The use of maggot debridement therapy in the treatment of chronic wounds in hospitalised and ambulatory patients

• **Objective:** To summarise our experience of the use of medicinal maggots for the debridement of necrotic chronic wounds and to try and identify prognostic factors for debridement success and associated pain.
• **Method:** During the years 1996–2009, 723 wounds of 435 patients (180 females and 255 males) were treated with maggot debridement therapy (MDT) in 16 departments and units of the Hadassah Hospital in Jerusalem, Israel. Overall, 261 patients were treated during hospitalisation, while 174 were treated as ambulatory patients. In 90.5% of the patients the wounds were located on the leg, but only 48.0% had diabetic foot ulcers. The wound duration range from one to 240 months (mean=8.9; median=4 months). Sterile maggots of the green bottle fly, *Lucilia sericata*, were used for MDT. In 90.6% of the cases, maggots were placed directly on the wound using a cage-like dressing and left for 24 hours, while in 9.4% of the patients maggots concealed in a tea-bag like polyvinyl netting were used. The concealed maggots were left on the wound for 2–3 days.
• **Results:** The number of treatments was 1–48 (mean=2.98; median=2) and the duration of the treatment varied between one and 81 days (mean=4.65; median=3). In 357 patients (82.1%) complete debridement of the wound was achieved, while in 73 patients (16.8%) the debridement was partial and in five (1.1%) it was ineffective. Increased pain or discomfort during MDT were reported in 38% of the patients.
• **Conclusion:** MDT is a very safe, simple and effective treatment modality for chronic wounds in ambulatory and hospitalised patients.

• **Declaration of interest:** There were no external sources of funding for this study. The authors have no additional conflicts of interest to declare.

Lucilia sericata, maggot debridement therapy, Hadassah Hospital, Jerusalem, Israel

L. Gilead,[1] MD;
K.Y. Mumcuoglu,[2] PhD;
A. Ingber,[1] MD;
1 Department of Dermatology and Venereology, Hadassah University Hospital, Jerusalem, Israel;
2 Department of Microbiology and Molecular Genetics, the Kuvin Center for the Study of Infectious and Tropical Diseases, Institute for Medical Research Israel-Canada, the Hebrew University, Hadassah Medical School, Jerusalem, Israel.
Email: kostam@cc.huji.ac.il

Maggot debridement therapy (MDT), also called larval therapy, the intentional treatment of suppurative skin infections with the larvae of calliphorid flies, was first introduced by Baer in 1931.[1] This method was used extensively in the 1930s and early 1940s in over 300 hospitals in the USA alone,[2–4] but was abandoned with the introduction of antibiotics and the use of aggressive surgical debridement.

Since 1989 in the USA,[5–7] and the mid-1990s in Israel[8–10] and Great Britain,[11,12] MDT has been re-introduced for the treatment of intractable wounds, as well as more recently in Sweden,[13] Germany, Switzerland, Austria, Ukraine, Thailand and Canada. Today, this treatment modality is being used in over 30 countries, with more than 60000 patients treated in over 3000 medical institutions worldwide over the past 20 years. Over 4000 therapists are using maggot therapy worldwide, and approximately 50000 treatments were applied to wounds in the year 2006.[14–16]

The aim of this study was to summarise our experience with MDT in the frame of a modern hospital and in the treatment of hospitalised and ambulatory patients with intractable, chronic wounds. Despite the retrospective nature of this report, we intended to try and analyse the data to identify positive and negative prognostic factors for the success of the treatment and for side-effects.

Method

Participants

During the years 1996–2009, 435 patients (180 females, 255 males) were treated with MDT in 16 departments and units of the Hadassah Hospital in Jerusalem. Of the 435 patients, 243 were treated in the department of dermatology, 38 in the department of vascular surgery, 37 in the department of internal medicine, 31 in the department of orthopaedics and the remaining 86 patients were treated in the departments and units of diabetes, plastic surgery, cardiology, day care, emergency, neurosurgery, haematology, intensive care and urology. The age of the patients varied between 19 and 100 years (mean=66.3 years, median=68 years; Table 1).

