A Retrospective, Quality Improvement Review of Maggot Debridement Therapy Outcomes in a Foot and Leg Ulcer Clinic

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Abstract
Maggot debridement is the deliberate use of larvae known to consume only necrotic tissue. A retrospective quality improvement analysis of maggot debridement therapy (MDT) was conducted among patients with devitalized tissue or gangrene attending a Canadian foot and leg ulcer clinic who received MDT between January 2001 and June 2006. MDT was applied every 48 hours until >90% of necrotic tissue was debrided. The authors identified MDT patients in the clinic database and reviewed their medical records for age, gender, presence of diabetes or peripheral arterial disease (PAD), type of wound, number of maggot applications required, wound outcomes, and nursing visit costs (week before, during, and after MDT) and noted patient experiences. Records of 68 patients (average age 71, range 22 to 95, years) were identified and abstracted. Of those, 44% had leg ulcers and 67% had both diabetes and PAD. The majority (39, 58%) of wounds required three debridement sessions. All but one patient achieved debridement of >90% of necrotic tissue in 2 to 10 days. Most wounds (56) healed with follow-up moist wound care. Only one patient withdrew from MDT. No other patient or safety concerns were documented. Total nursing visits for all patients the week before and then after MDT were 307 and 102, respectively. These findings confirm results of previous reports about the effectiveness of MDT for wound debridement. Randomized, controlled clinical studies are needed to confirm the efficacy and cost-effectiveness of MDT compared to other debridement modalities.

Keywords: retrospective study, larva, wound, debridement, foot ulcer

Background
William Baer, an American surgeon, was aware of Napoleonic and Civil War anecdotes of positive wound outcomes following maggot infestation, but an experience during World War I changed his career. Two soldiers with maggot-infested compound femur fractures and abdominal wounds were found on the battlefield 7 days after they were injured. Baer records, “We removed their friends which had been doing such noble work…,” to find clean granulated wounds. At a time when compound femur fractures were associated with 75% to 80% mortality, both soldiers were infection-free and proceeded to heal. Baer used the scientific method to identify how maggots prevented or cured osteomyelitis; Treatment of Chronic Osteomyelitis with the Maggot (Larva of the Blow Fly) was published in 1931 and concluded that maggots removed necrotic tissue, caused the wound to become alkaline, reduced micro-organisms, and were less toxic than chemical disinfectants of the time.

Improvement in anesthetics and surgical debridement combined with antibiotic introduction replaced maggot debridement therapy (MDT) as a treatment for osteomyelitis in the 1940s. Renewed interest in MDT developed to meet the need for a safe and inexpensive debriding process and as a result of the rise in antibiotic-resistant micro-organisms.

Potential Conflicts of Interest: none disclosed

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Necrotic tissue debridement. Maggot debridement is the deliberate use of larvae known to consume only necrotic tissue. Maggots used for MDT must be provided by an approved supplier to ensure appropriate type and larval sterilization. The most common species used is *Phaenicia (Lucilia) sericata* (Green Bottle Fly), a member of the blow fly family, because it consumes only necrotic tissue. Proteolytic enzymes secreted by the larvae transform necrotic tissue into a semi-liquid state. Selective debridement occurs when the larvae gorge on the digestible liquid of organisms and wound debris.

There are two larval application techniques: *free range*, where five to eight larvae per square cm of wound surface are confined by a dressing that allows wound drainage and air exchange; and *contained*, in which a specially designed bag holds larvae and allows secretion and wound exudate exchange that results in debridement. The number of larvae per bag depends on the producer, and the clinician experience with MDT determines the number of bags to be applied on the wound surface. In a prospective study, Steenvoorde et al assigned 64 patients to either contained or free-range larval techniques. The free-range technique was significantly better for debridement (*P* = 0.028) and required fewer applications (*P* = 0.028) and fewer larvae (*P* < 0.001).

