic wounds. From this review, we conclude that hydrosurgery provides rapid and effective debridement in chronic wounds, even though there is no difference between the periods of wound closure. However, high-quality studies are limited, and the number of cases included in each study was small. Therefore, further controlled trials need to be performed before hydrosurgery can become the standard care in the debridement of chronic wounds.

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CONFLICT OF INTEREST

All authors declare that there is no conflict of interest regarding this research.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

1. Dowsett C, Ayello E. TIME principles of chronic wound bed preparation and treatment. *Br J Nurs*. 2004;13(15):S16-S23.
2. Ligresti C, Bo F. Wound bed preparation of difficult wounds: an evolution of the principles of TIME. *Int Wound J*. 2007;4(1): 21-29.
3. Pilcher M. Wound cleansing: a key player in the implementation of the TIME paradigm. *J Wound Care*. 2016;25(3 Suppl): S7-S9.
4. Reyzelman AM, Vartivarian M. Evidence of intensive autolytic debridement with a self-adaptive wound dressing. *Wounds*. 2015;27(8):229-235.
5. Rosenberg L, Krieger Y, Bogdanov-Berezovski A, Silberstein E, Shoham Y, Singer AJ. A novel rapid and selective enzymatic debridement agent for burn wound management: a multicenter RCT. *Burns*. 2014;40(3):466-474.
6. Draeger RW, Dahners LE. Traumatic wound debridement: a comparison of irrigation methods. *J Orthop Trauma*. 2006;20 (2):83-88.
7. Swanson T, Lazaro-Martinez JL, Braumann C, Kirchhoff JB, Gachter B, van Acker K. Ultrasonic-assisted wound debridement: report from a closed panel meeting. *J Wound Care*. 2020; 29(2):128-135.
8. CAt M, Chatman BC, Rhemtulla IA, et al. Ultrasonic debridement management of lower extremity wounds: retrospective analysis of clinical outcomes and cost. *J Wound Care*. 2019;28 (Sup5):S30-S40.
9. https://training.cochrane.org/online-learning/core-software-cochrane-reviews/revman. Cited July 5, 2020.
10. Matsumura H, Nozaki M, Watanabe K, et al. The estimation of tissue loss during tangential hydrosurgical debridement. *Ann Plast Surg*. 2012;69(5):521-525.
11. Hyland EJ, D'Cruz R, Menon S, et al. Prospective, randomised controlled trial comparing Versajet™ hydrosurgery and conventional debridement of partial thickness paediatric burns. *Burns*. 2015;41(4):700-707.
12. Rappl T, Regauer S, Wiedner M, Wittgruber C, Schintler M, Scharnagl E. Clinical experiences using the Versajet® system in burns - indications and applications. Handchirurgie Mikrochirurgie Plastische. *Chirurgie*. 2007;39(5):308-313.
13. Kakagia DD, Karadimas EJ. The efficacy of versajet™ hydrosurgery system in burn surgery. A systematic review. *J Burn Care Res*. 2018;39(2):188-200.
14. Edmondson SJ, Ali Jumabhoy I, Murray A. Time to start putting down the knife: a systematic review of burns excision tools of randomised and non-randomised trials. *Burns*. 2018;44(7): 1721-1737.
15. Kimble RM, Mott J, Joethy J. Versajet® hydrosurgery system for the debridement of paediatric burns. *Burns*. 2008;34(2): 297-298.
16. Klein MB, Hunter S, Heimbach DM, et al. The Versajet™ water dissector: a new tool for tangential excision. *J Burn Care Rehabil*. 2005;26(6):483-487.
17. Legemate CM, Goei H, Gostelie OFE, Nijhuis THJ, van Baar ME, van der Vlies CH. Dutch burn repository G. application of hydrosurgery for burn wound debridement: an 8-year cohort analysis. *Burns*. 2019;45(1):88-96.
18. Moher D, Altman DG, Liberati A, Tetzlaff J. PRISMA statement. *Epidemiology*. 2011;22(1):128.