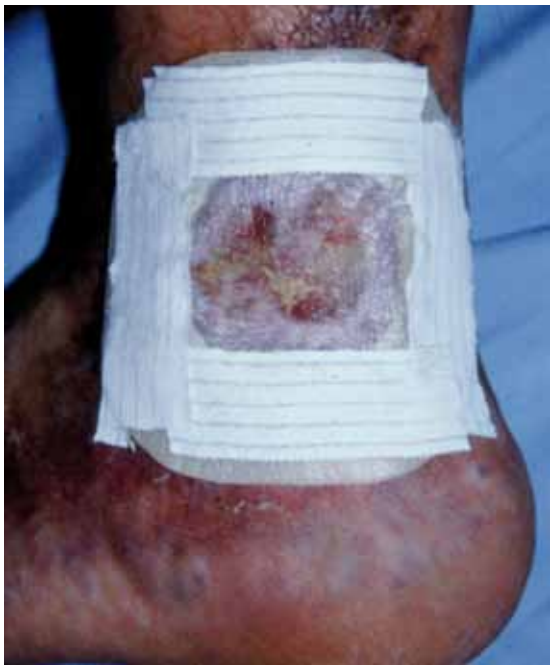

Fig 1. Applications of maggots directly on the wound using adhesive bands and/or hydrocolloidal strips applied on the periphery of the wound. A fine nylon netting, slightly larger than the wound but smaller than the first layer of tape or hydrocolloid strips, was attached with adhesive tape on the top of the first layer, leaving an opening through which the maggots were introduced, while the remainder of the dressing was hermetically closed

Table 1. Demographics and general medical background of patients treated with maggot debridement therapy

No. of patients	435
Sex	
• Male	255 (58.6%)
• Female	180 (41.4%)
Age (years)	66.3
• Median	68 (19–100)
Place of treatment	
• Hospitalised	261 (60.0%)
• Ambulatory	174 (40.0%)
Patient affiliation	
• Dermatology	243 (63.1%)
• Vascular surgery	38 (9.6%)
• Internal medicine	37 (9.6%)
• Orthopaedics	31 (8.1%)
• Other	86 (9.6%)
No. of wounds	725
• Mean no. per patient	1.6
• Median no. per patient	1
Location of the wounds	
• Legs	656 (90.5%)
• Sacrum	58 (8.0%)
• Hands	11 (1.5%)
Wound duration (months)	1–240
• Mean	8.9
• Median	4
Background disease	
• Diabetes	209 (48.0%)
• Venous stasis	74 (17.0%)
• Vascular stasis	48 (11.0%)
• Other	104 (24.0%)

Results given as n (%), unless otherwise specified

Maggots and their application

Sterile maggots of the green bottle fly *Lucilia sericat*, were cultured according to the methods described in the website of the International Biotherapy Society.[17] Maggots were usually placed directly on the wound using a cage-like dressing. For this purpose, adhesive bands or hydrocolloidal strips were applied on the periphery of the wound in order to cover only the skin peripheral to the wound. A sterile piece of fine nylon netting, slightly larger than the wound but smaller than the first layer of tape or hydrocolloid, was attached with adhesive tape on the top of the first layer, leaving an opening through which the maggots were introduced. The netting, which prevents maggots from escaping, allows air to reach the maggots and facilitates the drainage of liquefied necrotic tissue through the top of the dressing with the help of absorbing gauze and pads (direct application], also known as free-range technique; Fig 1).

As an alternative application mode, maggots that were concealed between two 0.5mm thin layers of polyvinyl alcohol netting, sealed together with a heat-sealer over a small cube of a spacer material, were used (caged application, also known as contained, concealed, tea-bag or biobag technique; Fig 2).

