Impact on wound healing and efficacy of various leg ulcer debridement techniques

Martin Doerler, Stefanie Reich-Schupke, Peter Altmeyer, Markus Stücker
Department of Dermatology, Venereology and Allergology, Vein Center, Departments of Dermatology and Vascular Surgery, University of Bochum, Germany

Summary

Aim: To evaluate the evidence on the impact of different debridement techniques on healing and their efficacy in the treatment of leg ulcers.

Methods: Web-based search (PubMed) for trials investigating surgical, enzymatic, autolytic, osmotic, ultrasound-assisted, and biosurgical wound debridement on leg ulcers with regard to healing and efficacy.

Results: Both surgical and hydrosurgical methods proved to be effective debridement techniques. For conventional surgical debridement, a significantly greater reduction of the wound surface area and a higher healing rate were reported. Studies on autolytic, osmotic, and enzymatic wound debridement showed effective debridement for krill enzymes, dextranomer and manuka honey. Only for manuka honey was there a significantly greater reduction of the wound surface area compared to standard treatment. One study comparing fibrinolysin/DNAse with placebo and one comparing autolytic with enzymatic debridement showed no significant differences between the respective techniques. Trials on ultrasound-assisted wound debridement reported a positive impact on healing. A significant wound surface area reduction was demonstrated in one of them. Maggot therapy led to effective debridement. The largest trial showed no significantly improved healing.

Conclusions: Further studies are needed to strengthen the evidence for a significant impact of wound debridement on the healing of leg ulcers.

Introduction

Removal of non-vital tissue – debridement – is a standard treatment procedure for chronic wounds and is considered an essential part of proper wound care [1, 2]. Foul-smelling ulcers and lesions with a “dirty” or cloudy appearance are a burden for the patient and are a breeding ground for bacteria [3]. Along surgical wound debridement, autolytic, enzymatic, osmotic, and biosurgical procedures as well as debridement using low-frequency ultrasound are the most common techniques. Despite its widespread and routine use – especially of surgical wound debridement – only a few studies have investigated the impact of regular wound debridement on the healing of leg and foot ulcers. The majority of studies have merely reported on the achievement of a clean wound bed and thus effective debridement. Other criteria are seldom used, such as a reduction in wound size, time to healing, or healing rate which would objectively wound healing. The present review summarizes studies on various debridement methods for leg and foot ulcers with a view to discussing their evidence base in relation to healing and efficacy as well as their impact on quality of life.

Methods

We conducted a PubMed-based literature search for studies up to 2011 using the search term “leg ulcer.” For studies on methods of wound debridement, we further defined the search term as follows: “wound debridement and randomized controlled trial”, “ultrasound therapy and randomized controlled trial”, “ultrasound-assisted wound debridement”, “surgical wound debridement”, “enzymatic wound debridement”, “autolytic wound debridement”, and “larval therapy.” To evaluate the influence of wound debridement on the quality of life, we searched for: “leg ulcer and wound debridement and quality of life.” Studies were excluded that did not evaluate the efficacy of at least one method of debridement for leg or foot ulcers, reviews, case reports, and studies on high-frequency ultrasound therapy without reference to its debridement effects.
Results and discussion

Our search yielded a total of 20 studies (Tables 1–4) on the following debridement methods: surgical-hydrosurgical (n = 5), autolytic, enzymatic, or osmotic (n = 6), low-frequency ultrasound therapy (n = 4), biosurgical (n = 5). Of these, 14 studies were prospective controlled studies: surgical-hydrosurgical (n = 4), autolytic, enzymatic, or osmotic (n = 6), low-frequency ultrasound therapy (n = 3), biosurgical (n = 1). One prospective study without a control group on ultrasound and larval therapy was also included as were a single retrospective study on surgical and biosurgical debridement and two case-control studies on larval therapy.

Quality of life was only studied for ultrasound-assisted, surgical, and biosurgical wound debridement methods. The most important results are discussed in the following. The reader should be aware that references to reviews, case reports, and studies of various wound types are also included which are not listed in the results tables.

