Ultrasound-assisted wound debridement device

Wound debridement is an essential part of wound bed preparation, as it helps to remove non-viable tissue which can delay healing and act as a focus for infection. Many debridement techniques exist, all of which require varying levels of expertise and have their advantages and disadvantages in terms of time taken, expense, patient acceptability and ease of use. This article details low frequency ultrasound debridement, an easy to use and quick form of debridement, and presents several case reports of its use in clinical practice.

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Wound bed preparation
Debridement
Ultrasound
Sonoca®

It is now well known that wound bed preparation (WBP) offers clinicians a comprehensive approach to removing barriers to healing and stimulating the healing process. A key basic component of this is the removal of necrotic material and reduction of wound bioburden through tissue management.

Most chronic wounds commonly contain necrotic or compromised tissue, and its timely and effective removal is an important goal if healing is to occur.

Debridement takes away non-vascularised tissue and cells that may obstruct wound contraction, the formation of granulation tissue and the migration of epithelial cells from the wound edge (Falanga, 2000) to create a wound environment that promotes healing. The removal of this tissue should also reduce wound bioburden, thus discouraging the development of infection. Furthermore, the removal of foreign bodies and devascularised and necrotic tissue helps the clinician to assess the severity and depth of the ulcer by exposing undrained exudate, bone or tendon (Steed, 1998). Unlike acute wounds which usually only require debridement once, if at all, most chronic wounds will require repeated debridement (Falanga, 2004).

There are numerous methods reported in the literature for the debridement of wounds, including surgical, chemical, enzymatic, mechanical and biological techniques (Bradley et al, 1999).

Ultrasound debridement
Sonoca is recommended for ultrasonic-assisted wound treatment. This compact control unit is connected to an autoclavable, reusable handpiece that has a detachable cannulated titanium probe (sonotrode), the tip of which vibrates. The handpiece is connected to a gravity-fed saline drip that conducts the ultrasonic energy and lubricates the tip’s progress across the wound.

Figure 1. Sonoca-185 device (Söring).

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The control unit uses electrical input to generate a permanently set working frequency of 25kHz, which is transmitted to the handpiece—a transducer—where ceramic lead zirconate titanate discs generate the ultrasound waves and transfer them to the tip of the sonotrode. It is important to avoid contact of the vibrating sonotrode with metallic objects.

The sonotrode is activated by a foot pedal, and its amplitude can be adjusted on the control unit to increase or decrease debridement strength by using four pre-indexed amplitudes. The ultrasonic amplitude is ideally set at 80–100% (Breuing et al, 2005), but it is advisable to always start the treatment with a power setting of 40% on the unit and increase the power step by step depending on the patient’s comfort.

The irrigation fluid (sterile saline) acts as a coupling medium to transmit the sound waves from the sonotrode tip to the tissue.

The rate of drip of the saline is controlled on the intravenous (IV) tube, and a lever is present on the hand piece to start and stop the flow of saline.

When the oscillating ultrasound waves are transmitted through the saline coupling fluid, thousands of micro-sized gas-filled bubbles or cavities are created, which are visible as a mist.

As the tip is gently and continuously moved over the wound surface, the bubbles oscillate to create a shearing force against the tissue as the bubbles implode on contact (Tan, 2007).

The gas bubbles test the strength of each cell, and because necrotic tissue has less tensile strength than healthy tissue, the cavitations separate the non-viable proteinous material from the wound base (Torke, 2004). In this way, low-frequency ultrasound distinguishes between necrotic and healthy tissue. Only necrotic films, cell debris, biofilms and contamination are targeted, detached and rinsed away by the saline coupling fluid. Healthy tissue is not damaged in any way.

In addition to the non-thermal cavitation effects, low-frequency ultrasound also results in streaming; the uni-directional mechanical movement of fluids along the cell membrane as a result of the ultrasound pressure wave. Streaming results in altered cell membrane permeability which, in turn, may result in increased protein synthesis (Harvey et al, 1975; Webster et al, 1978), increased production of growth factors by macrophages (Young and Dyson, 1990) and degranulation of mast cells. The degranulation of mast cells releases histamine and other chemical mediators which attract neutrophils and monocytes, accelerating the acute inflammatory phase and promoting wound healing (Torke, 2004).