The size of the cage application was adapted to the size of the necrotic tissue on the wound and usually 30–60 maggots were concealed in the netting and left for 48–72 hours. The maggots were thus able to feed through the netting and their excretions/secretions to reach the wound in order to extra-corporeally digest the necrotic tissue. In case of the direct application, the maggots were left on the wound for approximately 24 hours, while the

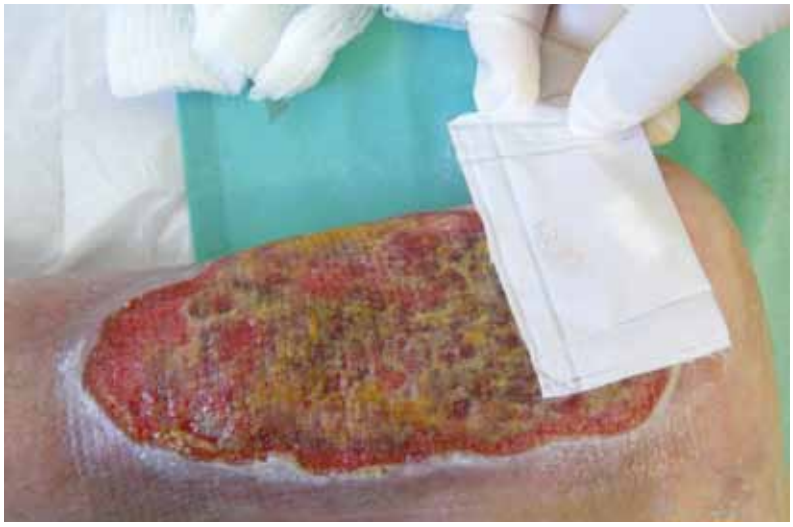

Fig 2. Caged application of maggots to a chronic wound. The maggots were caged between two 0.5mm layers of polyvinyl alcohol netting sealed together with a heat-sealer over a small cube of a spacer material

number of applied maggots varied between 1 and 400, depending on the size and depth of the necrotic tissue in the wound; usually 10–15 maggots/cm^2 of necrotic tissue were applied.

After each treatment cycle with direct application, the dressing was removed and the wound thoroughly washed with sterile saline solution, which removed the majority of maggots, while the remaining maggots were removed with a forceps and/or cotton tipped applicator. When maggots were left more than 24 hours on the wound, the outer, absorbent dressing was changed at least once a day.

Patients and treatment

All treatments were conducted by one of the authors (KYM), who is a parasitologists and biotherapist. Written informed consent was obtained from all patients or their custodians, as well as from the responsible physician. Patients with acute, rapidly advancing, life- or limb-threatening infections, with septicaemia or high fever of unknown origin were excluded from treatment with MDT.

The treatments were carried out in a form of an open study. After each cycle of treatment, the wound was opened, the dressing and maggots were removed and, if necessary, the wound was debrided surgically by removing loose large necrotic tissue fragments, which were usually at least partially separated from the living tissue by the maggots. In cases where additional necrotic/sloughy material remained within the wound bed, new maggots were introduced for an additional treatment cycle. MDT was discontinued when no necrotic tissue was left in the wound, when granulation tissue could be seen in the wound or when no improvement could be seen in the debridement of the wound. When maggots were left on the wound for more than 24 hours, the dressings were inspected daily and the secondary, external dressing (gauze and padding) were changed when necessary. The success of the debridement was evaluated by the responsible physician, such as complete or partial debridement.

Statistical analysis

Patient demographics and medical history and data were recorded and collected using a spreadsheet. Data was analysed using a pivot table and simple associations were examined.

Results

Overall, 261 patients (60.0%) were treated while they were hospitalised, while 174 (40.0%) were treated as outpatients. Overall 725 wounds were treated; the number of wounds per patient varied between 1 and 25 (mean=1.6, median=1). In 90.5% of the cases the wounds were located on the legs, while in 8.0% on the sacrum and 1.5% on the hands. The duration was 1–240 months (mean=8.9 months; median=4 months) before MDT was applied.