Maggot debridement effectiveness depends on appropriate patient selection and application technique. Larvae require soft necrotic tissue; hard eschar can be scored with a scalpel to provide an opening to allow the larvae to burrow under the eschar. Wounds that may communicate to the airway or oral cavity are inappropriate for MDT due to the risk of larval migration and aspiration of proteolytic enzymes in the exudate. Allergy to eggs, soy, or formalin is a contraindication, because these products are used during production and sterilization of larvae. Psychological aversion is a contraindication but should be differentiated from anxiety, which can be addressed through information and support. The dressing used to contain larvae must allow air exchange and exudate drainage.

In a prospective study among eight patients with spinal cord injury with pressure ulcers, Sherman et al examined the impact of MDT and reported a 22% average decrease of necrotic tissue per week compared with increasing necrotic tissue before MDT (*P* < 0.001). Sherman’s subsequent retrospective study compared the rate of debridement, granulation development, and closure rates for diabetic foot and leg ulcers in 18 patients with 20 ulcers. Conventional therapy was used for six wounds, maggot therapy for six wounds, and unspecified “conventional” therapy followed by maggot therapy for eight wounds. The conventional group received surgical or nonsurgical therapy as directed by their care team. The MDT group achieved 50% debridement of necrotic tissue in 9 days (*P* < 0.001), whereas the conventional group did not reach this outcome until 29 days. At 4 weeks, the MDT group had faster granulation (56%) than did the conventionally treated group (15%) (*P* = 0.016). More of the MDT wounds than the conventionally treated wounds closed, but the difference was not significant. Sherman recommended maggot debridement be considered early in wound management.

Prompt MDT has been associated with both clinical and economic benefits. Steenvoorde et al’s retrospective case series analyzed the effect of combined surgical debridement, antibiotics, and biobag larvae debridement in the treatment of 15 patients with necrotizing fasciitis. Study participants were divided into two groups: early treatment within 9 days of diagnosis (n = 8) and treatment after 9 days (n = 7). The early treatment group had fewer debridement surgeries (1.8 versus 4.1, *P* = 0.001), shorter intensive care unit stays (4 versus 29 days), and shorter hospital stays (30 versus 59 days) than the later treatment group.

In Mexican clinical guidelines, Contreas-Ruiz et al designated an expanded role for MDT due to its accessibility and cost, for patients with surgical risk, for tissue preservation, and to determine the extent of injury. In a case study, Roja and Geraghty discussed safe debridement with maggots of a patient with hemophilia, hepatitis, and acquired immune-deficiency syndrome. Steenvoorde and van Doorn reported a case of an 84-year-old woman with a mixed arterial-venous ulcer experiencing bleeding during MDT. The home care nurse noticed the bleeding during the daily assessment and sent the patient to hospital where she was successfully treated with a blood transfusion. This case underscores the need to monitor therapy. Gericke et al successfully treated a patient with an extremely high anesthetic risk who had an infected orbit exenteration surgical site using MDT in combination with systemic antibiotics.

Reduction in wound organisms. Another function of MDT is reducing wound surface organisms. Two processes reduce wound bacteria in MDT: ingestion and antibacterial secretions. Thomas et al’s laboratory study identified a reduction in methicillin-resistant *Staphylococcus aureus*.
(MRSA), *Streptococcus* A and B, *S. aureus*, and *Pseudomonas spp* but found no noticeable effect on *Escherichia coli*, *Proteus*, or *Enterococcus*. Jaklic et al’s extensive in vitro review of the antimicrobial activity of maggots supports the impact of maggots on Gram-positive organisms; however, he stressed wounds have multiple organisms, some highly susceptible, and others less so or not influenced by antibacterial maggot secretions.

MRSA treatment with antibiotics is expensive, and at times patients cannot tolerate or are allergic to the drugs. In Bowling et al’s observational study of changes in MRSA wound cultures during MDT, 12 of 13 patients with diabetes and MRSA-positive foot ulcers were decontaminated in 3 weeks, far shorter than conventional vancomycin therapy (28 weeks) and at subsequently less cost. The European Wound Management Association’s position document on management of wound infection supports the benefit of MDT against MRSA and other Gram-positive organisms.

