Maggot Debridement Therapy and its role in chronic wound management

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Keywords
Maggot Debridement Therapy; chronic wound healing; debridement; wound bed preparation

Abstract

Background: Successful chronic wound management begins with effective debridement of devitalised tissue. Without sufficient removal of devitalised tissue, the normal healing cycle is greatly impeded. Maggot Debridement Therapy (MDT) is a form of debridement which has been shown to be effective and efficient in the removal of devitalised tissue. Podiatrists regularly treat chronic foot wounds and the majority of these are related to diabetes. Several forms of debridement tools are available to podiatrists, and they vary in how evasive or traumatic to the wound bed. MDT is one such debridement option available to clinicians in Singapore.

Design: From February 2010 to March 2011, 14 participants from three Singapore hospitals participated in MDT and their progress were documented. All participants selected for the trial were scheduled for amputation and MDT was used as a "last resort" prior to lower limb amputation. A successful clinical outcome in this study was defined as "a wound bed that was effectively cleaned of devitalised tissue and had granulating tissue sufficient to begin alternative secondary dressings to assist wound healing/closure".

Findings and discussion: Results showed that 64.28% of participants returned a successful clinical outcome yielding an average of 2.5 MDT dressings per participant in six treatment days. To achieve the successful clinical outcome, an average of 4.14 vials of maggots were required by each participant. These results show that MDT is an effective form of debridement in chosen participants. With careful patient selection and use of MDT in the early stages of chronic wound management, MDT will prove an important tool for the debridement of chronic wounds with higher clinical success rates.

Introduction

Chronic wounds are defined as wounds having been presented for more than six weeks duration without progressing (Bale & Jones, 1997). For various reasons, the wound healing cascade cannot naturally develop and instead becomes fixed in the inflammatory phase. A cycle develops and the wound cannot progress on to the next stage of healing and ultimately closure (Mast & Schultz, 1996). Clinically chronic wound beds contain devitalised tissues, including slough, and gangrene (Figures 1 and 2) and their production is usually accelerated by the presence of pathogenic microbial colonies creating and accelerating zones of necrosis.

Figure 1 Gangrene and slough

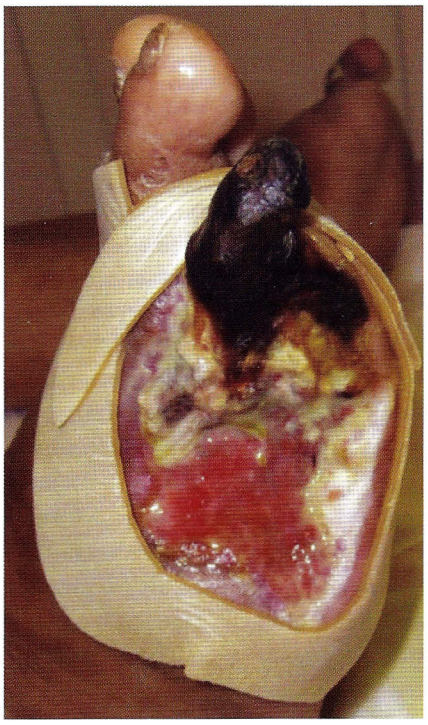
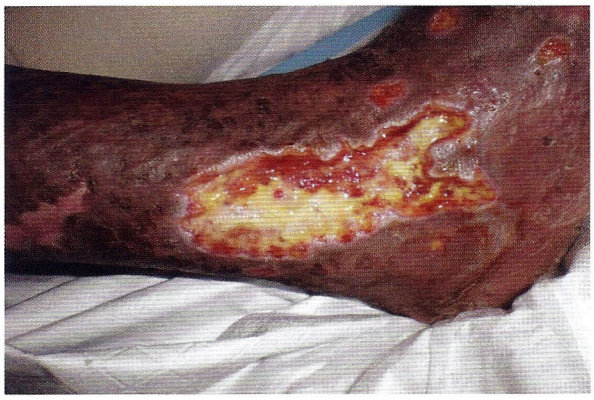


Figure 2 Adhered slough



Devitalised tissues are a by-product of this necrotising cycle and are defined as a collection of over processed inflammatory cells which are sloughed away into the wound bed. If these tissues remain in the wound bed, the wound will not progress forward through the documented phases of healing. Additionally, with pathogenic microbes assisting the formation of these devitalised zones, inflammation forms the aetiology for being stationary in the inflammatory phase. Debridement is the process of removing non-living tissue from a wound bed and is paramount as it is the precursor for all wound healing stages (Robson, Mannari, Smith, & Payne, 1999; Steed, Donohoe, Webster, & Lindsley, 1996).