The majority of patients with leg ulcers had diabetes (48%), venous ulcers (17%), mixed venous and arterial vascular ulcers (11%), pyoderma gangrenosum (3%), lupus (2.8%), arterial insufficiency (ischaemic ulcers, peripheral vascular disease [PVD]; 2%), while the remaining 16% had autoimmune and Burger's diseases, burn wounds, carcinoma, cellulitis, cerebrovascular accident (CVA), dementia, dermatitis herpetiformis, erysipelas, hemiplegia, AIDS, leukaemia, lymphoma, lymphostasis, neuralgia, paraplegia, polycythemia, sarcoma, scleroderma, tetraplegia, thalassaemia, trauma, thrombophlebitis or undiagnosed diseases. The majority of patients, who were treated for pressure ulcers were paraplegic, hemiplegic, s/p CVA or had advanced dementia.

The number of treatments varied between one and 48 (mean=2.93, median=2), while the treatment period lasted for 1–81 days (mean=4.65 days, median=3 days). In 90.6% of the cases, the direct application method was used and the maggots were left on the wound for 24 hours, while in 9.4% of the patients the caged application method was used and the maggots were left on the wound for 2–3 days, while gauze and pads covering the caged application maggots were replaced daily (Table 2).

In 357 patients (82.1%) complete debridement of the wound was achieved, while in 73 patients (16.8%) the result was partial debridement and in five (1.1%) it was ineffective. In at least 55 cases, an imminent amputation, which has already been contemplated and indicated in the patients' charts, was prevented due to positive results of MDT.

An analysis of the cumulative demographic data and medical history of all patients treated with

maggots in our cohort failed to demonstrate any single or combination of factors that could predict the result of treatment in any patient. However, when checking MDT results vs the patient's age, it was found that, while in patients <60 years old the risk of debridement failure was almost 0.2%, patients over 70 years had a 7% reduction in the chance of achieving complete debridement compared with the mean success chance in patients up to 70 years old (85%). A comparison of MDT results and the disease responsible for most of our patients' ulcers revealed a 2.3% risk of MDT failure in patients with leg ulcers with mixed venous and arterial insufficiency, compared with only 1.5% in patients with venous insufficiency alone and patients with diabetes alone. Thalassaemia had the worst MDT results, with a 50% risk for failure (only six patients).

Overall, 38% of the patients reported increased pain during MDT and were treated with analgesics. Five patients discontinued the treatment due to MDT-induced pain. An analysis of the cumulative demographic data and medical history of all patients treated with maggots in our cohort failed to demonstrate predictive factors for MDT-associated pain. However, MDT-associated pain was most commonly reported by patients whose wounds were secondary to pyoderma gangrenosum, carcinoma, lymphoma, lupus and other autoimmune diseases, and in patients with vascular problems, venous, arterial and mixed. Men complained of pain more than women, and younger patients (<55 years old) complained 25% more than patients older than 55 years. There was no significant correlation between wound duration and MDT-associated pain. Despite our clinical impression that caged application MDT was associated with less pain than direct application MDT, our data show no difference in MDT-associated pain reporting between the two groups. The details regarding the pain caused by maggots and the medication used to alleviate their pain will be reported elsewhere.

This case-report demonstrates a representative case of patient, who was treated with MDT.

Case report

A 57-year-old man presented with a diabetic foot ulcer with a duration of around 3.5 months (Fig 3a). Previously, he was treated at home with conventional wound treatment methods, but the wound did not heal and was extremely painful. The patient was admitted to the Hadassah University Medical Centre Dermatology Department for MDT treatment. Three treatments, with approximately 100–200 maggots each, cleaned the wound within 3 days (Fig 3b). During this time, the patient reported increased pain and required analgesics. After MDT, the patient was transferred to the plastic surgery department for skin grafting, which was successful. Following grafting, wound-associated pain subsided significantly within 2–3 days and disappeared within 10 days of grafting.

