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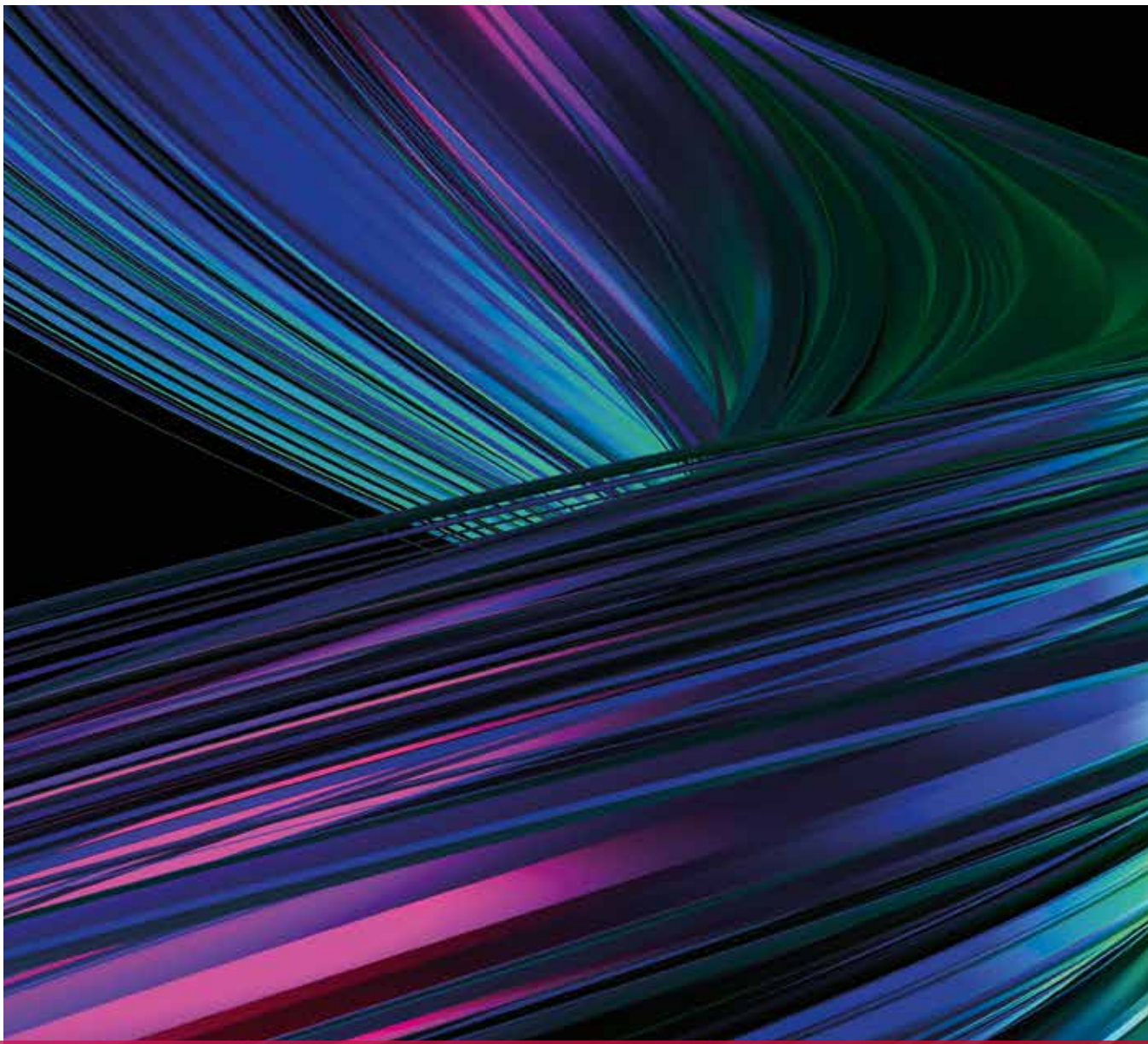

Addressing the challenges of open wounds with single-use NPWT

Avelle NPWT System: optimising the wound bed with Hydrofiber technology and a 30-day NPWT pump

Contents

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Declaration of interest

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Foreword

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In the UK and Europe, there has been a significant shift in the provision of specialist care, including wound management, from acute to community settings, including the patient's home. Hastened by the COVID-19 pandemic, this is largely due to demographic changes, with an associated increase in morbidity and thus the number of hard-to-heal (chronic) wounds, which are now being managed in community (primary) healthcare settings.

The traditional (larger) versions of negative pressure wound therapy (NPWT), a management system that converts an open wound to a closed wound, have been widely accepted as an advanced therapy for some years now. Nonetheless, anecdotal evidence indicates that use of the smaller, portable and single-use NPWT systems introduced more recently, is not so well established, and that they have mostly been adopted by health professionals who have been using NPWT for a long time, are confident in their use, or are supported with ongoing education in areas where these devices are advocated or prescribed for wound management.

Nevertheless, during the past two decades, the use of all types of NPWT, with and without canisters, has increased in the community, where, following a holistic patient assessment, the therapy has been applied to an increasing variety of wound types.[1] The prophylactic use of single-use NPWT devices without a canister, such as Avelle NPWT System (ConvaTec), has, in the author's experience, increased to continue post-discharge as part of a care strategy to minimise the risk of wound infection, surgical site infection (SSI) and dehiscence (breakdown).

By minimising the risk of postoperative wound dehiscence, for example in caesarean sections, single-use devices enable earlier discharge of hospitalised patients, with associated cost savings.[2] Other advantages are that they can improve the wound-healing environment and associated symptomatology, allow better utilisation of hospital beds, increase healing rates and reduce hospital readmissions.[3]

These smaller single-use NPWT systems are more accessible to all health professionals and can be used, with training, by all qualified staff, not just specialists. They can also be operated by patients, under the supervision of a health professional, who have sufficient manual dexterity to do so. These smaller devices are well accepted by patients, as they are small, discreet (can easily be hidden by clothing) and quiet during use. Patients have reported that their use improved aspects of their quality of life, such as mobility, social interactions and sleep.[3]

This supplement overviews NPWT and its mode of action, and presents an evidence-based case for its use on acute and hard-to-heal wounds, particularly in community settings, with a flowchart that can be adapted to suit local needs. The focus is on the 30-day single-use Avelle NPWT System, which is designed to improve the accuracy of exudate assessment and thus avoid unnecessary dressing changes. The cases presented here show it can be safely used on a variety of wound types, including those with fragile periwound skin, as well as with compression therapy. The authors demonstrate how it can help stabilise and improve graft take and accelerate healing in slow or hard-to-heal wounds. Health professionals present clinical insights and case studies on how they have used Avelle to its best effect to improve outcomes. There is also a short section with patient information on the device.

Based on the information presented here, there is a clear need for more community-based health professionals to consider the use of smaller single-use NPWT devices, in collaboration with patients and their family/carer, at an earlier stage in the care pathway when indicated. Not only can this improve patient quality of life and wound outcomes, but it can also achieve health-service cost savings.