Surgical and hydrosurgical wound debridement

Debridement refers to the removal of non-vital human tissue such as necrotic tissue and fibrin [4]. Some authors also include bacterial coatings as well as foreign bodies and dressing remnants [5, 6]. Generally speaking, surgical debridement is performed with a curette or a scalpel. Hydrosurgical debridement is performed with a high-pressure jet of sterile saline [7]. This method is believed to achieve a clean wound bed, an essential component in healing, but there is currently little scientific evidence available to back up this theory [8, 9].

Both techniques - surgical and hydrosurgical wound debridement - are reportedly effective [10, 11]. In a retrospective analysis of two prospective, randomized studies, Cardinal and colleagues showed a significantly larger reduction in wound surface after surgical debridement compared to sessions without debridement (p = 0.019). Higher healing rate at centers which more often performed surgical debridement (p = 0.007 for venous leg ulcers, p = 0.015 for diabetic ulcers).

The debridement frequency/patient showed a tendency toward a higher healing rate for diabetic ulcers (OR: 2.35, p = 0.069).

Table 1: Studies evaluating surgical and hydrosurgical wound debridement of leg ulcers.

<table>
<thead>
<tr>
<th>Author</th>
<th>Number of patients/ulcers</th>
<th>Design and methods</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caputo et al., 2008</td>
<td>41 patients with leg ulcers</td>
<td>Prospective controlled study comparing Versajet™ (n = 22) with conventional surgical debridement (n = 19) Observation period: 12 weeks.</td>
<td>• Time needed for debridement was 10.8 min compared with 17.7 min and thus significantly shorter for the Versajet™ group (p &lt; 0.008) • The median wound healing time was 71 days for Versajet™ and 74 days for conventional surgical debridement and not significant (p = 0.733)</td>
</tr>
<tr>
<td>Cardinal et al., 2009</td>
<td>366 venous leg ulcers and 310 diabetic ulcers</td>
<td>Retrospective analysis of data from 2 prospective randomized studies. Treatment duration: 12 weeks.</td>
<td>• Significantly larger wound surface reduction after surgical debridement compared to sessions without debridement (p = 0.019) • Higher healing rate at centers which more often performed surgical debridement (p = 0.007 for venous leg ulcers, p = 0.015 for diabetic ulcers) • The debridement frequency/patient showed a tendency toward a higher healing rate for diabetic ulcers (OR: 2.35, p = 0.069)</td>
</tr>
<tr>
<td>Mosti et al., 2005</td>
<td>167 patients with chronic leg ulcers: Versajet™- n = 68, control group with moist wound dressings n = 99</td>
<td>Prospective study to evaluate effectiveness and tolerability of debridement using Versajet™ compared with wound therapy with moist dressings</td>
<td>• In 46/68 patients treatment with Versajet™ was adequate for achieving a clean wound bed. 17 patients needed 2 sessions and 5 patients needed 3 sessions • Median treatment duration of ca. 5 min</td>
</tr>
<tr>
<td>Steed et al., 1996</td>
<td>118 patients with diabetic foot ulcers</td>
<td>Prospective randomized multicenter study to evaluate the effectiveness of rhPDGF vs. placebo in diabetic ulcers in combination with surgical debridement.</td>
<td>• Lower healing rates at centers with less frequent use of debridement • Improved response with more frequent debridement was independent of treatment group (rhPDGF vs. placebo)</td>
</tr>
<tr>
<td>Williams et al., 2005</td>
<td>53 patients, 55 chronic venous ulcers</td>
<td>Prospective controlled study to evaluate the effectiveness of surgical debridement using curettage (n = 28) with a control group without debridement (n = 27)</td>
<td>• Significantly larger reduction in wound surface at 4 weeks (p = 0.02) and 20 weeks (p = 0.008) after debridement • Complete healing of 16% of ulcers in the debridement group vs. 4.3% in the control group between weeks 8 and 16</td>
</tr>
</tbody>
</table>
higher at centers which performed surgical debridement more frequently (p = 0.007 for venous leg ulcers, p = 0.015 for diabetic ulcers). A prospective study on conventional surgical wound debridement in 41 patients with leg ulcers showed a significantly greater reduction in wound surface after 4 (p = 0.02) and 20 weeks (p = 0.008) compared with a control group without debridement as well as a higher healing rate [13]. These results were confirmed in a multicenter prospective study on the evaluation of rhPDGF (recombinant human platelet-derived growth factor) compared with placebo in diabetic ulcers combined with surgical debridement. The results showed a lower healing rate at centers which less...
frequently use debridement, irrespective of treatment group [14].