Namias et al reported a case where maggots were used to debride a fourth-degree burn to salvage the limb, avoid blood vessel injury, reduce blood loss, and treat sepsis in combination with antibiotics. Orkiszewski et al’s case study discusses MDT used for a 10-year-old child with infection of a surgical revision of a traumatic amputation (hemipelvis) that resulted in necrotic zones. The authors reported maggot debridement with antibiotics was performed safely near large blood vessels, bladder, and rectum and that surgery was avoided. In addition, a review found MDT useful specifically for disinfection when antibiotics were ineffective or not tolerated.

**Wound healing.** Maggot excretions or secretions promote fibroblast motility through remodeling the extracellular matrix and stimulating cellular responses. The exact mechanisms of wound healing stimulation are not completely understood, but accelerated fibroblast production and migration have been identified. Other suggestions include mechanical stimulation of the wound surface, changes in wound surface pH, and contributions from larval metabolic byproducts. Wollina et al used remittance spectroscopy to identify increased tissue oxygenation with MDT, another potential wound healing stimulation factor.

**Biofilms.** van der Plas et al found low *in vitro* concentrations of excretions or secretions from larvae prevented biofilm development and high concentrations of degraded biofilms, depending on the organisms involved. These findings were confirmed by Harris et al. Larvae have been found in *in vitro* study to reduce both planktonic and mature biofilms of *Pseudomonas aeruginosa* and *S. aureus* within 24 hours and eliminate colony-forming units after 48 hours’ exposure.

Cowan et al demonstrated the efficacy of MDT in managing biofilms on pig skin in a controlled *in vitro* setting and is planning a human study. If proven effective, biofilm reduction and eradication with MDT may be an alternative to antibiotic therapy to reduce the risk of patient sensitization and resistant organisms.

**Efficacy and cost.** MDT may prevent expensive hospitalization and has been performed safely in the outpatient setting in a descriptive case series involving 21 outpatients.

Gilead et al conducted a retrospective review of the use of MDT that included 435 inpatients and outpatients treated from 1996 to 2009 at a single institution. They reported complete debridement of the wound in 82.1% of participants and a treatment duration range of 1 to 81 days. Increased pain was noted in 38% of the patients.

In a prospective, randomized comparison of hydrogel and MDT in 12 patients for debridement of slough in venous ulcers, Wayman et al found a median cost of £78.63 for MDT compared with £136.23 for hydrogel (*P* < 0.05). In separate reviews, Thomas and Jones and Thomas found MDT cost effective compared to hydrogel. It is estimated that more efficient debridement of wounds could save the National Health Service in the United Kingdom £162 million annually. Dumville et al’s prospective, three-arm randomized controlled study compared healing and debridement with MDT (loose or bagged larvae) and hydrogel in 267 patients with venous or mixed venous and arterial ulcers with a minimum ankle-brachial index (ABI) of 0.6. Debridement with MDT was significantly faster than hydrogel but was associated with more pain and no difference in wound healing. This study was challenged by clinicians, researchers, and maggot producers as having a flawed design and questionable conclusions. Letters to the *British Journal of Medicine* argued that healing was an inappropriate endpoint; also, factors contaminating the findings and subsequent conclusions included not following larvae supplier directions, failing to ensure appropriate pain management, and using less compression in the MDT group. In addition, if the Dumville study had important limitations, use of the same data by Soares et al in their cost analysis compromises their conclusion that benefits and costs are not different between MDT and hydrogel.