**Indications**

Ultrasonic-assisted wound treatment is indicated for use in leg ulcers of venous, arterial or mixed aetiology, diabetic foot ulcers, pressure ulcers, trauma wounds, burns, septic events in orthopaedic and trauma surgery and pre-operative wound preparation.

Sonoca uses three different handpieces, each with a uniquely shaped tip for accessing wounds with difficult topography and tunnels:

- Double ball indicated for use in wound cavities, such as pressure ulcers
- Hoof for superficial wounds
- Spatula for use in wound clefts, such as between the toes (Figure 2).

As the application results in fast and gentle removal of necrotic tissue, it is ideal as prep for negative pressure wound therapy (NPWT). Ultrasound can also be used in conjunction with hydroactive or conventional primary wound dressings.

The use of low or high frequency ultrasound is contraindicated in patients with neoplastic or haemorrhagic conditions, thrombophlebitis, tissue previously treated with radiation or over exposed spinal cord (Stanisic et al, 2005). Care should be taken with wounds where tendons and bones are exposed as treatment can be painful in these cases.

Practice protocol

Before using Sonoca, the clinician should wear protective personal equipment, including protective gown, gloves, shoes, face shield, etc (Figure 3), and the patient should wear a face mask during the procedure to prevent inhalation of aerosol mist and spreading of microbes, as recommended for the operation of all medical devices that create an aerosol vapour (Stanisic et al, 2005).

It is recommended that all wounds should be treated for 20 seconds per cm² (Breuing et al, 2005). The handset should be constantly moved during treatment.

Figure 2. Different handpieces for use with the Sonoca device.

Figure 3. Protective clothing should be used during a procedure with Sonoca to prevent inhalation of aerosol mist.
Evidence for use
Low pain wound cleaning
Ultrasonic-assisted wound debridement is a relatively painless method of removing non-viable tissue, fibrotic debris and biofilm from the wound bed (Torke, 2004; Breuing, 2005). Thus, it can be a useful debridement technique for patients who cannot tolerate or refuse sharp debridement since, in addition to reduced pain, there are also shorter treatment times which may increase compliance and patient tolerance.

In a study of 15 patients with 22 recalcitrant chronic wounds and severe morbidity, Schulze et al (2000) reported that ultrasound debridement was carried out at a low pain level in most cases, resulting in a high level of patient compliance and wound healing.

In addition to low levels of pain, ultrasound has a positive effect on wound healing.

Wound healing effects
Dyson et al (1976) reported a significant improvement in wound healing in a controlled trial of 25 patients with venous leg ulcers where ultrasound was compared with placebo therapy.

Peschen et al (1997) used ultrasound to treat patients with venous leg ulcers. Results showed a significant difference in healing with a 40% improvement in the wounds of the group treated with ultrasound compared with control.

A study by Tan et al (2007) evaluated the use of a low frequency ultrasound device in the debridement of 19 patients with leg ulceration of at least six months duration, who had previously been treated with compression which continued throughout the study. Patients were treated with 25kHz delivered with the portable Sonoca-180 handheld probe using saline as an irrigation/coupling medium for 10-20 seconds. Results showed symptomatic relief (pain and odour) in six patients and ulcer healing in seven patients. Eight patients remained the same, and the researchers concluded that ultrasound may help to heal recalcitrant ulcers in patients where compression therapy has failed, and may achieve symptomatic relief in others.

Stanisic et al (2005) reported on the successful use of ultrasound (25kHz device) to achieve rapid and thorough debridement of fibrin from wound surfaces, without macroscopic evidence of harm to tissue and no discomfort to patients with sacral pressure ulcers and leg ulcers.