To our knowledge, there are no studies on the impact of hydrosurgical wound debridement on healing compared with a control group who did not undergo debridement. A study by Caputo and colleagues, found no significant difference in median wound healing time between patients who received hydrosurgical (71 days) and conventional surgical therapy (74 days) [10].

In our study, we found that laser therapy (low-intensity laser therapy, LILT) for surgical wound debridement was only reported in two case studies. One reported a reduction of the wound surface [15] and the other reported healing in combination with standard measures including conventional surgical debridement [16].

Large multicenter prospective studies evaluating the effects of surgical debridement on healing rates of leg ulcers are still lacking. There is comparatively little scientific evidence on the usefulness of surgical wound debridement, despite its frequent use in everyday clinical practice. This is underscored by the results of two systematic Cochrane reviews on debridement of diabetic ulcers and surgical wounds [17, 18]. An analysis by Edwards and colleagues included only one randomized controlled study on surgical debridement of diabetic foot ulcers; there was no significant advantage compared with standard therapy [17].

**Table 3: Studies evaluating ultrasound-assisted wound debridement of leg ulcers.**

<table>
<thead>
<tr>
<th>Author</th>
<th>Number of patients/ulcers</th>
<th>Design and methods</th>
<th>Results</th>
</tr>
</thead>
</table>
| Herberger et al., 2011 | 67 patients with leg ulcers of vascular origin | Prospective randomized controlled study (single center) on efficiency and tolerability of low-frequency ultrasound compared with surgical wound debridement | • Median patient benefit index (0–4) was 2.2 ± 1.0, > 1 for 88 % of patients in the ultrasound group and 2.1 ± 1.1 and > 1 for 85.2 % of patients in the surgical wound debridement group  
• Significant improvement in quality of life in both groups without any statistically significant difference between groups  
• Significant improvement in wound score for criteria fibrin, granulation, and necrosis in both groups without any statistically significant difference between the groups |
| Kavros et al., 2007 | 70 patients with leg or foot ulcers in chronic critical leg ischemia | Prospective randomized controlled study on the effectiveness of low-frequency ultrasound (n = 35) compared with standard therapy alone (n = 35). Treatment was applied 3×/weekly for 5 min | • After 12 weeks 63 % of the ultrasound group vs. 29 % of the control group had wound healing of more than 50 % (p < 0.001) |
| Peschen et al., 1997 | 24 patients with venous leg ulcers | Prospective randomized controlled study on the effectiveness of low-frequency ultrasound (30 KHz, 100 mW/cm², 3×/weekly with foot bath) compared with standard therapy (hydrocolloid plus compression) | • After 12 weeks a reduction in wound surface (measured by planimetry) of around 16.5 % in the control group vs. 55.4 % in the ultrasound group (p < 0.007) |
| Tan et al., 2007 | 19 patients with leg ulcers for ≥ 6 months | Prospective pilot study on ultrasound debridement (25 kHz with isotonic saline solution as a coupling medium) | • Each patient received an average of 5.7 treatments of 5–20 min, depending on ulcer size  
• After 12 weeks 38.9 % of ulcers had completely healed (average initial ulcer size 4.72 ± 1.872 cm²) |

**Autoytic, enzymatic, and osmotic wound debridement**

Autoytic debridement is selective elimination of dead tissue through release of the body’s own enzymes and activation of phagocytes by maintaining a moist wound milieu [7, 9]. This includes wet-to-dry techniques, debridement using hydrogels, and modern hydrofiber wound dressings. Enzymatic wound debridement consists of selective removal of non-vital tissue using proteolytic enzymes [9]. Osmotic debridement, on the other hand, is generally performed using hyperosmolar sugar- or honey-based preparations [7].