Opletalova et al conducted a blinded, prospective, randomized, controlled study comparing MDT to sharp debridement under topical anesthesia with EMLA® cream (lidocaine 2.5% and prilocaine 2.5%, AstraZeneca [London, UK]) for the treatment of leg ulcers in 119 patients with an ABI of 0.8 or greater. MDT was performed twice a week and sharp debridement was performed three times a week. Patients were hospitalized for 2 weeks and treated by experienced nurses. Debridement was significantly faster (54.5% higher in the MDT group versus 66.5% in the control group) (*P* = 0.04) for the first week with MDT, but healing rates, culture results, and pain reports were not significantly different. Both groups reported crawling sensations equally, suggesting this was a subjective perception. MDT required less nursing time, clinical training, and skill than sharp debridement. The time required for wound care in the surgically debrided control group was significantly longer than that required for MDT (*P* < 0.001).
Patient experience. The media and clinicians have mentioned the “yuck” factor of maggot use, but experienced clinicians report patients are more accepting than expected. In the current author’s experience, the combined need for debridement, experienced clinicians, and patient involvement improves acceptance of MDT. In contrast, Petherick et al.39 preparing for a trial to evaluate the effectiveness of maggots, randomly assigned 35 patients to a choice of free-range or bagged larvae or hydrogel, and 25% of the patients refused MDT.

Mumcuoglu et al.40 examined the pain experience in 435 patients to recommend identification of increased pain risk, expand pain management to include opiates or nerve blocks, and adapt MDT to reduce pain by using fewer maggots with shorter application times. Sherman’s41 review article found preexisting wound pain influenced the probability of pain associated with MDT, and pain generally could be controlled with analgesics or removal of maggots. Steenvoorde et al.’s42 retrospective analysis of 41 patients treated with MDT found a pre-MDT regimen with a 50 μg fentanyl transdermal system, followed by 25 μg every 3 days, plus paracetamol 1 g three times daily, managed pain for 78% of the study population. Patients with diabetes had significantly less pain than patients without diabetes (P < 0.05).

Clinical indications. The resurgence in MDT started with chronic nonhealing wounds, including gangrene, osteomyelitis,43 diabetic foot ulcers,7 and pressure ulcers.44 When amputation was recommended, limb salvage often has been associated with MDT.45 Targeting one or more of the actions of MDT has transformed this therapy from a last resort to an adjunct to solve complex wound problems when surgery, antibiotics, or conventional therapy may be ineffective.

When Sherman et al.46 surveyed clinicians for “uncommon and off-label experience,” he added odor control, drainage reduction, determination of tissue viability, and necrotic tumor palliative care to the list of possible uses of MDT.

Limb salvage. Specialized wound clinics, such as the author’s Foot and Ulcer Leg Clinic in Victoria, BC, improve limb salvage through early diagnosis, management by qualified professionals, and expert wound care, which is especially important for patients with diabetes and PAD, owing to their increased risk of limb loss.47 In the author’s experience, necrotic tissue in nonhealing wounds delays healing, increases the risk of infection, and masks the extent of tissue loss.

Steenvoorde et al.48 enrolled 101 patients with infected wounds with gangrenous or necrotic tissue in a prospective MDT study; most were worst-case scenarios, with MDT used as a last resort. The author identified factors associated with reduced healing potential through univariate analyses: older age (≥60 years, P = 0.033), limb ischemia (P < 0.001), nontraumatic wound (P < 0.001), wound duration >3 months (P < 0.001), deep wound (P < 0.001), and septic arthritis (osteomyelitis, P < 0.001). Steenvoorde suggested successful outcomes for limb salvage research should consider both wound healing and prevention of major limb amputation. In his study, 78 wounds (67%) had successful outcomes.

Summary. Over the years, maggot debridement has evolved from last-resort therapy for necrotic and gangrenous wounds to an option exploiting the potential of maggots beyond debridement to include wound disinfection, biofilm disruption, and stimulation of healing. Because necrotic tissue, gangrene, and infection contribute to lower limb amputation, MDT may be associated with limb salvage. Adverse events that must be considered are pain, allergy, and bleeding, but few data quantify these risks.

With this information in mind, the health authority administration at the Foot and Leg Ulcer Clinic, Vancouver Island Health Authority, Victoria, BC, Canada requested a retrospective quality improvement review to determine the impact of MDT on patient wound outcomes, cost of nursing resources, and patient experience. The study addressed the following questions:

1. How did MDT affect wound management and outcomes as measured by effectiveness of debridement and wound outcome?
2. What was the impact of MDT on the number of nursing visits?
3. How did use of MDT reduce the cost of nursing services?
4. What was the patient experience?