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Single-use negative pressure wound therapy: benefits for hard-to-heal wounds

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Use of negative pressure wound therapy (NPWT) is well established in the acute setting. However, there is increasing clinical data on its effectiveness on hard-to-heal wounds, which means that there is a place for it in the community, including the patient's home. Traditional NPWT devices are too large and cumbersome to be used to best effect in this setting, for which the smaller, portable, single-use devices are better suited. This article describes how to maximise use of these smaller devices in the community

Negative pressure wound therapy (NPWT) has been used successfully in both primary (community) and secondary settings since the 1990s. Both the concept of NPWT and its therapy-delivery units have evolved since then for the benefit of a range of patients of all ages with wounds—acute and hard-to-heal (chronic)—in all settings.[1]

During the past two decades, the use of NPWT has increased significantly in primary care for several reasons. One of the risk factors for hard-to-heal wounds is older age.[2] Given the increase in the ageing population throughout Europe,[3,4] the requirement for NPWT is likely to increase, in part due to the need to manage excess exudate and thus correct any moisture imbalance within the wound margins, but also to reduce the tissue oedema often observed adjacent to these wounds on the lower limb.[5]

The increasing number of wounds being treated in the community is incurring higher costs there. In the UK, the 85+ age group is set to double to 3.2 million by mid-2041 and treble by 2066 to 5.1 million (7% of the population).[4] In the EU-27, it is projected that there will be close to half a million centenarians by 2050.[3] In the UK, a key recommendation of the NHS Long Term Plan is for more patients to be cared for in primary rather than secondary settings.[6] This aim was reflected in the 2020 NHS Strategy document.[7] The health economic burden incurred by wound care in the community has increased. Guest et al. calculated that, in 2017/2018, 3.8 million people with wounds were managed in the NHS in the UK, with an annual cost of £8.3 billion, of which £6.8 billion was spent in the community, mostly on hard-to-heal wounds.[8]

Consequences of the increasing shift in provision of wound management to the community setting include the promotion of more supported patient self-care, possibly hastened by the COVID-19 pandemic,[9] and the adoption of more advanced therapies, such as NPWT, for the complex wounds being treated there.[6]

The European Wound Management Association (EWMA) has defined advanced therapies as those based on novel principles or technologies with a range of modes of action supported by comparative evidence.[10] Modern 'interactive' wound management dressings have been defined as, 'materials that help to create/maintain the optimum wound healing environment'.[11]

It can, therefore, be argued that all health professionals must be familiar, not only with modern 'interactive' wound management products, but also advanced 'active' therapies, such as NPWT (all versions: large, portable and single use). Similarly, all health professionals have a responsibility to ensure their wound-care practice is not only clinically up to date and effective, but also cost-effective.

Development

The traditional modern NPWT systems, pioneered by Argenta and Morykwas,[12] were first brought to market in 1995. They applied a mechanical vacuum, delivered through a polyurethane (PU) foam filler that covered the wound surface.

This development was followed by NPWT devices with instillation and then smaller portable versions of the NPWT technology described above. Since then, a variety of portable, and latterly, single-use NPWT systems have been launched.

More recently, many of the small, single-use NPWT devices have replaced exudate canisters, wound fillers and securing film membranes with wound management dressing materials (interfaces) such as foam or Hydrofiber (ConvaTec)-based products, which are attached to the device/pump via a connection tube. The main difference between PU foam and Hydrofiber relates to their ingredients and composition: Hydrofiber (sodium carboxymethylcellulose) has additional stitched fibres that increase its tensile strength, and it gels when in contact with exudate to absorb excess wound fluid and thus maintain a warm (37°C) moist environment.[13] Both foam and Hydrofiber are designed to protect the periwound skin.[14] These single-use systems are, therefore, particularly suited to managing low to moderately exuding wounds.

How negative pressure wound therapy works

NPWT has been defined as 'wound dressing systems that continuously or intermittently apply sub-atmospheric pressure to the surface of a wound to assist healing'.[15] The mechanisms of action of NPWT are summarised in Table 1.

Wound-volume reduction

Deformation of the cells under NPWT can help reduce the wound volume. Macro-deformation is the term used to describe the force exerted on the entirety of a wound's surface when suction is directed from the pressure-controlled device through a wound interface/dressing. It has been postulated that, when cells are sufficiently stretched, they tend to divide and proliferate.[16] Macro-deformation has been shown to promote a tissue-shearing force at the wound-dressing interface that encourages wound contraction.[17]

Mechanical tissue deformation also stimulates the expression of angiogenic growth factors and receptors, such as vascular endothelial growth factor (VEGF), VEGF receptors and the angiopoietin system receptors.[18,19] It will also result in increased fluid flow within the spaces of the tissue matrix.[20] Mechanical stress also promotes the production of extracellular matrix (ECM) components such as collagen, elastin, proteoglycans and glycosaminoglycans.[19,21]

Table 1. Summary of the mechanisms of action of negative pressure wound therapy systems (based on Apelqvist et al.)[23]

Wound retraction/volume reduction
The negative pressure acts on the wound filler, which pulls together the edges of the wound, reducing the surface area. This accelerates healing
Stimulation of granulation tissue formation
Granulation tissue forms in the moist wound environment, including over tendon and bone. This improves wound healing rates
Reduction in proteases
Removal of excess wound exudate results in the reduction of proteases, such as elastase, within the wound margins. This enhances the potential for healing
Continuous removal of excess wound exudate
This converts an open wound into a closed wound, resulting in fewer dressing changes than would be required with traditional dressings
Effective mechanical wound cleansing
• Removal of small tissue debris by suction minimises the risk of slough or necrotic tissue forming within the wound margins. • Pressure-related reduction of interstitial oedema. This leads to an improvement in microcirculation, as well as stimulation of blood flow and oxygenation
Dressing interface prevents ingress of bacteria and seals the wound
This prevents entry of external bacteria and the spread of the patient's own wound bacteria to the external environment. The wound can be continually monitored when a transparent dressing, such as a film membrane, is used to seal the wound

Removal of excess exudate and stimulation of blood flow

The prevention and reduction of periwound oedema, such as that related to the inflammatory response, has been linked to the removal of excess exudate and stimulation of blood flow.[22] Oedema increases pressure in wound tissue, which compromises microvascular blood flow, reducing the inflow of lymphocytes (white blood cells), nutrients and oxygen to the site. This compromised microvascular blood flow reduces resistance to infection as lymphocytes are forced to move towards the endothelium of the vessels instead of flowing freely through them; if the inflammatory response is prolonged, this can inhibit healing.[22] Some of the excess fluid associated with the inflammatory response and periwound oedema will manifest as increased exudate. To facilitate wound healing, it is important to reduce tissue oedema.[23]

NPWT compresses the tissues closest to the wound surface,[24] which is believed to reduce interstitial

oedema. Although there are few published studies on this subject, there is widespread agreement among health professionals that NPWT eliminates tissue oedema.[12,24] There is some supporting evidence. NPWT has been reported to increase perfusion and reduce oedema in patients with bilateral hand burns.[25] High-frequency ultrasound has been used to quantify the reduction of oedema in periwound tissue in a small group of pressure ulcer (PU) patients receiving NPWT: it reduced by 43% after 4 days.[26] It has been argued that oedema and exudate levels are reduced directly through mechanical removal of excess fluid and indirectly via the altered microcirculation that occurs following application of NPWT.[23]

Wound fillers

The larger NPWT devices use interface materials, such as foam and gauze, with compressible open porous properties to fill the wound, although their features, such as pore size and stability, will vary.[23] The choice of wound filler can have a considerable influence on the healing process.[23] For example, the reported increase in blood flow associated with the use of NPWT was noted to be similar with all wound fillers, but wound contraction was more pronounced with foam than gauze.[27] Health professionals using NPWT devices, therefore, need to be aware of some technical considerations when applying NPWT wound fillers.

Polyurethane foam

PU is the most widely used type of wound filler. It was first introduced in 1997 in black (pore size: 400–600µm) and then in 1998 in white (pore size: 60–1500µm). The black foam is hydrophobic, whereas the white foam has hydrophilic properties and so can hold moisture. White foam can be used over structures such as tendon, bone and hardware.

Polyvinyl alcohol foam

Polyvinyl alcohol (PVA) foams have been reported to form a fairly strong mechanical bond with the wound tissue after approximately 3–4 days, due to the ingrowth of granulation tissue.[23]

Gauze

The gauze used for this purpose has a spiral shape and is impregnated with polyhexanide biguanide (PHMB) (0.2%). Fraccalvieri et al. reported that its use with NPWT increased revascularisation, as the reduction in scar tissue was accompanied by increased formation of new mini vessels, which leads to the restoration of the physiological condition.[28]

However, in wounds with a very dry wound bed, pressure distribution within the wound bed is similar for both gauze and foam, with the differences in performance between the two interface materials relating to the structure of the material and its mechanical effects on the wound.[29]

When using gauze on a wet wound, a perforated drainage tube needs to be inserted into the wound filler to apply a good pressure transduction to the wound bed.[27]

Selection

When selecting an NPWT filler, the morphology of the wound, the wound characteristics, patient feedback, the presence or a patient's risk of infection and scar-tissue formation should be considered[23] and the manufacturer's instructions consulted.