The studies on autoytic, enzymatic, and osmotic wound debridement (n = 6) are difficult to compare due to great differences. In some instances, the primary endpoints are not sufficiently defined. Only one study showed a significant improvement in healing.

One study reported that manuka honey treatment achieved a significantly larger reduction in the wound surface (34 %
Debridement of ulcers

Table 4: Studies evaluating biosurgical wound debridement of leg ulcers.

<table>
<thead>
<tr>
<th>Author</th>
<th>Number of patients/ulcers</th>
<th>Design and methods</th>
<th>Results</th>
</tr>
</thead>
</table>
| Armstrong et al., 2005 | 60 patients with diabetic foot ulcers | Case-control study on the effectiveness of maggot therapy | - No significant difference in healing rates between the maggot group and control group (57 % vs. 33 %)  
- Significantly shorter time to healing in the maggot group (18.5 ± 4.8 vs. 22.4 ± 4.4 weeks) |
| Dumville et al., 2009  | 267 patients with venous or venous-arterial leg ulcers with fibrin or necrotic coatings | Multicenter, prospective randomized and controlled study on the effectiveness of maggot therapy compared with treatment with a hydrogel in three groups: open maggot therapy, maggots in bags, hydrogel | - Significantly faster wound debridement for maggot therapy (free-range and in bags) compared with control group (p < 0.001)  
- Maggot therapy did not lead to significantly faster healing (p = 0.54)  
- Comparable quality of life and bacterial colonization in the 3 groups  
- Significantly more pain related to the ulcers in the maggot group (p < 0.001) |
| Paul et al., 2009     | 59 patients with diabetic ulcers | Case-control study lasting 18 months on the effectiveness of debridement with Lucilia cuprina compared with conventional debridment | - 29 patients were treated with maggots. 14 wounds healed completely  
- Of the 30 patients who underwent conventional debridement, 18 wounds healed completely  
- The differences were not statistically significant |
| Sherman et al., 2003  | 18 patients with 20 non-healing foot and leg ulcers | Retrospective study on the effectiveness of maggot therapy based on reduction of necrotic tissue and wound surface:  
- 6 wounds underwent conventional therapy  
- 6 wound were treated with maggot therapy  
- 8 wounds underwent conventional followed by maggot | - After 14 days no significant reduction in necrotic tissue in the standard group vs. 4.1 cm² in the maggot group (p = 0.02)  
- After 5 weeks in the conventional group more than 33 % of wound surface had necrotic coatings  
- In the maggot group, complete debridement after 4 weeks (p = 0.001)  
- Faster granulation tissue formation and higher healing rate with maggot therapy |
| Wollina et al., 2002  | 30 patients with chronic leg ulcers | Prospective study on the effectiveness of maggot therapy | - Significant improvement in wound score of 13.5 ± 1.8 to 6.3 ± 2.7 (p < 0.001) |

vs. 13 %, p = 0.001) after 4 weeks compared with standard therapy (hydrogel) [19]. In this multicenter prospective study, there was also a greater reduction in ulcer coatings (67 % vs. 52.9 %) and a significantly higher rate of healing (44 % vs. 33 %, p = 0.037) in the manuka honey group. The debriding properties of manuka honey are attributed to osmosis and autolysis [20, 21]. A comparison between autolytic debridement using TenderWet®24 and enzymatic debridement with IruXO™ N on 42 patients showed a tendency toward more effective debridement for the TenderWet®24 group (eschar reduction of 19 % vs. 9 % within 14 days). The differences were not statistically significant, however [22].