Methods

The Research Ethics Committee of the Foot and Leg Ulcer Clinic, Vancouver, in response to a request for information about the quality improvement review, stated ethics approval was not required because MDT is an accepted therapy, care was based on need, and patient consent had been obtained for data to be used for clinical care, education, or research.

Standard MDT procedures used. In the clinic, patients with devitalized tissue or gangrene are offered MDT providing they do not have a history of allergy to products used in the production of larvae (ie, soy, eggs, or disinfectants), psychological aversion, need for urgent surgical intervention for extensive necrotic involvement, risk of function loss, or deep tissue infection.

Informed consent is obtained from each patient at the time of treatment following an explanation of how maggots debride necrotic tissue, the benefits and risks, the MDT procedure, and assurance of access to a nurse during treatment to address patient or care provider concerns. Patients attend the clinic for initial assessment, MDT, and post-MDT care planning without a change to their residence or primary care team. Care instructions are given to the patients, and a phone number is provided to enable contact with the on-call MDT nurse should the patient or caregivers have any concerns. If necessary, the MDT nurse can arrange an extra clinic or home visit.

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Standard wound care used at the clinic includes cleansing with potable water or saline, topical antibiotics, and dressings based on the individual case. Topical antimicrobials are stopped two dressing changes before MDT and not used during treatment to protect the maggots from potentially toxic material that could impair performance or survival. Nurses in the various patient settings provide care.

Larvae were purchased from Monarch Laboratory (California, USA). Maggots are applied free-range, with confinement by a corral dressing, for all patients. The clinic nurse applied the larvae according to a standard dressing process:

- Periwound skin protection with a hydrocolloid dressing, which adheres to create a corral to confine and protect larva;
- Washed undyed cotton material application to cover the wound surface and larvae;
- Transparent dressings with a window for air exchange and drainage management are used to hold the cotton cover in place; and
- A highly absorbent incontinence pad placed over the dressing to contain drainage and changed as necessary to reduce odor.

After the initial application of maggots, patients return to the clinic for assessment of MDT progress every 48 hours until at least 90% necrotic tissue is debrided. The clinical nurse assesses the debridement effect after opening the top cotton layer of the dressing and irrigating out the larvae. Clinical needs of patients determine the frequency of nursing review. More frequent assessments occur if there is a risk of infection, exudate management problems, or a need to evaluate pain control.

To encourage patient feedback and avoid influencing responses, an open-ended question (“How are you doing?”) is routinely used to inquire about patient experience and perceptions. Because MDT is a new intervention for the authors’ facility, it is important to be open to additional questions to clarify patient perceptions, symptom experience, and impact on quality of life. If >10% devitalized tissue remains at the dressing change, new larvae are applied. If <10% devitalized tissue remains in the dressing base, the dressing base remains in place if intact. The MDT dressing base is removed if devitalized tissue remains and individual needs are not met. MDT is discontinued if pain cannot be managed or if the patient declines therapy.