Table 2. Number and period of treatments with maggot debridement therapy and the outcome of the therapy

Treatment modality	
• Direct application of maggots	394 (90.6%)
• Caged application of maggots	41 (9.4%)
Number of treatments	1–48
• Mean	2.9
• Median	2
Period of treatment (days)	1–81
• Mean	4.6
• Median	3
Results	
• Complete debridement	357 (82.1%)
• Partial debridement	73 (16.8%)
• Unchanged	5 (1.1%)

Results given as n (%), unless otherwise specified

Discussion

Wound debridement has long been considered an essential initial step in the initiation of a healing process in a chronic wound. While the presence of necrotic tissue in a wound is considered a sign of chronicity, a clean wound bed with healthy granulation tissue and without necrotic tissue is an indicator of significant progression towards healing. Although quick debridement, by itself, does not promise a speedy healing, it makes it possible and achievable. MDT has been accepted as one of the most effective, and in most cases quickest, means of selectively debriding necrotic tissue.[18]

In the present study, 60% of the patients were treated while they were hospitalised and 40% were ambulatory treated. Since MDT was re-introduced as a treatment modality for wounds, patients are treated both ambulatory and while hospitalised. In the UK, trained nurses visit the patient at their home and apply maggots to their wounds.[19]

The majority of our patients with leg ulcers also had diabetes (48%), venous ulcer (17%) or mixed aetiology vascular ulcers (11%). During the past 25 years, MDT has been used to debride many different types of skin and soft tissue wounds, including pressure, arterial ulceration, venous ulceration, neurovascular and diabetic foot ulcers, traumatic and post-surgical wounds, osteomyelitis and burns.[8,19,20]

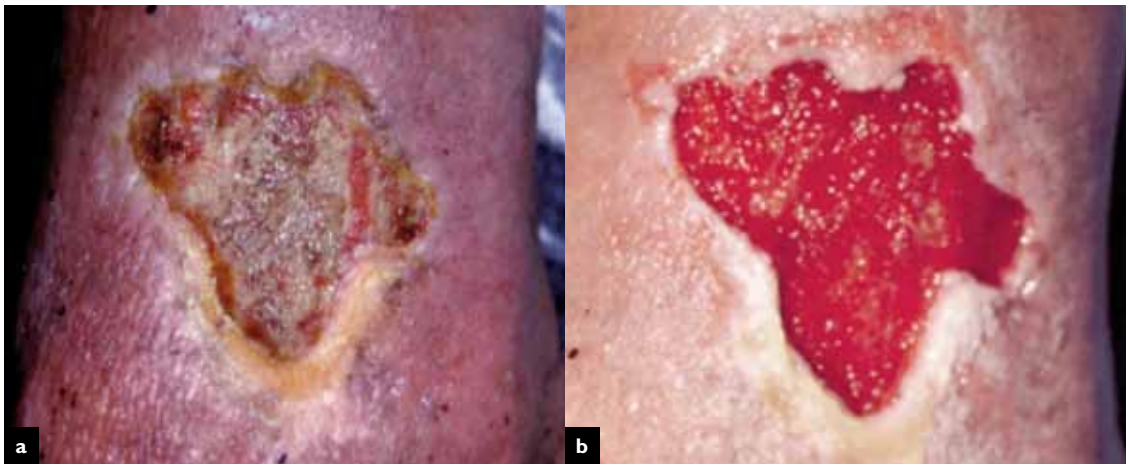

Fig 3. Foot ulcer of a 57-year-old diabetic patient, (a). The wound was previously treated with conventional methods for 3.5 months. Prior to maggot therapy, the wound was covered with purulent material. After a single treatment with approximately 100 maggots, the wound was completely debrided within 19 hours, (b)

In the present study, the number of treatments varied from one to 48 (mean=2.9, median=2), while the treatment period lasted for 1–81 days (mean=4.7, median=3). Steenvoorde et al.[21] reported a mean number of maggot application of 2.8 (range 1–11).

In 90.6% of the cases, the direct application methods was used and the maggots were left on the wound for 24 hours, while in 9.4% of the patients the caged application method was used and the maggots were left on the wound for 2–3 days, while replacing daily the gauze and pads, placed on top of the caged application. The latter method was introduced in our cohort only in the past 3 years; hence, the relatively low number of participants compared with the direct application method.

Other confounding factors resulted from our clinical impression that contained maggots cause less pain, the treatment is aesthetically more acceptable to patient and health professionals than the direct application technique, there is no need to prepare a cage-like dressing (adhesive bands, damage to skin), there is a far lower risk of maggots escaping the wound, and a practical aspect when dressings could not be opened and maggots could not be changed daily (weekends). Therefore, the caged application method was preferentially used in superficial and very painful wounds, as well as in areas where an effective cage-like dressing was not possible.