Studies on modern wound dressings with debridement effects such as hydrofiber dressings were not included in the present analysis. Studies were either done on different types of chronic wounds (not only leg ulcers) or they did not investigate the debridement properties of the dressing per se [23, 24]. Effective debridement has also been reported for enzymes from Antarctic krill Euphausia superba [25]. In an in vitro study on the evaluation of the efficacy of enzymes on bloody crusts, fibrin, and necrosis compared with trypsin and streptokinase-streptodornase, the results showed that krill enzymes were clearly superior, especially in regard to necrosis [26]. No significant differences were found when comparing three different enzymatic preparations (Table 3) and when comparing enzymatic debridement using fibrinolysin/DNAs with placebo [27, 28]. The latter study included results for the impact on ulcer size and necrotic tissue in venous leg ulcers. Yet in an uncontrolled study on infected accidental or surgical wounds, debridement using fibrinolysin/desoxyribonuclease was reportedly effective [29]. More rapid wound cleansing and faster healing have been reported for osmotic debridement with dextranomer for venous ulcers [30]. This debridement method was also analyzed in a 2011 Cochrane review on surgical wound debridement. Only one out of four randomized controlled studies found significantly faster debridement when
Debridement of ulcers

Ultrasound treatment of chronic wounds

Ultrasound treatment of the wound base

Sound therapy (30 kHz, 100 mW/cm²) for venous ulcers was treated with ultrasound. A controlled study with 24 patients reported a significantly larger reduction in wound surface (55.4%) compared with a control group. The method in the above-named studies, however, was the lacking control group. In our opinion, there is a low level of evidence to support the usefulness of autolytic, enzymatic, and osmotic debridement methods for healing chronic leg ulcers.

Ultrasonic treatment of the wound base

Ultrasonic treatment of chronic wounds is believed to have not only debridement effects but also to promote granulation. For the treatment of leg ulcers, frequencies range between 25 kHz and 3 MHz. Delivery is directly to the wound or indirectly in a water bath. For wound debridement, treatment with low-frequency ultrasound is the most common [6, 31], while for regimes with higher frequencies more rapid wound healing due to increased collagen synthesis and increased elasticity of the collagen connective tissue have been reported [32].

Our research uncovered four studies that used low-frequency ultrasound-assisted debridement. A pilot study on 19 patients reported that after 12 weeks 38.9% of ulcers had healed completely after treatment with low-frequency ultrasound via isotonic saline solution as a coupling medium along with compression therapy [33]. One drawback of the study – especially for evaluating the method’s effectiveness – was the lacking control group.

A controlled study with 24 patients reported a significantly larger reduction in wound surface (55.4%) compared with standard therapies (hydrocolloid and compression) alone (16.5%) after 12 weeks (p < 0.007) [34]. The chronic venous ulcers were treated with ultrasound (30 kHz, 100 mW/cm²) 3 x/weekly using a foot bath. Improved wound healing after low-frequency ultrasound therapy has also been reported in patients with chronic ulcers [35]. A study from 2011 compared ultrasound-assisted debridement with surgical wound debridement (curette) in 67 patients with leg ulcers [36]. The results were measured using a wound score. In each of the two treatment groups, 23 photos were taken before and after treatment to evaluate the presence of fibrin, granulation, epithelialization, and necrosis. Both treatment groups showed significant improvement in fibrin, granulation, and necrosis (Table 3). The methods were also rated by the patients using a patient benefit index (0 = no benefit, 4 = maximum benefit) and a survey on the quality of life. No significant differences were found between conventional surgical debridement using a curette and ultrasound-assisted debridement. Both treatment groups had a significant improvement in quality of life. The study underscores the importance of the patient’s role in evaluating the chosen method. In our view, the use of a wound score does not allow for a sufficiently accurate assessment of the impact on healing. The use of planimetry for wound size assessment, as described in the methods section, is desirable.

More studies are available on the use of high-frequency ultrasound ulcer therapy. A systematic review of this method for the treatment of venous leg ulcers, by Collum and colleagues, contained five randomized controlled studies which showed significantly higher rates of healing after 7–8 weeks compared with control groups. Yet after 12 weeks, the difference was no longer significant [37]. Studies on low-frequency ultrasound therapy have comparatively smaller numbers of patients. Additional limitations include not using control groups, lacking evaluation of complete healing, and the failure to assess wound size over time. Despite positive assessments of the method in the above-named studies, there is limited evidence of improved healing with ultrasound-assisted wound debridement.