<table>
<thead>
<tr>
<th>Wound type</th>
<th>Number of patients</th>
<th>Gender female/male (percentage)</th>
<th>Average age (range)</th>
<th>Number of patients with diabetes</th>
<th>Number of patients requiring one to five applications</th>
<th>Total number of nursing visits before, during, and after MDT</th>
<th>Withdrawals from MDT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg ulcers</td>
<td>30</td>
<td>16/15 (57%)</td>
<td>71 (57–94)</td>
<td>19</td>
<td>4/16/10</td>
<td>94/66/34</td>
<td>1 death*</td>
</tr>
<tr>
<td>Surgical wound failure</td>
<td>17</td>
<td>5/12 (35–88)</td>
<td>62 (35–88)</td>
<td>14</td>
<td>1/2/13</td>
<td>106/44/32</td>
<td>1 pain*</td>
</tr>
<tr>
<td>Pressure ulcer</td>
<td>9</td>
<td>4/5 (47–87)</td>
<td>77 (47–87)</td>
<td>6</td>
<td>1/2/6</td>
<td>41/23/16</td>
<td></td>
</tr>
<tr>
<td>Diabetic foot ulcer</td>
<td>7</td>
<td>1/6 (46–80)</td>
<td>59 (22–80)</td>
<td>7</td>
<td>1/5/1</td>
<td>36/22/13</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>5</td>
<td>1/4 (22–88)</td>
<td>59 (22–80)</td>
<td>3</td>
<td>4</td>
<td>30/15/9</td>
<td></td>
</tr>
<tr>
<td><strong>Total nursing visit cost</strong></td>
<td><strong>68</strong></td>
<td><strong>29/39 (43%/57%)</strong></td>
<td><strong>71/47 (22–94)</strong></td>
<td><strong>47/64 (69%/94%)</strong></td>
<td><strong>21/39/0/1</strong></td>
<td><strong>307/170/102</strong></td>
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<td><strong>0</strong></td>
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**Table 1. Maggot debridement therapy (MDT) patient data**

* Patient died due to comorbid disease; patient data on prior and post-MDT nursing visits not included
** Patient withdrew due to pain; only wound type, number, gender, age, diabetes, or PAD data included
*** Nursing visit costs = $150 times x number of visits for the week; PAD=peripheral artery disease

After the initial application of maggots, patients return to the clinic for assessment of MDT progress every 48 hours until at least 90% necrotic tissue is debrided. The clinical nurse assesses the debridement effect after opening the top cotton layer of the dressing and irrigating out the larvae. More frequent assessments occur if there is a risk of infection, exudate management problems, or a need to evaluate pain control.
Quality review data collection. The clinic database from January 1, 2001 through June 30, 2006 was reviewed. During that time, an average of 433 patients were treated annually. A total of 68 patients who had received MDT were identified. Their medical records were reviewed and the following variables were abstracted: age, diagnosis (diabetes, PAD), type of wound, nursing visit information, referrals, and wound outcomes, including wound closure, surgery, palliative care, or patient withdrawal. Clinic nurses interpreted the patient experience from communication notes and consultation with patients, care providers, and physicians involved. Clinic staff entered data on a spreadsheet with each patient assigned a number (1–68); after data entry, the name list was shredded.

To summarize the outcomes, wounds were grouped by etiology as follows: leg ulcer, diabetic foot ulcer, pressure ulcer, surgical wound failure, and other. Wound outcomes were categorized as closure, surgical referral, palliative, and withdrawal. Patients declining MDT and those lost to review or death were recorded as withdrawn and the reason abstracted. Surgical referrals were classified by the surgery performed: minor amputation (foot-sparing), major amputation (lower extremity), vascular graft, and revision to initial surgical site. Patients who sought palliative care were asked to share their rationale. Nursing visits were counted for the week before, during, and after MDT. Weekly nursing visit cost was the number of visits multiplied by the administrative cost of $150 CDN per visit.

Results

Patient population. Sixty-eight (68) patients — 29 (43%) women, 39 (57%) men, average age 71 (range 22 to 95) years — consented to MDT. The majority of the patients had both diabetes and PAD (47, 69%); the remainder had only PAD (17, 25%) and neither diabetes nor PAD (4, 6%) (see Table 1).

MDT outcome. Figure 1 illustrates the distribution of patients by wound outcome after MDT. Sixty-eight patients started MDT; 67 (98.5%) achieved the standard protocol outcome of debridement of >90% of necrotic tissue. One (1.5%) patient withdrew due to severe pain within 1 hour of larval contact. This patient had experienced severe pain with many interventions. Patients completing MDT did not report increased pain or pyrexia (fever).

All patients were assessed every 48 hours, and the number of maggots applications required was one (n = 6), two (n = 21), three (n = 39), and five (n = 1) for a duration of 2, 4, 6, and 10 days, respectively. Figure 2 illustrates typical MDT progress. The highly absorbent incontinence pad was changed an average of every 8 to 12 hours but sometimes more frequently depending on the size of the wound and amount of drainage.

