

Wound debridement for diabetic foot ulcers: a clinical practice review

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Article points

1. This article discusses autolytic, enzymatic, surgical, mechanical, and biologic wound debridement for diabetic foot ulcerations.
2. There is limited clinical evidence for use of one debridement method for diabetic foot ulcerations.
3. Wound debridement in general is pivotal to decreasing diabetic foot wound healing time.

Key words

- Diabetic foot
- 3D printing
- Footwear
- Machine learning
- Microclimate
- Ulceration

Authors

Author details can be found on page 64.

Wound debridement is an integral part of wound management. A clinician's ability to assess the wound and select the proper debridement technique is as critical as addressing all aspects of wound management, including vascular assessment, offloading, infection control and selecting the appropriate wound dressing regimen. In this article, the authors aim to review the literature and evaluate outcomes of debridement methods for diabetic foot ulcers (DFUs). The authors hope this summary will serve as useful clinical practice review for clinicians managing DFUs and highlight conditions of the wound, patient and/or the modality that should be considered when selecting wound debridement techniques that could increase healing rates and improve outcomes.

Approximately 15% of patients with diabetes will develop an ulceration and 15–20% will have an ulcer that ultimately leads to an amputation (Frykberg, 1999). The foundation of wound management is wound debridement, removal of non-viable tissue, as failure to do so can result with inflammation, infection and delayed healing. There have been several attempts to determine which if any wound debridement method is superior as it relates to outcomes in wound healing. In 2016, Elraiyah et al performed a systematic review of wound debridement in chronic diabetic foot ulcers (DFUs), determining that the literature supports the utilisation of surgical, autolytic and larval debridement techniques. However, there was low-quality comparative evidence to support one method was superior to another. The authors believe this is because wounds are dynamic and unique, thereby, requiring wound care providers to constantly change their wound care techniques to meet the demands of the ever-changing wound environment.

In this review, the authors aim to take a different approach to determine if the literature provides practical clinical pearls that can aid clinicians in the selection of a particular wound debridement modality

and how to employ techniques in a manner that will improve outcomes for patients.

Methodology

The authors sought out to identify the literature reviewing the different wound debridement modalities and techniques. PubMed was searched using an advanced filter to limit the results to clinical trials written in English. The key words included in this search included: “diabetic foot”, “diabetic feet”, “ulcer(s)”, “debridement”, “autolytic”, “biologic(s)”, “collagenase”, “dressing”, “enzymatic”, “lavage”, “maggot(s)”, “mechanical”, “ointment”, “santyl”, “surgery”, “surgeries”, “surgical”, “surgically”, “topically”, “ultrasound” and “versajet”. Inclusion criteria that allowed studies to be evaluated for the final review process included studies that focused on diabetic foot ulcerations with evaluation of a specific wound debridement type as the focus of the study. Studies that were describing non-debridement wound techniques or did not discuss enough relevant wound healing information were excluded.