Biosurgical wound debridement

Biosurgical wound debridement (synonym: larval therapy) usually uses Lucilia sericata larvae [38]. The larvae may be placed on the wound as “free-range” maggots or in bags [39]. Our search yielded six studies on maggot therapy in chronic leg ulcers. The highest-quality study was done by Dumville and colleagues (VenUS-II team) [40]. Their multicenter prospective randomized study compared the efficacy of maggot therapy with a hydrogel dressing in 267 with fibrin-coated ulcers or ulcers with necrotic tissue coating. Both treatment with bag-less maggots and maggots in bags led to significantly faster wound debridement (p < 0.001), but without significantly improving wound healing (p = 0.54).

In two case-control studies on diabetic ulcers, the healing rates were not significantly better with biosurgical debridement [41, 42]. In one of the studies, the use of maggot therapy significantly improved the rate of healing [42]. Two smaller studies found maggot therapy to be an effective debridement method and reported improved healing [43, 44]. Yet the results should be viewed critically given that in one case the evaluation was with a wound score and the other was a retrospective analysis.

In summary, all five studies showed maggot therapy to be an effective debridement method for quickly achieving a clean wound bed. Yet larger studies have failed to show any significant improvement in healing following biosurgical wound debridement. The VenUS-II team performed a cost effectiveness analysis for maggot therapy which was found to have similar costs as hydrogel therapy [45]. Given the lacking evidence of improved healing, the usefulness of this cost effectiveness analysis is limited. The costs for healing chronic ulcers are a critical issue, however, given their high incidence. This underscores the importance of evidence-based treatment.

The studies included here show that a clean wound bed can be achieved and thus demonstrate the effectiveness of various debridement techniques. Only a few studies included clear endpoints such as healing rate, reduction in wound size, or the time needed for healing which would be appropriate measures for the objectification of improved healing. There are other flaws as well, such as small numbers of patients and lacking control groups and randomization (Table 1–4).

Along with healing, an improved quality of life is another issue that is important for many patients [46]. Prior studies have confirmed the negative impact of chronic ulcers on the quality of life, especially due to pain [47].

Influence on quality of life

The influence of debridement on the quality of life was only investigated in...
the studies on ultrasound-assisted debridement, conventional surgical, and biosurgical debridement. When ultrasound-assisted debridement was compared with surgical debridement, there was a significant improvement in quality of life in both treatment groups [36]. In the largest study to date on biosurgical wound debridement, in terms of quality of life (health-related quality of life) there was no significant difference between biosurgical methods and the use of hydrogel dressings [40, 45]. A limitation is that, at the end of the study, there was no evaluation of quality of life for more than 40% of study participants [45]. Additional prospective controlled studies are needed to strengthen the evidence for the influence of debridement on wound healing and quality of life in chronic leg ulcers.

**Conclusion**

Debridement of leg and foot ulcers is a part of everyday routine clinical care. In our opinion, there is currently a discrepancy between the scientific evidence for improved healing as a result on the one hand and clinical practice and experience on the other. Based on currently available studies, a positive influence on healing of chronic leg ulcers is probably best achieved with surgical wound debridement.

Considering that chronic wounds are an enormous healthcare expense [48], there is an urgent need for efficient and evidence-based treatment schemes. For patients with chronic wounds, not only healing but also quality of life is a critical factor. Future studies should thus include as primary endpoints complete wound healing, percentage reduction in wound size, and quality of life.

**Conflict of interest**

None.

---

**References**

24. Jude EB, Aplqvist J, Spraul M, Martini J. Prospective randomized


44 Sherman RA. Maggot therapy for treating diabetic foot ulcers unresponsive to conventional therapy. Diabetes Care 2003; 26: 446–51.