Eldridge and Gleaves (2005) demonstrated successful use of ultrasound in a patient with warfarin-induced skin necrosis, for which cessation of warfarin therapy and surgical sharp debridement, as usually indicated, could have been disastrous. Debridement was carried out with minimal damage to normal tissues, with no obvious bleeding occurring and a marked cosmetic improvement of the wound.

A randomised, controlled trial by Singh (2006) compared the use of ultrasound debridement with bedside sharp debridement in 59 patients with 60 ulcers, Wagners grade 1 and 2. The study found that ultrasound significantly increased the healing rate of recalcitrant, Wagners 1 and 2 diabetic foot ulcers, reduced the size of the ulcers and decreased the pain experienced by patients during debridement.

Antibacterial effects
Low frequency ultrasound-assisted wound debridement can be used to rapidly reduce the bioburden of the wound bed.

Several studies have demonstrated its ability to completely or partially eradicate bacteria, including common but particularly difficult to remove species such as Staphylococcus aureus, Streptococcus pyogenes, Pseudomonas aeruginosa.

An experimental study by Niezgoda and Schulze (2003) used four bacterial strains, S. aureus, S. pyogenes, P. aeruginosa, and Escherichio coel to create two wound models; a deep tunnelling wound and a superficial wound. When ultrasound was applied, 15 of the 16 superficial wound bacterial plates were sterilised, while the deep wound model showed a tenfold decrease in bacterial concentration after 60 seconds.

The bacterial effect of ultrasonic assisted wound treatment, based upon the cavitation effect, provides successful infection cleansing and thoroughly eliminates biofilm.

Pierson et al (2005) isolated 25 highly antibiotic-resistant Acinetobacter spp (primarily Acinetobacter baumannii) from wounded soldiers returning from Iraq. The use of ultrasound significantly reduced A. baumannii colony counts, as well as counts of S. aureus, S. pyogenes and E. coli.

The following case reports demonstrate the use of Sonoca-185 for the treatment of longstanding wounds.

Case reports
The Sonoca ultrasound device was used on six patients in a department of tissue viability in a secondary care setting and a diabetic podiatry department in a primary care setting.

Case report one
A 75-year-old male presented with a three-year-old sacral pressure ulcer, with a history of recurrent infection and delayed healing. The ulcer had previously been much larger and was originally graded 4. However, the base of the wound had remained constant with bone exposed. The ulcer measured 3.5x4.0cm at its aperture, leading into two undermined aspects.

First review
On examination, the presence of bone was evident in the base of the wound and the wound was producing large volumes of exudate and was covered with a thin film of slough with maceration at the wound margins (Figure 4). The wound was treated with the Sonoca-185 at 80% for 10 minutes each day for five days, with a silver alginate dressing to pack the wound. This dressing had been used in the weeks before treatment with ultrasound.

Final review (after five ultrasound treatments)
Although the dimensions of the wound had not altered (Figure 5), on examination...
daily treatments, not something that the practitioners would regularly do with this system. However, in such a protracted case, it seemed justified and the development of new granulation tissue provides hope for the future outcome of this patient.

Case report two
In this case, an 82-year-old male with a grade 4 pressure ulcer to the right heel, with chronic obstructive pulmonary disease (COPD), presented to the tissue viability department. The heel ulcer measured 6x4.5cm.

First review and treatment
The heel was found to be non-infected, with what appeared to be a 2–3mm layer of slough covering the underlying bone and wound bed (Figure 6). The wound was treated for five minutes with Sonoca-185 at 60%, which was stopped once the underlying structures had been revealed. A lighter application was used across the exposed structures. Minimal bleeding was observed and the patient did not report any pain during the procedure. The clinicians decided that following this procedure, the patient would be treated with a hydrogel and foam heel dressing to facilitate further debridement. The heel protracted in a Repose heel protector.

Conclusion
In this case the layer of slough was quickly removed, with no significant bleeding or reports of pain. The treatment allowed exposure of the underlying structures.

Case report three
An 86-year-old male with longstanding health problems presented with a grade 4 pressure ulcer to his left heel, which had previously been treated with a hydrogel and foam heel dressing (Figure 8). This regimen had reduced the bulk of slough and necrosis. The wound measured 4.5x3.5cm at initial presentation.