The ideal negative pressure

There is general agreement that a clinically effective range of negative pressure is between –50mmHg and –150mmHg.[23,30] However, the debate on what constitutes the optimal level of negative pressure for clinical use continues in the literature.[23]

Initially, with reference to NPWT in a secondary healthcare setting, Morykwas et al.[31] suggested that a suction level of –125mmHg is optimal for new tissue formation and wound cleansing. However, certain factors will affect the pressure applied. Pressure distribution into the wound is dependent on the wound filler coming into direct contact with the wound tissue; tissue that is not in contact with the wound filler will not be subject to the suction force.[32] Use of a wound contact layer, such as a soft silicone dressing, as an interface between the wound filler and friable wound tissues, to minimise the risk of the filler adhering to the wound bed and causing bleeding on removal, has been noted to slightly lower the level of negative pressure delivered to the wound.[33] However, the author and others[33] have observed that the level of negative pressure can be adjusted in various clinical circumstances without adversely affecting the healing outcome. For example, an NPWT system's default negative pressure can be increased when profuse or unanticipated excess exudate levels are encountered, patients experience pain associated with the use of the chosen NPWT device or there is poor circulation (both superficial and deep) to the wounded tissues.[23,34]

Traditional (large) NPWT systems use an electrically powered pump to generate negative pressure at the wound bed. Developments since 2010 have led to the introduction of portable and, more recently, single-use devices that deliver NPWT that do not require mains

power supply. These smaller, lightweight, single-use devices are mechanically (they incorporate specialised springs) or battery powered and generate continuous sub-atmospheric pressures of between –75mmHg and –125mmHg to the wound bed. When used on smaller or closed wounds, mechanically/battery powered systems have been reported to show similar efficacy and biomechanical properties, functional wound-healing benefits, ease of use and acceptability to health professionals and patients alike, when compared with electrically powered NPWT systems.[35]

In brief, there is clear evidence that suggests both high and low levels of suction within a range of -75mmHg to -125mmHg will induce macro-deformation and are clinically effective, with the level selected depending on the device, the patient and the wound characteristics.[23]

Implementation

The first step of implementation is a holistic patient assessment to determine that the wound and care environment are suitable and safe for the chosen wound management device.[36] The principle underpinning systematic wound assessment is to assess the whole of the patient and not just the hole in the patient. Therefore, assessment should consider the patient's medical history (including their current and past medical conditions); their psychological, social and spiritual history; their physical condition, including the characteristics of the wound bed, edges and surrounding skin (noting any previous wound-management regimens); and their access to specialised health services for the management of their medical condition and any ongoing wound-care needs. Full details are available elsewhere.[37]

NPWT should be given as part of an agreed wound management plan that has been discussed with the patient and/or their carer. As NPWT is expected to create or enhance a moist wound environment, alleviate wound symptoms, improve the condition of the wound bed, potentially reduce the bacterial burden within the wound margins and reduce the wound dimensions (Table 2), it is important to regularly reassess whether its use is still required.

Issues related to the unsuccessful implementation of NPWT in community settings include untimely patient referrals for NPWT to the community service/tissue viability lead responsible for agreeing funding, lack of training for staff and patients, complicated funding pathways, a lack of coordination between secondary and primary care, and delayed initiation of therapy.[38] Therefore, the implementation process for NPWT needs to be evidence-based, consistent and agreed across organisational boundaries.[39]

Table 2. How negative pressure wound therapy promotes healing

Moist wound healing
NPWT helps address the effects of excess chronic wound exudate, which contains higher levels of pro-inflammatory cytokines and lower levels of growth factors than acute wound exudate,[65] by removing excess fluid to promote a moisture balance in the wound margins.[23]
Reducing bacterial burden
The ongoing debate about the effect of NPWT on the bacterial burden within the wound margins has been summarised previously.[23] Apelqvist et al. reported that, as the adhesive drape/securing wound management material provides a barrier against secondary infection from an external source, NPWT will further reduce the bacterial load in the wound. Furthermore, a reduction of the wound infection rate and the degree of bacterial load has been described as a secondary endpoint.[23]
Wound contraction
NPWT mechanically produces a suction pressure on the wound edges that pushes onto the wound and initiates contraction.[12,31] The mechanical effects precipitate tissue remodelling, which can facilitate wound closure.[66]

Maximising use

In the author's experience, NPWT devices/pumps were first used on acute wounds, primarily large, open or heavily exuding lesions. However, there is a growing body of evidence supporting the use of NPWT on both acute and hard-to-heal wounds.[35,40,41]

The large, traditional NPWT devices usually need to be carried by the patient or are attached to an infusion stand with wheels that the patient moves when mobilising; on occasion, this can adversely affect the physical domain of the patient's health-related quality of life (HRQoL), sometimes so severely that the therapy has to be discontinued.[42,43] Use of large NPWT devices has been reported to impair psychological aspects of patients' HRQoL, such as sleep patterns, resulting in a feeling of increased stress for some.[44]

Since the introduction of the portable and single-use NPWT systems in the community, increasing numbers of patients with hard-to-heal, complex (non-healing) or at-risk wounds have been treated at home with the therapy.[38] This has been reported to facilitate earlier discharge of hospitalised patients,[45] with associated cost savings.[2] Other benefits for the healthcare system are improvements in wound symptomatology, an improved wound-healing environment, better utilisation of hospital beds, higher healing rates and a reduction in hospital readmission rates.[23,46,47] The main indications for NPWT are listed in Table 3.

In the UK, it is now much easier to order portable NPWT devices systems before a patient's planned hospital discharge date as the consumables are available on FP10 (UK reimbursement system for devices prescribed in the community), supporting their

Table 3. Summary of the main clinical indications for NPWT (based on Collier 2003; Gleeson and Bond 2013)[22,51]

Traumatic wounds
Traumatic: ● Usually, to convert an open to a closed wound ● Management of excess exudate
Acute burns and scalds
Postoperative wounds
Orthopaedic: ● Periprosthetic infections of the hip and knee joint ● Treatment of osteomyelitis and surgical site infection; ● Exposed tendon, bone and hardware
Plastic and reconstructive surgery: ● Abdominal surgery: direct fascial closure and hernia repair
Post-cardiovascular and vascular surgery: ● Treatment of infected blood vessels ● Vascular grafts ● Lymphocutaneous fistulas
To reduce the number of days in intensive care, the length of hospital stay and mortality associated with surgical interventions
Hard-to-heal wounds
To stimulate or restart the healing process: for use in all healthcare settings and specialist wound centres or clinics, such as leg ulcer, pressure ulcer and diabetic foot ulcer clinics
Prophylactically, to minimise the risk of surgical site infection, wound breakdown and/or readmission to secondary care:[67] relevant to both secondary and primary care healthcare settings, as well as any post-surgical wound assessed as suitable for management in a non-acute care setting, further to a comprehensive discussion about the patient between relevant staff before discharge

smooth transition from a secondary to a primary care setting.[45] Despite this, pressures on prescribing budgets might still, in some cases, inhibit the use of NPWT in primary healthcare settings.

Arguably, single-use NPWT devices are being increasingly used, particularly in the community, because they are small, discreet, simple to use and can be operated by the patient if they have sufficient manual dexterity. They also do not hinder socialising with family and friends. An individual's ability to self-manage is linked to their sense of empowerment or personal strength.[48] This can help promote patients' general health and wellbeing, which increases self-efficacy.[49] Finally, single-use NPWT devices, with their intuitive function, convenience and ease of use, are designed to support patient mobility and increase patient involvement, while remaining both clinically and cost-effective.[50,51] A comparison of three single-use NPWT systems is given in Table 4.