History of Maggot Debridement Therapy

The application of fly larvae for wound healing has been well-documented and is not a new discovery. Napoleons' personal surgeon, Baron Larrey, is credited with the first use of fly larvae in wounds. He reported that the wounds which acquired maggots on the battlefield reduced the development of infection and accelerated healing (Larrey, 1832).

The first clinical applications of maggot therapy were performed by Zacharias and Jones during the American Civil War (Baer, 1931). Later, William Baer refined the technique by using sterile maggots to treat osteomyelitis and other soft tissue infections (Baer, 1931).

During the 1930s, the therapy became more popular and was widely used for the treatment of chronic or infected wounds. The introduction and widespread use of antibiotics in the 1940s saw the popularity of maggot therapy gradually regressed. Then, in the 1990s with increasing reported cases of antibiotic resistance, and the emergence of methicillin-resistant *Staphylococcus aureus* (MRSA) and the number of diabetes related wound increasing, Maggot Debridement Therapy (MDT) has re-established itself as a viable clinical tool for debridement (Beasley & Hirst, 2004; Bowling, Salgami, & Boulton, 2007).

Maggots' mode of action

Debridement and secretions

Maggots possess mandibles which are used to facilitate movement through their food source (Barnard, 1977). Scientists first postulated that a benefit of using maggots for therapy was due to their micro-massage effect as they moved through their food source (Namias, Varela, Varas, Quintana, & Ward, 2000). Maggots also use their mandibles to secrete proteolytic enzymes. These enzymes devitalise tissue selectively and they liquefy the tissue into a 'soup' which they can easily ingest. These enzymes effectively degrade extracellular matrix components, including laminin and fibronectin. The secretions could therefore assist in the digestion of the necrotic wound matrix, leading to effective debridement (Chambers, Woodrow, & Brown, 2003).

Beneficial excretions

Various studies have highlighted the presence of antibacterial substances in maggot excretions. These excretions have an inhibitory effect on Gram-positive and Gram-negative bacteria, including methicillin-sensitive *Staphylococcus aureus (MSSA)*, MRSA, *Escherichia coli* and *Pseudomonas aeruginosa* (Bexfield, Nigam, Thomas, & Ratcliffe, 2004; Pavillard & Wright, 1957). Other studies detail that ammonia excreted by maggots increases wound pH, thereby generating an adverse environment for bacterial growth (Messer & McClellan, 1935; Robinson, 1940). Robinson and Norwood (1933) also reported that destruction of ingested microbes were evident, since the stomach and foregut were heavily contaminated with viable bacteria yet the hindgut was sterile. Later, Mumcuoglu, Miller, Mumcuoglu, Friger and Tarshis (2001) confirmed similar findings.

Indications

MDT is most useful when a wound contains devitalised tissue, such as slough, necrosis or gangrene. Maggots will quickly debride these tissues, leaving healthy tissue and a granulating wound bed undamaged. Patients whom are declared unsuitable for surgery but require rapid wound cleaning are excellent candidates for MDT. Quick debridement of these wounds may reduce the chance of infection and therefore reduce the need for antibiotics. With the evolvement of antibiotic resistance, MDT has been demonstrated to be useful in wounds infected with MRSA (Bowling et al., 2007).

Contraindications

Since maggots ingest by liquefying and sucking the devitalised tissues, most patients will not feel painful during treatment. The exception is when the patient with an ischaemic component to their wound. Pain is caused by the change of pH within the wound, and usually a slight increase in analgesics is required (Gumbrell, Peura, Kun, & Dunn, 1998). Precaution should also be taken when using MDT with wounds containing fistula or when connect with vital organs (Thomas, 2002).

Osteomyelitis is commonly cited a contraindication since the maggot is able to ingest this devitalised tissue. The authors' observations in clinical setting have demonstrated that careful use of MDT with osteomyelitis is actually beneficial, as long as the clinician is aware of the extent and depth of osteomyelitis present.

Maggot larva of *Lucilia cuprina* have difficulty in ingesting *Pseudomonas aeruginosa* due the quorum-sensing (QS)-regulated virulence. Wounds heavily colonised with *P. aeruginosa* should be a contraindication for MDT unless used in combination with appropriate systemic antibiotics (Andersen et al., 2010). Other infections including MRSA, MDT can be used without introduction of systemic antibiotics.

Methods

From February 2010 to March 2011, 14 MDT participants from three Singapore hospitals were placed on MDT and observed until a successful or unsuccessful clinical outcome was achieved.