First review and treatment
The wound was treated for five minutes with Sonoca-185 at 60% power, which was stopped once the underlying structures had been revealed. A lighter application was used across the exposed structures. Following treatment it was possible to observe the tendons, but there was no evidence of underlying bone or damage to the tendons (Figure 9). The wound bed was exposed and the patient returned to his previous station.

Conclusion
This patient's sacral pressure ulcer had been present for many years and had resisted various treatments including NPWT and antimicrobial agents to promote healing. Following treatment with low-frequency ultrasound technology, granulation tissue formed across the wound bed. This was confirmed by physical examination and X-ray. However, the wound remains a clinical challenge and active treatment continues. In this case, the aim was to re-balance the wound bioburden and promote granulation tissue growth. This required...
treatment, including a Repose heel protector.

**Case report four**

On admission, this 75-year-old female with breast cancer and general ill health presented with a developing sacral pressure ulcer. After two weeks the ulcer had demarcated and appeared ready for debridement. The wound measured 6x6.5cm before debridement (Figure 10).

**First review and treatment**

Sonoca-185 was used at 40% for four minutes to establish an edge at the perimeter of the wound where the slough was superficial. However, it became evident that progress would be slow and that the use of a scalpel and forceps would facilitate debridement more quickly. This was undertaken and a large undermining cavity was exposed (Figure 11). The edges of the wound were left undisturbed as the patient had become uncomfortable on her side. The wound was filled with silver sulfadiazine cream, with a non-adherent dressing to reduce the bacterial load and facilitate autolytic debridement.

**Conclusion**

In this case, the Sonoca-185 device successfully established separation at the wound margin, but the size of the wound and the need for speed meant that using a scalpel and forceps was a more efficient method of debridement.

**Case report five**

In this case, an 86-year-old male with general poor health, who was awaiting transfer to a medical rehabilitation ward, presented to the diabetic foot ulcer clinic post debridement by the orthopaedic department to treat a deep-seated spreading infection. The patient was suffering from diabetic peripheral neuropathy but did have palpable pulses.

**First review and treatment**

The heel wound was treated for five minutes using Sonoca-185 at 60%, which was stopped once the underlying structures had been revealed. A lighter application was used across the exposed structures. There was minimal bleeding and the exposed bone was not damaged (Figure 13).

**Conclusion**

The slough was reduced across the wound bed and no damage was done to the exposed bone.

**Case report six**

A 44-year-old male with type 1 diabetes, no previous history of ulceration and who was unknown to the podiatry department, presented to the diabetic foot ulcer clinic post debridement by the orthopaedic department to treat a deep-seated spreading infection. The patient was suffering from diabetic peripheral neuropathy but did have palpable pulses.

**First review and treatment**

The wound was dressed with Aquacel® Ag (Convatec), Mepilex® foam (Mölnlycke Health Care), latex, crepe bandages and Comfi-Fit®, with a forefoot pressure relief shoe. The patient was also provided with a Seal-Tight dressing protector to prevent the dressing from becoming wet during baths or showers.

**Conclusion**

After debridement with the Sonoca device, the wound was cleaner with less slough present and is continuing to heal with no further signs of infection (Figures 14 and 15).

**Discussion**

Both authors have had extensive experience with wound debridement using sharp, hydrotherapy, larval and autolytic debridement techniques before using Sonoca-185. The authors received tuition in the use of the technology, with practice on simulated tissue, as well as face-to-face support before undertaking
The patient, environment and user are required when using the Sonoca-185 device. The small head size of the tool facilitated its use in small/medium wounds, but this was not beneficial in the large sacral wound, where sharp debridement was used and hydrodurgery or larval therapy could have been used.

The Sonoca ultrasound device is probably best suited to the specialist nurse or podiatrist, who is regularly in contact with wounds which benefit from rapid removal of slough. Further clinical audit/research is needed to inform the specialist practitioner of the potential of this ultrasound-assisted wound debridement method.

References