Use on hard-to-heal wounds

Venous leg ulcers

The most reported hard-to-heal wounds are venous leg ulcers (VLUs).[2] The gold standard treatment for VLUs is compression therapy,[52] which is predominately delivered in primary healthcare settings. However, leg ulcers have a high tendency to recur,[23] as they are often not assessed properly (for example, with Doppler ultrasound). Wide variations in practice have been reported, including in the use of compression therapy, which is not always applied in a timely manner.[53] In the UK, the National Wound Care Strategy Programme recommendations for the lower limb aim to address these issues and standardise care (www.nationalwoundcarestrategy.net/lower-limb).

NPWT was quickly used for symptoms associated with hard-to-heal leg ulcers (LUs), such as the management of excess exudate, including the large amounts produced by recurrent or long-established superficial non-healing LUs,[23] and to reduce the high interstitial pressure caused by chronic oedema.[26] Case studies and publications have suggested that NPWT improves LU symptomatology, enabling earlier use of interactive dressings.[50,54,55] However, there remains a lack of high-quality evidence to support the use of NPWT in the management of all LUs. A Cochrane systematic review concluded there is limited evidence on the clinical effectiveness of therapy for the treatment LUs.[56] More research is required.

Pressure ulcers

A Cochrane review concluded that use of NPWT to manage PUs is not supported by 'sufficient evidence', and there is still some uncertainty among health professionals about its effectiveness for this indication.[57] Nevertheless, NPWT is increasingly being used in PU management pathways in all settings, primarily due to its flexibility.[23] It has been reported that it is effective in cleansing and managing exudate in this wound type,[58] with associated cost savings, due to a reduction in dressing-change frequency and nursing time, when compared with similar patients managed with traditional dressings.[59]

Diabetic foot ulcers

NPWT can be an important adjuvant therapy for the management of diabetic foot ulcers (DFUs) and its use for that indication is increasing, particularly by diabetologists and diabetic nurse specialists.[23] A Cochrane systematic review concluded that 'there is low certainty evidence to suggest that NPWT reduces the time to healing or increases the proportion of wounds healed, for postoperative foot wounds and DFUs when compared with wound dressings'.[60] However, NICE recommended that 'NPWT should be considered after surgical debridement for DFUs, on

Table 4. Comparison of three single-use negative pressure wound therapy systems

Device characteristics	Negative pressure achieved in use	Patient friendliness	Wound interface	Maximum pump use	Best evidence
PICO (Smith and Nephew)	-80mmHg	Yes: small, quiet, easy to use and comfortable to wear	Combination of silicone adhesive layer, superabsorbent core and top film layer	14 days	Multiple publications including RCTs and observational studies; NICE Medical Technologies Guidance[68]
SNAP (3M/KCl)	Presets of -75, -100 and -125mmHg	Yes: small, quiet, easy to use and comfortable to wear	Foam interface-hydrocolloid seal	3–7 days, depending on the selected preset (can be 'recharged' manually multiple times as required due to the proprietary spring mechanism that generates consistent, even levels of negative pressure)	Two published RCTs and multiple case studies
AVELLE (ConvaTec)	-80mmHg ± -20mmHg	Yes: small, quiet, easy to use and comfortable to wear	Hydrofiber technology	30 days	Eight general subject papers referred to and multiple case studies

NICE: National Institute for Health and Care Excellence; RCT—randomised controlled trial
Note: the above information is taken from relevant company websites; for indications, refer to the manufacturer's instructions for use

the advice of the multidisciplinary foot care service.[61] The findings of a meta-analysis of 11 randomised controlled trials (RCTs) 'supports the use of NPWT in the treatment of DFUs and post-operative wounds in diabetic patients', while acknowledging that more robust RCT evidence is needed to substantiate this.[62] Nevertheless, its conclusion also informed the latest SIGN Management of Diabetes Guideline.[63]

More recently, Borys et al.[1] concluded that, 'NPWT is a safe treatment for neuropathic, non-ischemic, and noninfected DFU in patients with type 2 diabetes mellitus', and Bishop reported benefits, including increased perfusion and reduction of oedema, when NPWT is used as part of the overall care package for these patients, provided the wound bed is prepared properly and there is support from the foot care team.[64]

Benefits

The cost of advanced therapies may seem high. It has been suggested that an expensive therapy can be defined as one that does not work, cannot achieve the clinical goal or is inappropriate for the patient. This will prolong healing, reduce patient adherence to treatment and, potentially, have adverse outcomes. Advanced treatments are not expensive when used appropriately.[2] The benefits of single-use NPWT systems for primary healthcare settings are given in Box 1. The overall benefits of NPWT are summarised in Box 2.

Box 1. Benefits of single-use negative pressure wound therapy in primary settings

- Small and portable
- Lightweight and single use: individual units can be used for between 7 and 30 days*
- Quiet and discreet (can be hidden under clothing, depending on the wound site)
- Intuitive and easy to use
- Reported to improve a patient's quality of life
- Minimises the negative impact on a patient's 'normal' activities of daily living
- Clinically and cost effective

** Refer to relevant manufacturer's instructions*

Box 2. Additional reported benefits of the use of negative pressure wound therapy in all settings

- Reduction in wound dressing costs by improving outcomes and reducing the need for interactive wound dressings
- Improved healing outcomes, with reduction in wound size and accelerated wound healing, and more effective management of symptomatology, such as exudate control[67]
- Facilitation of earlier patient discharge from secondary healthcare settings[67]
- Negligible administration costs (single-use pump systems can be prescribed, so no need to transfer funding costs between organisations)[51]

Fig 1. Flowchart: initiating negative pressure wound therapy in primary healthcare settings as part of a wound management pathway

1. Has the patient (also involve next of kin or carer):
- been assessed using a systematic and holistic assessment process (this should include the periwound skin)
- been referred for care that involves the multidisciplinary team
- been referred to a specialist unit or complex wound clinic in either a primary or secondary healthcare setting
- been identified as at risk of surgical site infection (SSI) or had an SSI previously
- collaborated in the development of their treatment goals and are they aware of and in agreement with their wound management plan? This may include some of the following treatment objectives:
  - Manage excess exudate and/or reduce interstitial oedema
  - Reduce the number of dressing changes required
  - Minimise any potential pain at dressing change
  - Decrease the wound size (dimensions and volume)
  - Optimise the wound-healing environment and, therefore, the patient's wound-healing potential
  - Promote formation of granulation tissue
  - Protect against external contamination
  - Promote an enhanced quality of life
  - Promote cost benefits for the healthcare setting
- has the manual dexterity to operate the chosen negative pressure wound therapy (NPWT) system and is able to self-care (undertake a risk assessment, if appropriate)

NO → Consider alternative management plan

YES

2. Ensure that the patient's wound:
- is indicated for this therapy, as outlined in the manufacturer's instructions for use and the local NPWT guidelines; for example, that it is a:
  - surgically closed incision, where the aim is to prevent dehiscence
  - subacute and dehisced wound, such as a post-caesarean section
  - ongoing acute or traumatic wound management post-hospital discharge, where the aim is to continue to manage the symptomatology, minimise risk and optimise the patient's wound-healing potential
  - hard-to-heal wound, such as a venous, pressure or diabetic foot ulcer
  - flap or skin graft (preparation or management) pre- and/or postoperative
  - traumatic wound
- fits comfortably within the chosen wound management pad/dressing area and that the port can be appropriately positioned

NO → Consider alternative management plan

YES

3. Has the patient been given information in a format they are happy with so that they:
- understand the need to be adherent to the therapy
- can operate the chosen NPWT system?
- can recognise if they have a problem with either their wound or the NPWT system, and know how to report it

YES

When clinically indicated, apply the NPWT system in accordance with the manufacturer's application guidelines and tips for best practice

NO →

Review and re-assess:
- Change the wound dressing as indicated by the manufacturer's guidance or as clinically dictated, monitor the exudate level and assess for the presence of infection
- Check the patient's periwound skin
- If a wound filler has been used, change the filler and dressing securement (the film membrane or the adhesive attached to the edge of the dressing filler) at the same time
- Review and reassess the use of NPWT at each dressing change
- Discontinue NPWT when the patient or wound no longer meets the criteria for use and/or when the agreed management goals have been achieved

Fig 1 presents a pathway for implementation of NPWT in primary care settings. Like any flowchart, it will need to be adapted to reflect local healthcare provision and differing country healthcare systems, such as in Europe. For example, in France, patients who need NPWT must join a home care hospital, which will give them access to the therapy at home following an holistic assessment, supplemented with weekly assessments at the hospital's outpatient clinic, as well as training and support for the primary care team.