Results

The PubMed database search yielded 937 studies,

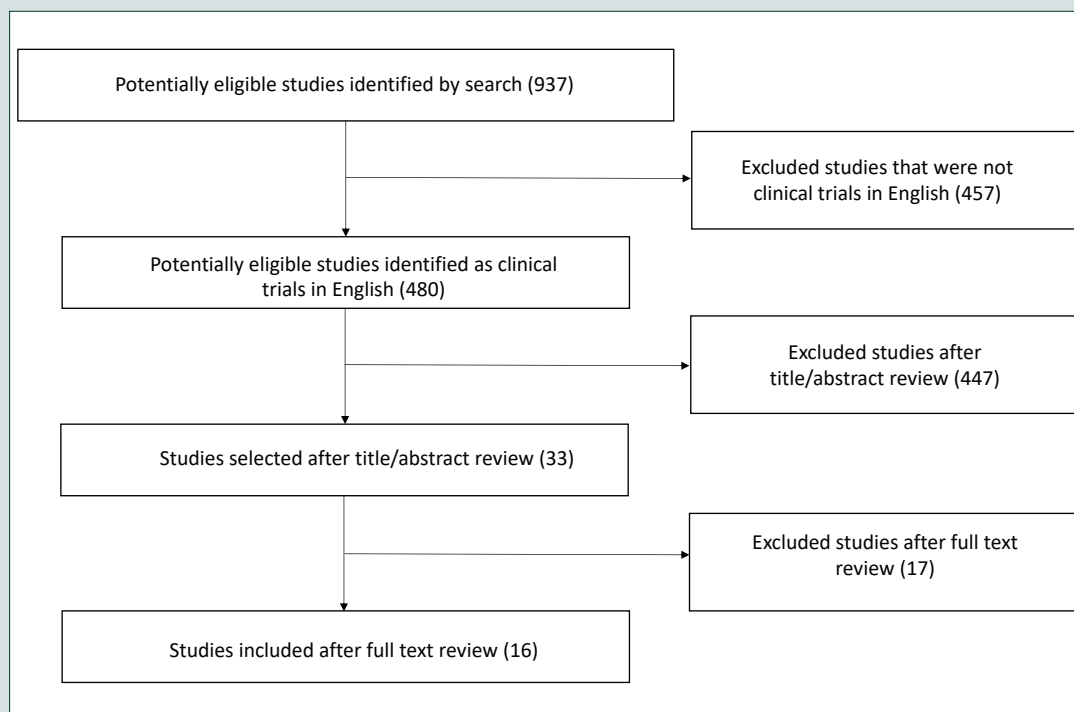


Figure 1. The process of study selection.

including clinical trials, as well as other studies. When clinical trials only were included, the results were narrowed down to 480 studies. After abstract review for potential inclusion in the study, 33 studies were reviewed in detail. Once the studies were reviewed for inclusion/exclusion to the final study, 16 studies were included for final review in this paper. The flowchart describing the study selection process can be seen in *Figure 1* and the studies included in our full text review can be seen in *Table 1*. The studies included provide some insight into demographic information, pertinent diabetes glycaemic control information, debridement type, wound healing rates, ulcer surface area, offloading information and potential blinding and cost data. There were some studies that did not include information in every category, but the majority of the information was discussed in the selected studies.

Discussion

Autolytic wound debridement

The simplest form of wound debridement is allowing the body to create a normal response. This is through natural proteolytic enzymes that degrade necrotic tissue. If using autolytic debridement as the main treatment, the wound should be in an acute state with a healthy granular base (Atkin, 2014). Different topical

therapies work with this secondary goal, while strictly providing moisture to the wound bed (Galperin et al, 2015). Many modalities exist, while some overlap with other properties or debridement avenues. A non-exhaustive list would include occlusive dressings, normal saline wet-to-dry or moist-to-dry, hydrogel medical grade honey, topical antibacterial therapies, and different compound formulas. Cost may be consideration with this therapy short term, however, duration of care may offset this when a wound transitions from an acute to chronic state. Studies suggest that adding an enzymatic topical, Clostridial collagenase ointment (CCO; Collagenase Santyl™ Ointment, Smith & Nephew) is actually more cost effective (Tallis et al, 2013; Motley et al, 2018).

Enzymatic wound debridement

Clostridial collagenase ointment is the only Food and Drug Administration (FDA) approved enzymatic agent for wounds and burns (Lantis and Gordon, 2017). This uses the bacteria *Clostridium histolyticum* to help digest native collagens and remove non-viable debris (Shi and Carson, 2009). This topical form should be sought out for when excessive production of non-viable tissue is overcoming the wound, such as when the wound reaches a chronic state. Collagenase ointment combined with sharp debridement can

Table 1. The studies included in our full text review.