This could explain why our data do not show a difference in MDT-associated pain reporting between caged application MDT and direct application MDT (39% and 38%, respectively). Superficial wound selection for caged application MDT is probably also the reason for the inverse ratio of length of treatment and number of treatments found in our data for both methods (mean 1.88 treatments over 3.2 days for caged application MDT, compared with 3.0 treatments over 4.8 days for direct application MDT).

These results contrast with our clinical impression that, in caged application MDT, the debridement is slower, MDT-associated pain is significantly reduced, the maggots can only be active and effective on the surface area on which the restrained maggots were placed and accordingly unable to reach hidden places (burrows and tunnels in the skin/wound), requiring more treatments to achieve complete debridement. This was also observed by Steervoorde et al.[21]

In the present study, complete debridement of the wound was achieved in 357 patients (82.1%), while in 73 patients (16.8%) the debridement was only partial and in five (1.1%) it was ineffective. In at least 55 cases, an imminent amputation was prevented due to positive results of MDT controlling the infection, preventing and reversing further deterioration of the wound, limb and patient condition. Sherman[14] compared MDT with conservative debridement therapy for the treatment of pressure ulcers and found that 80% of maggot-treated wounds and 48% of the conventionally treated wounds were completely debrided. Other groups found that with MDT 67–88% of the wounds could be successfully debrided.[10,16,22,23]

The majority of patients did not complain of any major discomfort during the treatment. In the present study, 38% of patients reported increased pain during MDT. Wolff and Hansson[13] treated 74 patients with necrotic or sloughy chronic ulcers of different aetiologies and found that maggots caused increased pain in 34% of the patients. Steenvoordeet al.[24] determined the pain levels in patients treated with MDT using a visual analogue scale and found that, while diabetic patients experienced the same amount of pain before and during MDT, eight out of 20 (40%) non-diabetic patients experienced more pain during MDT than before. Dumville et al.[18] reported that the mean ulcer related pain scores for the maggot group were about double than those of the hydrogel group.

No allergic reactions related to maggots were observed in this study. In rare cases, bleeding of the wound was seen; this usually happened after surgical debridement when the bleeding was stopped using pressure, and in patients on anticoagulants.

One of the major advantages of MDT was that the maggots separate the necrotic tissue from the living tissue, making a surgical debridement easier. The latter was used as often as possible during MDT to remove larger pieces of necrotic tissue so that only the debridement of thin layers of necrotic material over the living tissue is left to the maggots.

In January 2004, the FDA allowed the production and distribution of sterile maggots as a medical device. Again in 2004, the British National Health Service (NHS) permitted its doctors to prescribe maggot therapy. In 2006, approximately 300 centres in the USA and about 1000 centres in Europe were using maggot therapy, while in 2009 medicinal maggots were distributed to over 800 therapists and centres in North America. MDT is now being used by over 4000 therapists in over 30 countries. In 2011, the Israeli Ministry of Health recognised MDT as a treatment modality for chronic wounds.

Limitations

The present study had some limitations, as the patients were treated in an open clinical study. In addition, and according to the condition of the patient and the complications not directly related to the MDT, the patients were concomitantly treated with antibiotics and surgical debridement was conducted whenever necessary. During weekends, the wounds were usually treated with antiseptics, such as phenoxethol solution. Another limitation is that the endpoint of all MDT was complete debridement of wounds and not complete healing. The patients were collected from, and returned to, numerous locations, treated by numerous physicians, and in most cases their wounds were not followed by our team following completion of MDT. Therefore, at this point it is impossible for us to report on the number of patients achieving complete healing. However, it is obvious that achieving a complete debridement is a crucial step in the process of chronic wound healing and, once attained, indicates a significantly improved chance of complete healing.

Conclusion

MDT is a safe, simple, effective and cost-efficient treatment modality for chronic, intractable wounds in ambulatory and hospitalised patients. It can save surgical debridement (operations), amputations and use of antibiotics, as well as long periods of hospitalisation. ■

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