Conclusion

This review has discussed the concept of NPWT and its effective use in clinical practice, with suggested cost benefits for both primary and secondary healthcare settings. Seminal and more recent evidence has been used to support the use of NPWT in a variety of settings, as well as to highlight the need for a larger evidence base. All clinicians who use this therapy should have a clear knowledge of the NPWT device they are using. Patients should always be involved in setting treatment goals, and they should be given verbal and written information on how the NPWT device operates and what do if any problems occur. With consent from the patient, this advice should also be shared with carers and family members.

Acknowledgement

Additional content by Jenny Hurlow, Wound Specialised Nurse Practitioner, Advanced Wound Care, Southaven, Mississippi, US and Joy Tickle, Nurse Consultant, Isle of Wight Trust, UK

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Single-use negative pressure wound therapy with a Hydrofiber dressing: the perfect match

What is Avelle?

Avelle (ConvaTec) is a single-use, portable negative pressure wound therapy (NPWT) system indicated for a broad range of low to moderately exuding acute or chronic wounds.

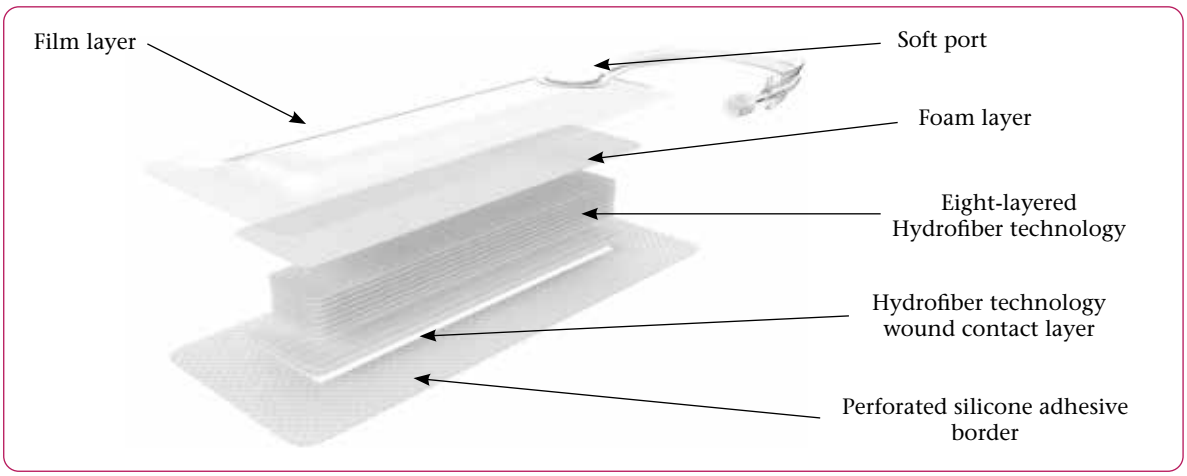
The Avelle pump is small and lightweight, with a single-button operation. It can be used for up to 30 days* to suit short or extended therapy requirements. A range of wound dressing sizes are available for use during this 30-day period, offering clinicians the flexibility to change the dressing size as the wound measurements and exudate levels change.

The dressing

The Avelle NPWT wound dressing is designed to allow transmission of continuous negative pressure of 80mmHg† across the wound surface, even under up to four layers of Aquacel Extra filler dressings (ConvaTec):1

- The primary dressing contact layer consists of one layer of apertured Hydrofiber technology, which forms a soft but viscous gel on contact with wound exudate
- The dressing pad contains an additional eight layers of apertured and fenestrated Hydrofiber technology for more absorption
- The pad is covered with polyester foam, which is designed to aid distribution of negative pressure across the dressing
- The next layer is a showerproof film cover, which is designed to provide a bacterial and viral barrier, while permitting evaporation of moisture vapour to aid overall fluid handling.
- The dressing is secured with a soft silicone border, along with film fixation strips to minimise risk of air leaks.

The interactive Avelle NPWT dressing responds to the wound environment by locking exudate and bacteria into its structure, while allowing transmission of NPWT to the wound. This mode of action facilitates a beneficial moist wound healing environment. The dressing is also capable of maintaining negative pressure within the dressing for up to 60 minutes after disconnection from the pump via a one way valve.[1]



*Battery change may be required † ±20mmHg

1. ConvaTec. Assessment of the in-vitro properties Avelle™ Negative Pressure Wound Therapy Dressing. WHRI4520 MS128. 2015. Data on file

Avelle: how clinicians make best use of it, in their own words

Philippe Leger, Angiologist, Wound Ulcer Centre, Clinique Pasteur, Toulouse, France

Q: What made you initially decide to use Avelle?

A: We first used Avelle on skin grafts and non-healing venous leg ulcers (VLUs) that were not responding to standard of care. At the time, we were using another type of portable negative pressure wound therapy (NPWT) and wanted to try out an alternative, to see if it would be easier to use.

Q: What indications do you use it on?

A: For several years now, we have been using Avelle on venous and arterial leg ulcers, diabetic foot ulcers (DFUs) and punch grafts.

Q: In your clinical practice, what are your key motivators for using Avelle?

A: Our main motivation is the clinical results that we have achieved with the device. Others are its ease of use, the speed with which staff can be trained on how to use it and how well tolerated it is by patients.

Q: How do you determine that it is safe to use Avelle?

A: In our experience, Avelle is safe for use on most of the wounds types we see: it has not caused any trauma to the wound bed or periwound skin, which is often fragile in the wound types that we use it on, and it is possible to visually check the amount of exudate that has been captured and thus determine if a dressing change is required. Furthermore, it can be used with compression therapy in VLUs and offloading in DFUs.

Q: When you apply Avelle, what are your typical treatment goals?

A: We mostly use Avelle either to restart the healing process, prepare for a skin graft or help with graft take. With DFUs, which we do not graft, we use it to obtain good granulation tissue.

Q: In general, at what stage in the treatment pathway do you apply Avelle?

A: When we first started using Avelle, we used to wait for quite a long time in before applying it (ie, until it was clear that the wound was not responding to standard of care). Now, we often suggest using it before grafting and on non-healing DFUs to save time.

Q: When you are considering Avelle, how do you involve the patient in clinical decision-making?

A: When we offer patients treatment with Avelle, we explain why it is needed and that the goal is to accelerate healing. We then show them the device, so they can see and handle it, give them photos of it in place on the same or similar wound type to theirs, and explain how the device is used and the wound's progress is monitored. Patients are usually quite happy to use it.

Q: How do you determine that Avelle has achieved your treatment goals and it is time to stop using it?

A: For grafts, we use it to prepare the wound for the procedure and to help to achieve graft take. In DFUs, we continue using it until there is a good progression towards healing and no slough. We then use standard of care alone.

Diego Mastronicola
Dermatologist, Outpatient Wound Healing Centre, Local Health System, Frosinone, Italy

Q: What made you initially decide to use Avelle?

A: The beneficial effects of negative pressure wound therapy (NPWT) combined with exudate management of carboxymethyl cellulose (CMC) fibres (Hydrofiber).

Q: What indications do you use it on?

A: Principally, venous leg ulcers (VLUs) that do not respond to standard treatment (compression therapy and advanced wound dressings). We also use it on small, shallow acute or traumatic wounds, small dehisced surgical wounds and low to moderately exuding hard-to-heal wounds, including diabetic foot ulcers (DFUs).

Q: In your clinical practice, what are your key motivators for using Avelle?

A: To stimulate healing and manage exudate under compression in VLUs, and to accelerate healing in other types of hard-to-heal wounds.

Q: How do you determine that it is safe to use Avelle?