Author/year/country	Study title
Motley (2018), USA & Canada	Clinical outcomes for diabetic foot ulcers treated with clostridial collagenase ointment or with a product containing silver
Michailidis et al (2018), Australia	Healing rates in diabetes-related foot ulcers using low frequency ultrasonic debridement versus non-surgical sharps debridement: a randomised controlled trial
Lantis and Gordon (2017), USA	Clostridial collagenase for the management of diabetic foot ulcers: results of four randomized controlled trials
Jimenez et al (2017), USA & Canada	Enzymatic debridement of chronic nonischemic diabetic foot ulcers: results of a randomized, controlled trial
Elraiyah (2016), Greece & USA	A systematic review and meta-analysis of debridement methods for chronic diabetic foot ulcers
Galperin et al (2015), USA	Anti-inflammatory effects of clostridial collagenase results from in vitro and clinical studies
Motley et al (2015), USA	Cost-effectiveness of clostridial collagenase ointment on wound closure in patients with diabetic foot ulcers: economic analysis of results from a multicenter, randomized, open-label trial
Motley et al (2014), USA	Clinical outcomes associated with serial sharp debridement of diabetic foot ulcers with and without clostridial collagenase ointment
Omar et al (2014), Saudi Arabia	Efficacy of shock wave therapy on chronic diabetic foot ulcer: a single-blinded randomized controlled clinical trial
Yao et al (2014), USA	A pilot study evaluating non-contact low-frequency ultrasound and underlying molecular mechanism on diabetic foot ulcers
Tallis et al (2013), USA	Clinical and economic assessment of diabetic foot ulcer debridement with collagenase: results of a randomized controlled study
Amini et al (2013), Iran	Low-frequency ultrasound debridement in patients with diabetic foot ulcers and osteomyelitis
Paul et al (2009), Malaysia	Maggot debridement therapy with <i>Lucilia cuprina</i> : a comparison with conventional debridement in diabetic foot ulcers
Ennis (2005), USA & Canada	Ultrasound therapy for recalcitrant diabetic foot ulcers: results of a randomized, double-blind, controlled, multicenter study
Sherman (2003), USA	Maggot therapy for treating diabetic foot ulcers unresponsive to conventional therapy
Jensen (1998), USA	Diabetic foot ulcerations. A controlled, randomized comparison of two moist wound healing protocols: Carrasyn Hydrogel Wound dressing and wet-to-moist saline gauze

facilitate the progression of wound closure (Tallis et al, 2013; Motley et al, 2014; 2015; Lantis and Gordon, 2017), especially in recalcitrant wounds (Lantis and Gordon, 2017).

It also has better results when compared to hydrogel combined with sharp debridement (Jimenez et al, 2017). Thus, it could be used to help facilitate sharp debridement and stimulate closure in non-healing wounds. Collagenase could also help bridge debridement appointments and offer pain relief for the sensate patient. Literature suggests

collagenase debridors have the ability to reduce local inflammation (Galperin et al, 2015). Though multiple theories exist on the mechanism of action, the *in vitro* study displayed a decreased in pro-inflammatory mediators (Galperin et al, 2015). This could be a special consideration in diabetic wounds since these wounds experience an exaggerated and prolonged inflammatory reaction (Acosta et al, 2008). Additionally, continual debridement may help prevent wound infections, however, this should be further tested (Motley et al, 2018).

Surgical wound debridement

Surgical or sharp debridement has traditionally been considered the gold standard of wound debridement (Acosta et al, 2008). This technique utilises a surgical instrument, such as a scalpel, curette, or tissue nipper to remove devitalised tissue. Its advantage is that it is selective, removing mainly non-vital tissue. Optimal use of surgical debridement requires a very skilled clinician to avoid damage to healthy surrounding tissue. Though quick, effective and commonly recommended, there is insufficient data from randomised controlled trials concerning diabetic foot wounds that prove surgical debridement is superior to any other form of debridement (Edwards and Stapley, 2010). In this literature review, sharp debridement is often combined with other wound debridement types, such as enzymatic and mechanical debridement to improve wound healing time than surgical debridement alone.