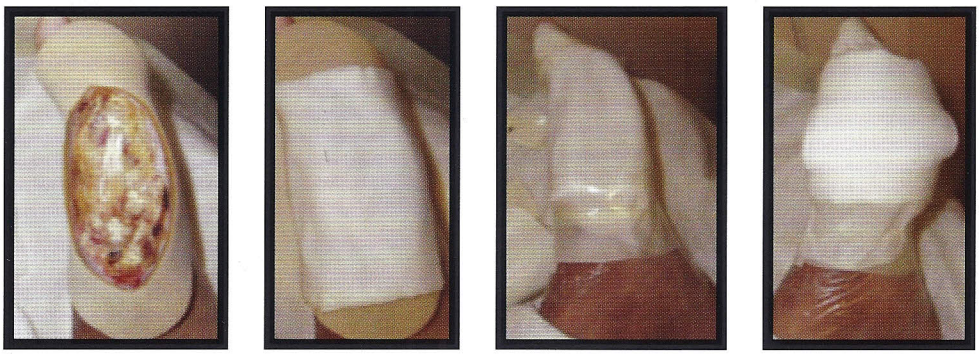
In this study, the authors define a successful clinical outcome as "a wound bed that was effectively cleaned of devitalised tissue and has granulating tissue sufficient to begin alternative dressings to assist wound healing/ closure". Usually when this outcome is achieved, in-patient wound care could stop and the wound closure be managed in the home setting. An unsuccessful clinical outcome was defined by the authors as "a wound bed that did not generate granulating tissue or was found to be not viable for limb salvage due to underlying complications". These complications ranged from extensive condition of osteomyelitis, presence of *Pseudomonas*, to very poor vascular status that does not permit healing or epithelisation.

Maggot application technique and management

MDT is administered by applying disinfected fly larvae to the wound, within a cage-like dressing. First, a hydrocolloid dressing is used to the surrounding skin of the wound, like a picture frame. This protects the healthy tissue from prolonged exposure to the powerful proteolytic enzymes and also prevents peri-wound maceration. The sterile larvae are placed within the wound (approx. 5-8 per square centimetre) with loose sterile non-woven gauze.

A sterile water-resistant adhesive tape is used to 'encage' the maggots within the wound area. The tape is adhesive only at the edges, thus allowing wound ventilation of atmospheric air containing oxygen. This is the known as the "primary dressing" and should be left untouched for two to three days. This cage-like dressing is then topped with light layers of gauze to absorb the necrotic drainage (the secondary dressing). This secondary dressing should be monitored and replaced every four to six hours to allow for good drainage from the wound bed (Figure 3).

Figure 3 Stages of dressing wound



Step 1:
Primary Dressing

Frame the wound with Hydrocolloid dressing

Step 2:
Primary Dressing

Place live maggots onto gauze and invert onto the wound

Step 3:
Primary Dressing

Encage using gas/air permeable tape

Step 4:
Secondary Dressing

Place moistened gauze lightly above the Bio Dressing

Maggot removal technique

After 48 to 72 hours, maggot removal is done conveniently at bedside. Maggots are removed by peeling off the dressing with one hand while wiping up the larvae with a wet gauze pad held in the other hand. Flushing the wound with saline will be enough to effectively remove all the maggots within the wound bed. These are doubled bagged and disposed as bio-hazard waste within the hospital environment.

Wound assessment for clinical success

Once the maggots were removed, the wound was inspected visually. The changes were noted and the wound measured. The amount of devitalised tissue was visually estimated to decide if MDT needed to be repeated or not. Re-application of the dressing would usually be conducted if the devitalised tissue covered more than 5% of the wound bed. The MDT was considered effective if the wound bed was cleaned of devitalised tissue, and granulating tissue was visible. Then the clinician decided on the ways and means of maintaining wound healing, encouraging epithelisation, and facilitating wound closure. The MDT durations and numbers of MDT dressings used for individual participants were documented. The information about wound management products used after the MDT and the wound closure rates was not recorded as it was not directly related to the objectives of this study.

Results

In this study, the use of MDT on 14 participants was monitored and the clinical outcomes documented and analysed. Table 1 presents a summary of the use of MDT and outcomes.