Following MDT, 56 wounds (82%) closed with moist wound dressings, and 10 wounds (15%) with extensive tissue loss were referred to surgery (see Figure 3 for an example of one case). Eight (12%) patients had surgery: one vascular graft, six minor amputation revisions, and one major amputation. Two patients declined the recommended major amputation, preferring palliative care. One (1.5%) death occurred due to comorbid disease, but the wound had been progressing and previous pain had been relieved.

Wound etiology and MDT outcome. The wound clinic’s main patient population are patients with foot and leg...
ulcers, which is reflected in the wound mix. Special requests for consultation and treatment—eg, pressure ulcers—were considered (see Table 2).

The majority of wounds referred were leg ulcers (30, 44%). Most had more than one etiology; venous/arterial involvement was the most common (27, 40%). One patient had a venous ulcer, one had vasculitis, and one required treatment of warfarin-induced skin necrosis. All leg ulcers closed except for one patient who died from pre-existing disease while wound healing was progressing.

Of the 68 patients treated with MDT, 17 (25%) were due to surgical wound failure. Amputation site breakdown was the most frequent etiology (15). One patient required debridement for osteomyelitis, and one wound had a wound failure following a vein harvest procedure. Amputation site wound failure outcomes included 10 closed wounds, three revisions, one arterial graft, and one patient who declined a major amputation and opted for palliative care due to advanced malignancy.

Pressure ulcers (nine, 16%) were mainly located on heels (five), followed by ankles (two) and one each on the calf and sacrum. Debridement exposed extensive tissue loss for one ankle ulcer. The patient declined a below-the-knee amputation and chose palliative care due to age and poor health.

Of the diabetic foot ulcers (seven, 10%), four wounds closed and three were referred to surgery for minor (two) or major amputation (one). The patient for whom major amputation was recommended had received the same recommendation earlier but reconsidered after MDT exposure of the extent of tissue loss.

Of the two trauma patients, one achieved wound closure and one was referred for minor amputation due to loss of tissue function. The two cases of toe gangrene and pyoderma gangrenosum achieved wound closure after MDT. A patient with pyoderma gangrenosum did not experience deterioration of the wound in response to minor trauma known as pathergy.

Nursing visits. Patients required a varying number of applications at 48-hour intervals ranging from one visit...
Qualitative patient experience. Patient feedback was mainly positive. Patients were anxious about possible pain, “creepy” sensations, and maggots escaping during the first application, but these concerns were not reported at subsequent visits. Wound sensation associated with larvae was infrequently reported. Pain did not increase with MDT with the exception of the patient who refused MDT. Sixty-seven patients required no change in analgesic medication. One patient had declined MDT for 3 months but was encouraged by the progress of other patients to try MDT. She experienced no problems and her wound closed within 8 weeks. Patient comments concerning MDT included the following: belief MDT played a part in wound closure and should have been provided sooner; appreciation for the opportunity to have MDT to try to salvage as much of their limb as possible; preference for knowing the extent of tissue loss exposed by MDT and for having a definitive care plan to address the finding; and belief quality of life improved following MDT because of wound progress, odor management, or a definitive decision about the potential to heal. No participant requested assistance or additional nursing from care providers by telephone.

Discussion

Maggots are highly selective for removing necrotic tissue and can be used when surgical debridement may be undesirable due to comorbid risk factors. This retrospective evaluation showed good wound outcomes, nursing cost efficiency, no adverse events, and general patient satisfaction.

Wound outcomes and referrals. Patients are referred to the Foot and Leg Ulcer Clinic when their wounds are not responding to conventional care. All wounds were at increased risk for infection due to the presence of necrotic tissue; many patients had been advised about amputation risk, should wound healing not occur. Successful amputation site closure or minor revision met the goal of limb salvage for 12 of the patients who were anticipating major amputation before MDT.