Mechanical wound debridement

Mechanical debridement technique physically removes tissue from the wound bed. A pitfall of this modality is that it is non-selective in nature, meaning non-vital tissue, as well as healthy tissue is removed in the debriding process. The most common form of mechanical debridement in regards to DFUs is wet to dry gauze dressings. However, this method can be very time consuming depending on frequency of dressing changes (Kavitha et al, 2014).

More advanced types of mechanical debridement include pulse lavage, hydrotherapy and low frequency ultrasound (LFU) debridement. In a 6-month study, Amini et al (2013) showed LFU in combination with sharp debridement can initially, in the second month of therapy, accelerate wound healing when compared to sharp debridement alone ($78\% \pm 28.7$ versus $55.7\% \pm 31.4$, $P=0.01$) (Amini et al, 2013). However, after 6 months, there was no significant difference between the two study groups. In a pilot study, Yao et al (2014) compared LFU combined with surgical debridement to surgical debridement alone and found that patients that surgical debridement with non-contact LFU as an adjuvant three times a week yielded the best wound area reduction. Larger, well-designed studies are needed to formulate specific conclusions regarding mechanical debridement as it relates to other debridement techniques. Nonetheless, the literature

suggests that mechanical debridement combined with surgical debridement may be advantageous for wound healing and wound size reduction.

Biologic debridement therapy

Biologic wound debridement has been a long standing wound debridement modality all over the world with clinical evidence to support its use since the 19th century. One example of this is with use of medicinal maggots, which secrete digestive enzymes that debride by dissolving necrotic tissue, disinfect and thereby promote wound healing. Sherman utilised maggot debridement therapy (MDT) in DFUs unresponsive to conventional therapy/wet to dry (Simmons, 1935; Pavillard and Wright, 1957; Vistnes et al, 1981; Pechter and Sherman, 1983; Mumcuoglu, 2001; Sherman, 2003). Sherman's study noted that patients that received MDT had 50% reduction in surface area in 9 days versus conventional therapy taking 29 days to reach a 50% surface area reduction. At 4 weeks, MDT had 0% necrotic tissue in wound base versus conventional therapy with 33% necrotic tissue still noted in the base of the wound at 5 weeks. Paul et al (2009) compared MDT versus conventional therapy using *Lucilia cuprina* instead of the classic blowfly *Lucilia sericata* in infected DFUs. *Lucilia cuprina*, which is a more common tropical blowfly, was found to be as effective in removal of necrotic tissue in wounds and stimulating of granular tissue. The end point for this study was a healed DFU or suitable for split-thickness skin graft. The clinical pearl illustrated by both of these studies is that for patients unresponsive to convention therapy or with infected DFUs, MDT should not be considered as a last resort, but sooner in debridement selection process. The demonstration of faster granular tissue promotion is useful for other adjunctive therapies, such as skin graft applications and in overall healing rates.

Other considerations

Wound offloading

Offloading is an integral part of diabetic ulcer healing strategies. Of the studies reviewed, 12 had offloading as a part of the protocol. The type of offloading system use was highly variable ranging from a non-specific offloading device to total contact casting. Based on the inconsistency of offloading systems, the authors could not conclude there was a debridement paired with offloading enhancing technique. They

suggest that all DFU care providers use standard of care as it relates to offloading.

Cost

There is increased pressure on cost containment in health care. Management of diabetes in the US is estimated at US\$217bn in direct cost in 2017 (Riddle and Herman, 2018) and, as the number of persons with diabetes continues to increase, the authors can expect this cost to continue to rise. The authors noted cost comparison within studies in this review and, of the 16 of studies that met this review criterion, the cost of the debridement modality was discussed in only three clinical trials (Jensen et al, 1998; Tallis et al, 2013; Motley et al, 2014). Future studies on wound debridement should consider cost as this is unfortunately often the basis for selection as providers in the US are relegated to use what insurance companies will cover and patients have the increased burden of making medical decisions based on what they can afford.