Table 1 Clinical outcomes

Participant No.	No. of dressing applications	No. of vials used	No. of days on MDT	Diabetic or not	Outcome	Evaluation
1	2	2	5	Yes	Stopped too painful	Unsuccessful
2	3	4	7	Yes	Pseudomonas	Unsuccessful
3	1	2	3	Yes	Deep OM	Unsuccessful
4	2	5	5	Yes	Cellulitis	Unsuccessful
5	3	6	7	Yes	Clean for skin graft	Successful
6	4	13	9	Yes	Poor vascular status	Unsuccessful
7	1	1	3	Yes	Clean for skin graft	Successful
8	2	5	5	Yes	Clean	Successful
9	3	5	7	Yes	Clean	Successful
10	2	3	5	No	Clean, discharged home	Successful
11	6	9	13	Yes	Clean, discharged home	Successful
12	3	6	7	Yes	Clean	Successful
13	1	1	3	No	Clean for skin grafting	Successful
14	2	2	5	Yes	Clean, discharged home	Successful
Total	35	58	84	12		

A total of 35 dressings were applied and 58 vials used on 14 participants in this study. Twelve of them were diagnosed with type 2 diabetes. Nine of the 14 participants (64.2%) were considered to have successful clinical outcomes. Among the 12 diabetic participants, seven had successful clinical outcomes (58.3%). On average, 2.5 dressing applications per participant were conducted, with the number of applications ranging from one to six. Each vial contained more than 200 maggots of the first instar stage. On average, 4.14 vials were applied per participant, with the number ranging from one to 13 for a participant. The durations of MDT treatment ranged from three to 13 days.

Discussion

In serious open wounds with devitalised tissues, debridement is used to remove the dead or infected tissue in order to improve the healing process of the remaining health tissue. Debridement could be surgical, chemical, or by MDT. Due to peripheral vascular changes, diabetic patients tend to have severe septic wounds on the lower limb. Surgical debridement is a selective process and should effectively remove large amount of necrotic tissues. At the same time, a part of healthy tissues could be removed. In the presence of ischaemia or in the geriatric care patient, chronic wounds may not have an adequate vascular profile, hence healing rates and responses are slowed. Over-debriding these wounds using the surgical method can yield unsuccessful results. When surgical debridement fails to improve healing, Lower Limb Amputations (LLA) is usually done to avoid the life-threatening septicaemia. Before deciding on LLA, some physicians would choose to use MDT as a last resort to save the limb and the costs of surgery and rehabilitation, and to promote quality of life. In this MDT study, all participants were given MDT as a last resort.

In this study, only one participant was taken off the MDT due to pain. Analgesics were offered, but this participant still declined to continue the therapy. Since MDT was discontinued, the clinical outcome was classified as unsuccessful. Hence 7.14% of the participants discontinued due to pain or phantom pain related issues. Managing the pain and association to this is critical to the success of MDT. For the diabetic participants in this study, a positive result (success rate 58.3%) was returned. This shows that swift and highly selective removal of devitalised tissue can be beneficial for the diabetic patients.

The maggots used in this study was charged at SGD$120 per vial. On average, each participant would incur SGD$300 per MDT treatment. This was more expensive than minor surgical debridement performed at bedside. But it was much cheaper than a major surgical debridement conducted in an operating theatre.

Today, there are many types of sophisticated but expensive dressings. All such dressings could only work effectively on a wound bed containing minimal devitalised tissues (Falanga, 2000). Wound infection accounts for nearly 20% of all diabetes-related hospital admissions and is a major risk factor for non-traumatic amputation (Cornell, 2010). Antibiotics and surface applications with antimicrobials (for example, silver dressing) are some of the ways of dealing with infections on wounds. With antibiotic resistance on the rise and with the surface antimicrobial yielding mixed results, the mechanical removal of infected wound beds (for example, by biofilms) is paramount to successful clinical outcomes. MDT offers an alternative to wound care.

MDT does have limitations with *Pseudomonas spp.* infections on wound beds. The maggots will not consume these infection zones. It is therefore imperative to screen for *Pseudomonas* infections prior to MDT.

Conclusion

For effective wound healing to occur, the first step of "debridement" needs to be effectively done. It is vital for the chronic wound care industry to attempt to develop treatment modalities and paradigms that promote effective wound healing, reduce the spread of infection, and limit progression from wound development leading to lower extremity amputation. MDT could be an important tool for the debridement of chronic wound.

MDT is currently used as a "last resort" prior to an LLA, mainly because of its cost. In this study, MDT has shown to reduce the eventual LLA numbers. Using MDT earlier in the debridement cycle or as an alternative to surgical debridement, it could yield more successful clinical outcomes. Rigorous randomised controlled trials need to be conducted to ascertain the effectiveness of MDT.

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