A: Absence of adverse events on wound bed; low to moderate exudate level and no maceration or damage to the periwound skin. We mainly use Avelle on VLUs and DFUs.

Q: When you apply Avelle, what are your typical treatment goals?

A: To stimulate granulation tissue formation, manage exudate, protect the periwound skin and accelerate healing in slow or non-healing wounds.

Q: In general, at what stage in the treatment pathway do you apply Avelle?

A: When the wound bed has been sufficiently debrided and comprises ≥80% granulation tissue, the exudate level is low to moderate, and there are no clinical signs of wound infection. The device's ability to lock in exudate and thus bacteria is particularly useful in wounds at high risk of infection, such as DFUs.

Q: When you are considering Avelle, how do you involve the patient in clinical decision-making?

A: Single-use NPWT is an easy-to-use adjunctive to standard of care. We explain the treatment goals to patients and their care-givers, and show them how to manage the system.

Q: How do you determine that Avelle has achieved your treatment goals and it is time to stop using it?

A: When the wound bed preparation has been optimised. For venous or mixed-aetiology leg ulcers and superficial surgical or traumatic wounds, when there is 100% healthy granulation tissue and the exudate volume is low, and there is evidence of epithelial tissue migration from the wound margins. For DFUs, this is when the wound bed is ready for grafting.

Endika Nevado Sánchez, Medical Doctor, Department of Plastic and Reconstructive Surgery, Burgos University Hospital, Burgos, Spain

Q: What made you initially decide to use Avelle?

A: Avelle combines the ease of use of portable negative pressure wound therapy (NPWT) with the exudate management and healing properties of Hydrofiber technology, enabling us to accelerate wound healing. We have also observed improved scar quality with the device.

Q: What indications do you use it on?

A: We use Avelle on skin grafts that have not responded to standard of care, where the quality of the wound bed is poor or irregular. We also use it to help grafts on complicated

anatomical locations, such as the extremities, to promote graft take with standard of care, or where a previous graft has failed. We have also used it on neuropathic, pressure, traumatic and dehisced wounds, as well as for fasciotomy closure.

Q: In your clinical practice, what are your key motivators for using Avelle?

A: We have been very satisfied with its use on skin grafts, from clinical, health-economic and patient quality-of-life perspectives. The therapy has helped promote epithelialisation and wound closure; the Hydrofiber dressing can be changed every 5–7 days, which is more comfortable for patients; this dressing change frequency reduces expenditure and resource use. In addition, we have found that NPWT helps reduce exudate volume, improves mobilisation and graft sealing, and reduces shear and the risk of seroma and haematoma. With hard-to-heal wounds, our motivators are the improved healing rates and dressing change frequency that we have observed with this therapy.

Q: How do you determine that it is safe to use Avelle?

A: Our confidence in the device is increasing. We feel more comfortable about using it, not just on hard-to-heal wounds and grafts, but also on high-risk patients, such as those with diabetic foot ulcers or arteriopathy, as we have found that it can reduce the risk of complications, such as infection, and seroma or haematoma after incision. Regarding closed surgical incisions, we have observed a reduction in infection, seroma/haematoma and dehiscence rates, as well as improved scar quality.

Q: When you apply Avelle, what are your typical treatment goals?

A: When we apply Avelle on skin grafts, our typical treatment goals are to accelerate healing, reduce the number of dressing changes, promote a moist wound-healing environment and reduce the risk of infection. With hard-to-heal or dehisced wounds containing fibrous tissue and slough, the aim is to promote granulation tissue formation, reduce exudate and bacterial load and, therefore, prepare the wound bed for treatment with partial-thickness skin grafts. We have also found that this therapy can improve graft take and reduce pain and the risk of complications.

Q: In general, at what stage in the treatment pathway do you apply Avelle?

A: Ideally, portable NPWT should be used on wounds with optimal (60–80%) granulation tissue to accelerate healing, reduce the number of dressing changes, promote a moist environment and reduce the risk of infection. However, this is not easy to achieve in hard-to-heal ulcers in older patients with multiple comorbidities. The majority of wounds that we graft do not present a perfect microenvironment prior to the application of skin grafts. They often have a more fibrous wound bed, and so they are mechanically debrided before grafting and NPWT with Avelle are undertaken.

Q: When you are considering Avelle, how do you involve the patient in clinical decision-making?

A: Patients find the device easy to wear and manage. It is necessary to explain to them why they need to wear it, how to operate it and when the dressing will need to be changed.

Q: How do you determine that Avelle has achieved your treatment goals and it is time to stop using it?

A: In hard-to-heal wounds, we use the device until more than 70% of the wound surface has reduced in size. In dehisced wounds in young patients without comorbidities, we use it until healing occurs, typically 15–21 days, with weekly dressing changes. In skin grafts, we use it until healing occurs, again typically 15–20 days, which usually involves two dressing changes, at which time we assess the graft.

- Note: the answers given above are the personal opinions of the authors. Users must always refer to the manufacturer's instructions for use before using the device

Avelle: information for patients

What is Avelle?

It is a small, portable, single-use system for delivering negative pressure wound therapy. It comprises a pump that is attached to an advanced wound dressing. This helps reduce excess fluid from the wound and promotes healing.

How long can I use it for?

Each Avelle pump lasts for up to 30 days, after which it is disposed of. However, the Avelle dressing will be changed more frequently, depending on how much fluid your wound is producing. Your wound will be assessed at each dressing change. Your clinician will stop using the therapy when it is judged that the wound is progressing well towards healing and an advance wound care therapy such as Avelle is no longer required.

What wounds can Avelle be used on?

Most non-healing wounds that are producing a low to moderate amount of fluid and have been assessed by a health professional as suitable for this therapy.

How will wearing this system affect my ability to lead my normal life?

As the Avelle pump is discreet, quiet and light, you should be able to resume your usual day-to-day activities when wearing it. The pump can be hidden under clothing or stored in a pocket. The product comes with a handy pump carry case.

Will using the Avelle system hurt?

Patients generally report that the system is comfortable to wear.

Is there a choice of dressings that can be used with Avelle?

The dressings used with Avelle contain Hydrofiber technology, which is designed to absorb exudate and promote wound healing. There is clinical and scientific evidence showing that it is effective in achieving these objectives.[1,2] The dressing comes in a range of different sizes, so it can cater for almost all wound sizes and shapes.

1 Carrere C, Nghi J, Duchier A et al. Community setting survey evaluating Aquacel dressings. J Wound Care. 2021; 30(9):763–774. https://doi.org/10.12968/jowc.2021.30.9.763
2 Krejner A, Grzela T. Modulation of matrix metalloproteinases MMP-2 and MM-9 activity by hydrofiber-foam hybrid dressing: relevant support in the treatment of chronic wounds. Cent Eur J Immunol. 2015; 40(3):391–4. https://doi.org/10.5114/ceji.2015.54605

Case study 1: venous leg ulcer

Philippe Leger, Angiologist, Wound Ulcer Centre, Clinique Pasteur, Toulouse, France

This case study describes an 80-year-old woman with colon cancer that had resulted in a colostomy. She was obese (body mass index: 35) and had diabetes mellitus type 2, which was well controlled with medication, as well as hypertension. She had limited mobility, requiring a walking frame.

The patient had had a venous leg ulcer (VLU) of 23 months' duration. She was treated at home by her home nurse and her local doctor. It is not known what wound-care treatments she received during this time. Due to the wound's failure to proceed towards healing, she was referred to our wound healing centre.

At presentation, the wound measured 21cm^2 (Fig 1). It was covered with 40% granulation tissue and 60% slough, and it was producing a high volume of exudate (4 on 4-point scale used in France, where 0=no exudate). The patient's self-reported pain score was 5 out of 10, where 10 is the maximum pain. There were clinical signs of spreading infection. A wound swab was taken for culture and sensitivity (C&S) testing. In addition, a Doppler assessment was performed and the ankle brachial pressure index (ABPI) was calculated; the result was normal (1.1 on the ulcerated leg and 0.98 on the other leg). Given the wound duration, a biopsy was undertaken, but the results showed no signs of malignancy.