Conclusion

The authors reviewed the wound debridement literature to determine if there was evidence to aid practitioners in the selection of one debridement modality over another and useful techniques in implementation of such modality to improve clinical outcomes. The authors recognise the limitations of this review and the evidence in this area. There are few high-quality studies, low patient enrollments, inconsistent head-to-head comparisons, variable randomisation and a lack of consistency in endpoints. In the opinion of the authors, future studies should target designs that eliminate these disparities. However, the evidence does support the general concept that using a wound debridement modality in DFUs is pivotal to decreasing wound healing times. ■

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Online CPD activity

Visit www.diabetesonthenet.com/cpd to record your answers and gain a certificate of participation

Participants should read the preceding article before answering the multiple choice questions below. There is ONE correct answer to each question. After submitting your answers online, you will be immediately notified of your score. A pass mark of 70% is required to obtain a certificate of successful participation; however, it is possible to take the test a maximum of three times. A short explanation of the correct answer is provided. Before accessing your certificate, you will be given the opportunity to evaluate the activity and reflect on the module, stating how you will use what you have learnt in practice. The new CPD centre keeps a record of your CPD activities and provides the option to add items to an action plan, which will help you to collate evidence for your annual appraisal.

- What APPROXIMATE percentage of people with type 2 diabetes are likely to develop a foot ulcer? Select ONE option only.
 - 15
 - 25
 - 33
 - 50
 - 66
- What APPROXIMATE percentage of people with diabetic foot ulcers will eventually need an amputation? Select ONE option only.
 - 20
 - 33
 - 50
 - 66
 - 75
- According to a 2016 study by Elraiyah et al, which ONE of the following, if any, is the MOST clinically effective wound debridement technique in diabetic foot ulcers? Select ONE option only.
 - Autolytic
 - Larval
 - Mechanical
 - Surgical
 - No clear evidence
- 947 studies were identified as suitable in a 2019 literature review by Holmes et al of different DFU wound debridement modalities and techniques. HOW MANY of these studies were included in the final review after exclusion and inclusion criteria were completed? Select ONE option only.
 - 16
 - 33
 - 101
 - 480
 - 937
- Which SINGLE naturally produced degradation agent is MOST LIKELY involved in the normal physiological response to the presence of necrotic tissue in a DFU? Select ONE option only.
 - Amylase
 - Collagenase
 - Lipase
 - Pepsin
 - Trypsin
- A 47-year-old woman has a DFU with necrotic, non-infected tissue. According to current evidence, which is the SINGLE MOST appropriate evidence-based topical treatment to recommend, if any? Select ONE option only.
 - Antibacterial
 - Medical grade honey
 - Normal saline wet-to-dry dressing
 - Occlusive dressing
 - No clear evidence
- What species of *Clostridium* is used in the only FDA-approved clostridial based ointment? Select ONE option only.
 - Botulinum*
 - Collagenovorans*
 - Difficile*
 - Histolyticum*
 - Perfringens*
- A 77-year-old man has a chronic right DFU with central necrotic tissue. It is not infected. According to current evidence, which is the SINGLE MOST appropriate wound debridement modality to recommend, if any? Select ONE option only.
 - Autolytic
 - Biologic
 - Enzymatic
 - Mechanical
 - Surgical
 - No clear evidence
- Which ONE of the following wound debridement modalities, if any, is MOST likely to result in the QUICKEST time to heal a necrotic DFU? Select ONE option only.
 - Autolytic
 - Biologic
 - Enzymatic
 - Mechanical
 - Surgical
 - No clear evidence
- According to Sharman et al, which is the MOST likely debridement modality, if any, to reduce necrotic tissue in a DFU to 0% at 4 weeks of treatment? Select ONE option only.
 - Enzymatic
 - Larval
 - Mechanical
 - Surgical
 - No clear evidence