Limb salvage programs attempt to prevent above the foot amputation or enable foot-sparing surgery. Armstrong et al’s prospective case-control study (N = 60 patients with diabetes, average age 72.2 years, with neuro-ischemic wounds and peripheral vascular disease) found no difference in the proportion of healing ulcers between the MDT and control groups. Time to heal was significantly shorter for MDT (P = 0.04), and fewer patients in the MDT group (10%) had high-level amputations, compared with 33% of the control group. In addition, the MDT group had more antibiotic-free days during follow-up than the control group. Armstrong’s study emphasizes the need to use outcome measures specific to the actions of MDT rather than closure of wounds that are frequently identified as nonhealing.

Cost. Efficient debridement provides an opportunity to reduce the cost of care by reducing treatment time. The current study found that the wounds of 67 of 68 patients (98.5%) were 90% debrided within 1 week, and the cost of nursing visits was 67% less the week following debridement. This figure underestimates potential savings, because data were collected only for the week after debridement; for most patients, the reduction in visit frequency continued. Soares et al found 71% of the total treatment costs in his analysis of lower limb ulcers, illustrating the importance of controlling nursing costs.

Patient experience. Compared to Gilead et al’s results, which reported pain in 38% of patients, current study participants were debrided successfully within 1 week.
with no additional pain management requirements. Differences in the pain experience may be due to patient selection, larvae application technique, number of larvae used, and experience of nurses, which may influence patient confidence and experience. Although some patients were anxious about MDT before the first application, no major concerns were expressed afterwards. Two patients requested maggot debridement for new wounds after the review was completed.

**Implications.** Future randomized controlled clinical studies to examine the efficacy of MDT must focus on debridement, infection, and healing rates. Research has expanded the use of MDT to combination therapy for trauma and necrotizing fasciitis to reduce tissue loss, debridement in high-risk anesthetic patients, and wound disinfection when antibiotic allergies exist. Successful use of MDT in the authors’ clinic provided after this review include cancer patients who required wounds closed before treatment, an infected knee replacement in a patient with hemophilia, and odor management for several palliative care patients. One patient whose wound was not successfully debrided despite viable maggots was found to have malignant melanoma.

The clinic experience of fast complete debridement and positive wound outcomes suggests MDT is a therapy that can be safely provided in various clinical settings. As more clinicians publish their experiences and outcomes and rigorous controlled clinical studies are conducted, the full potential of MDT may be realized. In a meta-analysis of four studies comparing MDT with standard therapy in the treatment of diabetic foot ulcers, Tian et al. found improved healing ($P = 0.013$), reduced healing time ($P = 0.001$), reduced amputation rates ($P = 0.02$), and more antibiotic-free days ($P = 0.001$) compared to control. Outcomes such as these underscore the need for more opportunities to conduct research, publish, and communicate with the wound care community.

**Limitations**

A quality improvement review is limited to the clinical care provided to a group of patients in a specific care setting and retrospectively focuses on services provided and resultant outcomes. This limits the generalizability of the outcomes reported. In addition, the patient population served by the clinic creates a selection bias for type of wound and comorbid factors. Also, data were abstracted for a period of 3 weeks only because many patients attended only for initial assessment, MDT, and post-MDT care planning. Finally, patient perceptions reported are anecdotal or based on the absence of expressed concerns.

**Conclusion**

The results of this retrospective review suggest MDT can be safely used in a clinic setting while patients continued to reside in the community or residential care. The vast majority of wounds contained $<10\%$ necrotic tissue after just a few applications, and healing outcomes were encouraging. Because many of the patients treated were at risk of amputation, the high wound closure rate plus foot-sparing surgery also may have improved the limb salvage rate.

**Acknowledgments**

This quality improvement review was independent of any corporate influence. Thank you to Ronald A. Sherman, MD, MSc, for his valuable critique of the manuscript. Editorial support was provided by Joanna Gorski of Prescriptum Health Care Communications Inc (Niagara-on-the-Lake, Ontario, Canada).

**References**

MAGGOT DEBRIDEMENT THERAPY