The culture results identified *Staphylococcus aureus*, with good sensitivity to amoxicillin and clavulanic acid, and clindamycin. Based on this, the patient was prescribed a 10-day course of oral antibiotics (amoxicillin and clavulanic acid). The wound was dressed with a polyabsorbent fibre dressing containing lipidocolloid technology, after which a two-layer compression bandaging system that applies 40mmHg at the ankle at rest was applied. Following administration of a local anaesthetic (lidocaine), the wound was sharp debrided at each dressing change.

Fig 1. Case study 1: venous leg ulcer (21cm^2) at presentation

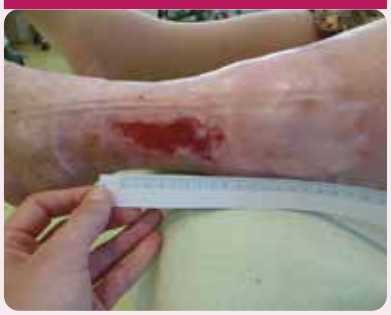


Fig 2. Case study 1: first application of Avelle

Fig 3. Case study 1: use of multilayer compression bandages with Avelle

Fig 4. Case study 1: the Avelle dressing selected was not big enough to cover the wound and became saturated

Fig 5. Case study 1: the exudate was well managed with a larger sized dressing

Fig 6. Case study 1: the wound is ready for grafting

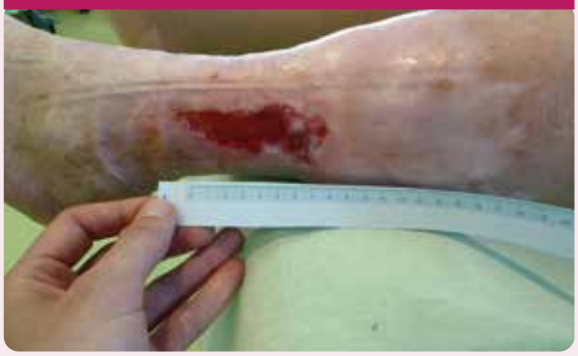


Fig 7. Case study 1: the healed wound post-grafting

Unfortunately, the patient's adherence to the compression therapy was poor, and she often did not attend all her clinic appointments for dressing changes. Approximately 5 weeks after the above initial infection was resolved, a local wound infection occurred. C&S tests again identified the presence of *S. aureus* with good sensitivity to amoxicillin and clavulanic acid, and clindamycin. This time it was treated with clindamycin. After this, no further courses of antibiotics were required.

The wound continued to produce a heavy volume of exudate. These outcomes reflect the patient's poor concordance.

After 7 months of this treatment, the wound had not changed in size and was still producing a moderate volume of exudate. At this point, it was covered with 70% granulation tissue and 30% slough, and the exudate score was 2/4. The patient's self-reported VAS score was now 4 out of 10.

Therefore, it was decided to use a single-use negative pressure wound therapy system (NPWT) (Avelle, ConvaTec) and, following discussion about the potential benefits, the patient was keen to try an advanced wound therapy (Fig 2). In France, patients using NPWT at home are cared for by dedicated nurses with specialist knowledge in wound care.

The nurse sharp debrided the wound at each home visit, using lidocaine for pain relief. The NPWT was applied underneath the two-layer compression bandaging system (Fig 3). The compression bandage was changed every 2–3 days, as is typical in France, and the NPWT dressing every 7 days. A large-sized dressing was needed to cover the wound (Figs 4 and 5).

During the first 2 weeks of treatment with the single-use NPWT system, the amount of slough present reduced rapidly, and the proportion of granulation tissue increased. By week 4, the slough had disappeared. The patient accepted the use of the NPWT system because it only needed changing once weekly, it did not cause her any pain and she found it easy to use. In addition, following discussion about the potential benefits, she was keen to try an advanced wound therapy.

After 6 weeks' treatment with Avelle, the wound had healed sufficiently to be grafted (Fig 6). The healed wound is shown in Fig 7.

Case study 2: Martorell's leg ulcer

Philippe Leger, Angiologist, Wound Ulcer Centre, Clinique Pasteur, Toulouse, France

A 74-year-old woman with a history of venous insufficiency (varicose vein surgery) presented at our wound clinic with a trophic lesion of 9 weeks' duration, on the external malleolus of her left lower limb. Her comorbidities were hypertrophic cardiopathy with atrial fibrillation, sleep apnoea syndrome and high blood pressure. She was allergic to adhesive plasters and codeine. The medications prescribed to the patient are listed in Box 1.

This is the first time that this patient had developed an ulcer on the leg. The ulcer was very painful (her self-reported pain score was 8 out of 10). The nurses who had been caring for her at home had tried different categories of wound dressings (alginate, Hydrofiber and foam), but the wound continued to deteriorate. They had also been attempting to mechanically debride necrotic tissue present on the wound, using xylocaine for pain relief. The wound, the high exudate level (assessed as 3 on the 4-point scale used in France, where 0=no exudate), daily dressing changes required, and, in particular, the pain, were all negatively affecting the patient's quality of life.

At presentation, the wound measured 48cm^2. It comprised 40% superficial necrotic tissue, 20% fibrinous tissue and 40% granulation tissue (Fig 8).

Vascular assessment ruled out arteriopathy (the ankle brachial pressure index was 0.92 and the duplex scan was normal), varicose veins and deep or superficial venous thrombosis. Martorell's ulcer was diagnosed.

Martorell's ulcer can develop in patients (generally elderly women) with chronic hypertension and, sometimes, diabetes, who develop arteriolosclerosis that causes tissue ischemia.[1] Little is known about its pathophysiology, and diagnosis is based on clinical signs and symptoms.

These ulcers, which often develop after a minor trauma, are most often located on the anteroexternal surface of the leg and are very painful. They have a punctiform, necrotic appearance. Initially, small areas of necrotic tissue appear, followed by purpuric blotches that spread rapidly and become blackish in colour. The necrotic ulcer is superficial, often bilateral, and its contours are irregular and map-like. The surrounding skin is typical of livedo reticularism (reddish-blue net-like pattern on the skin) and inflamed. The evolution of these ulcers is extensive: the necrosis proceeds to ulcerate, with no bulge. The pain remains intense, with paroxysms that are very difficult to calm with analgesics. After reaching its maximum size, the ulcer heals spontaneously. Treatment comprises skin grafting, which also has an analgesic effect. Skin grafting can be repeated as often as necessary.

In this patient, the diagnosis of Martorell's was based on the presence of hypertension and superficial necrosis, the high level of wound pain and the absence of any other explanatory aetiology.

It was decided to sharp debride the wound with a scalpel under local anaesthesia and then to perform a skin graft followed by application of negative pressure wound therapy (NPWT) to help improve graft take and reduce the wound pain. Avelle (ConvaTec) was selected because of its ease of use and suitability for moderately exuding wounds.

After 2 weeks of this regimen, the wound was ready for grafting. Figs 9 and 10 show the skin graft on the day of grafting. Following the grafting and application of NPWT, the wound pain improved, with the pain score reducing to 3 out of 10. On day 4, numerous parts of the skin graft were taking inside the wound (Fig 11). The wound had decreased slightly in size, measuring 47cm^2. There was a slight increase in the amount of devitalised tissue present (15%), which, in the author's clinical experience, is not unexpected for this type of wound, with the remainder of the wound bed comprising granulation tissue. The reduction in pain and dressing-change frequency (every 4–5 days) enabled by use of NPWT improved the patient's quality of life.

After 3 weeks of NPWT, the wound had improved: it now measured 30cm^2 and comprised 60% granulation tissue and 40% fibrous tissue (Fig 12). The pain score had reduced gradually from 3 to 1 during the first 2 weeks.

After 6 weeks of NPWT, the wound measured 3.96cm^2 and the wound bed comprised 100% granulation tissue (Fig 13). At this point, NPWT was discontinued, and a foam dressing was used instead.