19. https://www.crd.york.ac.uk/prospero/. Cited May 7, 2020.
20. https://www.cebm.net/2016/05/ocebm-levels-of-evidence/17. Cited May 7, 2020.
21. Higgins JP, Altman DG, Gotzsche PC, et al. Cochrane bias methods G, Cochrane statistical methods G. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ*. 2011;343:d5928.
22. https://training.cochrane.org/online-learning/core-software-cochrane-reviews/revman. Cited May 7, 2020.
23. Hinneburg I. ROBINS-1: a tool for asssessing risk of bias in non-randomised studies of interventions. *Med Monatsschr Pharm*. 2017;40(4):175-177.
24. Murad MH, Sultan S, Haffar S, Bazerbachi F. Methodological quality and synthesis of case series and case reports. *BMJ Evid Based Med*. 2018;23(2):60-63.
25. Caputo WJ, Beggs DJ, DeFede JL, Simm L, Dharma H. A prospective randomised controlled clinical trial comparing hydrosurgery debridement with conventional surgical debridement in lower extremity ulcers. *Int Wound J*. 2008;5(2):288-294.
26. Liu J, Ko JH, Secretov E, et al. Comparing the hydrosurgery system to conventional debridement techniques for the treatment of delayed healing wounds: a prospective, randomised clinical trial to investigate clinical efficacy and cost-effectiveness. *Int Wound J*. 2015;12(4):456-461.
27. Granick MS, Jacoby M, Noruthrun S, Datiashvili RO, Ganchi PA. Clinical and economic impact of hydrosurgical debridement on chronic wounds. *Wounds*. 2006;18(2):35-39.
28. Mosti G, Mattaliano V. The debridement of chronic leg ulcers by means of a new, fluidjet-based device. *Wounds*. 2006;18(8):227-237.
29. Hong CC, Nather A, Lee JK, Mao HT. Hydrosurgery is effective for debridement of diabetic foot wounds. *Ann Acad Med Singapore*. 2014;43(8):395-399.
30. Ferrer-Sola M, Sureda-Vidal H, Altimiras-Roset J, et al. Hydrosurgery as a safe and efficient debridement method in a clinical wound unit. *J Wound Care*. 2017;26(10):593-599.
31. Matsumine H, Giatsidis G, Takagi M, Kamei W, Shimizu M, Takeuchi M. Hydrosurgical debridement allows effective wound bed preparation of pressure injuries: a prospective case series. *Plast Reconstr Surg-Global Open*. 2020;8(6):e2921.
32. https://clinicaltrials.gov/. Cited November 7, 2020.
33. Dissemond J, Kroger K, Storck M, Risse A, Engels P. Topical oxygen wound therapies for chronic wounds: a review. *J Wound Care*. 2015;24(2):2-3, 53-54, 6-60, and 63.
34. Sen CK. Human wounds and its burden: an updated compendium of estimates. *Adv Wound Care*. 2019;8(2):39-48.
35. Best practice guidelines: wound management in diabetic foot ulcers; 2013. International Best Practice Guidelines: Wound Management in Diabetic Foot Ulcers. Cited July 12, 2020.
36. Schultz GS, Barillo DJ, Mozingo DW, Chin GA. Wound bed advisory board M. wound bed preparation and a brief history of TIME. *Int Wound J*. 2004;1(1):19-32.
37. Schultz GS, Sibbald RG, Falanga V, et al. Wound bed preparation: a systematic approach to wound management. *Wound Repair Regen*. 2003;11(Suppl 1):S1-S28.
38. Moore Z, Dowsett C, Smith G, et al. TIME CDST: an updated tool to address the current challenges in wound care. *J Wound Care*. 2019;28(3):154-161.
39. Mosti G, Iabichella ML, Picerni P, Magliaro A, Mattaliano V. The debridement of hard to heal leg ulcers by means of a new device based on Fluidjet technology. *Int Wound J*. 2005;2(4):307-314.
40. Jeffery SL. Device related tangential excision in burns. *Injury*. 2007;38(Suppl 5):S35-S38.
41. Rennekampff HO, Schaller HE, Wisser D, Tenenhaus M. Debridement of burn wounds with a water jet surgical tool. *Burns*. 2006;32(1):64-69.
42. Vanwijck R, Kaba L, Boland S, Gonzales y Azero M, Delange A, Tourbach S. Immediate skin grafting of sub-acute and chronic wounds debrided by hydrosurgery. *J Plast Reconstr Aesthet Surg*. 2010;63(3):544-549.

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