1. Alavi A, Mayer D, Hafner J, Sibbald G. Martorell hypertensive ischemic leg ulcer: an underdiagnosed Entity©. Adv Skin Wound Care. 2012; 25(12):563–72. https://doi.org. 10.1097/01.ASW.0000423442.08531.fb

Fig 8. Case study 2: the wound at presentation

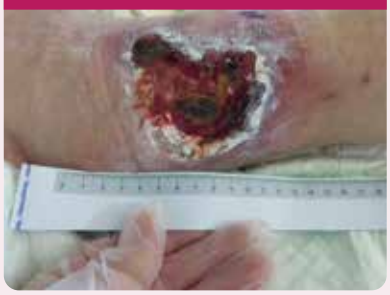


Fig 9. Case study 2: the donor site on the day of grafting

Fig 10. Case study 2: the skin graft on the day of grafting

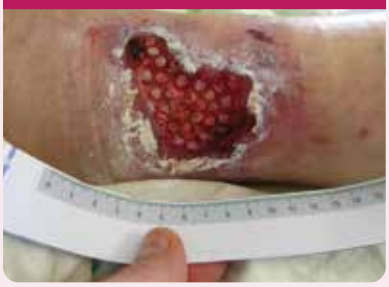


Fig 11. Case study 2: the wound on day 4 following grafting

Fig 12. Case study 2: the wound after 3 weeks of Avelle

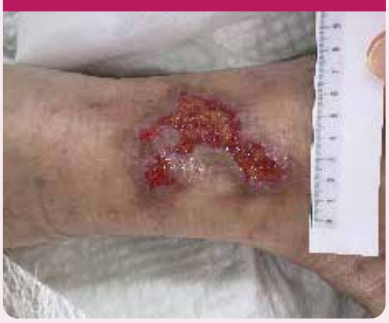
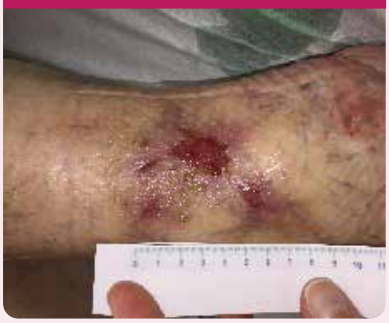


Fig 13. Case study 2: the wound after 6 weeks of Avelle



Box 1. Case study 2: prescribed medications
Ramipril 10mg
Amiodarone 200mg
Aldactone 25mg
Rivaroxaban 20mg
Pregabalin 100mg
Paracetamol 3g/day
Fentanyl 50 micrograms, one patch every 3 days*

**Analgesia was reduced as the patient's pain improved*

Case study 3: leg ulcer

Diego Mastronicola, Dermatologist, and **Paola De Bellis**, Clinical Nurse Specialist, both at Outpatient Wound Healing Centre, Local Health System, Frosinone, Italy

A 66-year-old woman presented with an extremely painful, microangiopathic ulcer on the left external malleolus, of approximately one year's duration. A biopsy and histologic evaluation had been performed previously in another clinic, which had treated the wound with non-adherent, antiseptic dressings, but without compression therapy, with poor results (there was no progression towards healing).

The patient's comorbidities included a 30-year history of rheumatoid arthritis (RA), which was treated with systemic steroids and antirheumatics, and Widmer's stage III chronic venous insufficiency due to varicose phlebopathy of the great saphenous vein (C6 CEAP) with no involvement of arterial stenosing (ABI 1.2). No other pre-existing medical condition were reported. Systemic steroids continued to be prescribed for the RA throughout the period described in this case study.

At assessment, the wound measured 7x5cm; the wound bed was fibrinous and dry, with adherent devitalised tissue and poor granulation. There were local clinical signs of infection, such as heat, pain, oedema and erythema on the periwound skin. Clearly, the wound was not progressing towards healing (Fig 14).

The ulcer was swabbed and tested positive for *Enterobacter cloacae*. A 10-day course of ciprofloxacin was prescribed. The wound was debrided with a curette and treated with dressings, such as hydrogels and collagenases, that promote a good moisture balance and stimulate autolysis and enzymatic debridement. This resulted in a reduction in the clinical signs of local infection but no improvement in the granulation tissue.

On day 14, the wound was producing a moderate volume of exudate, as often happens after debridement, but there was no longer any devitalised tissue present, and the wound edges and periwound skin were healthy (Fig 15). The treatment

Fig 14. Case study 3: the wound at presentation

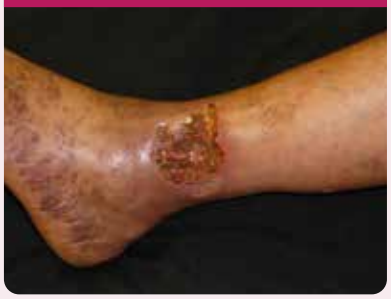


Fig 15. Case study 3: the wound on day 14 when compression therapy was first applied

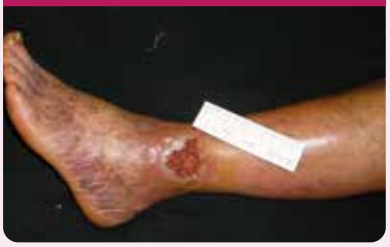


Fig 16. Case study 3: the wound after one week of compression therapy

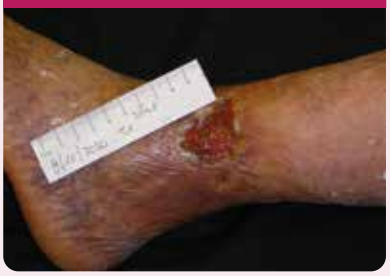


Fig 17. Case study 3: the wound after two weeks of compression therapy

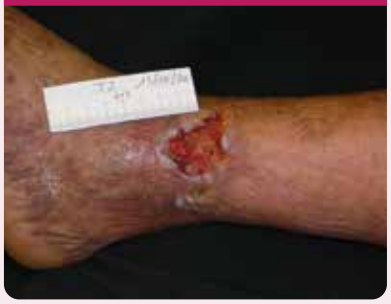


Fig 18. Case study 3: the wound after three weeks of compression therapy

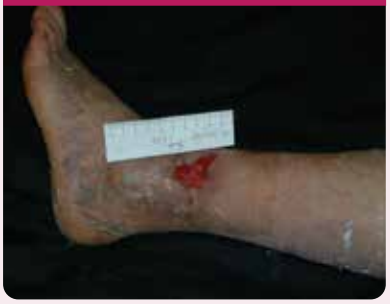
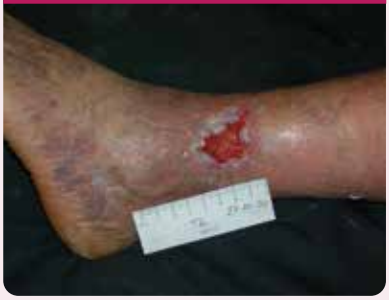


Fig 19. Case study 3: the wound after four weeks of compression therapy



regimen was changed to dressings that stimulate granulation formation by passive absorption of the exudate (calcium alginate, Hydrofiber and other gelling fibres), as well as a four-layer, multi-component, inelastic compression bandages with zinc oxide dressings designed to apply 25–35mmHg at the ankle.

Despite the adoption of standard treatment protocols, including use of compression therapy, after 6 weeks, there were no signs of any marked progression towards healing other than some granulation tissue formation (30–40%). Nevertheless, this was enough to reassure the patient that her wound was improving. Figs 16–19 show the wound at weeks 1, 2, 3 and 4 after initiating compression therapy). At week 6, it was, therefore, decided to initiate treatment with Avelle (ConvaTec) with the aim of accelerating granulation tissue formation and, therefore, promoting healing. Fig 20 shows the wound at this point

The wound was cleansed with a polyhexanide-based antiseptic, in line with the author's treatment protocol to combat any biofilm present at each dressing change, after which the single-use NPWT system (Avelle) and the multilayer inelastic compression bandaging system were applied. Fig 21 shows the single-use NPWT system dressing in place.

At the first NPWT dressing change seven days later (week 7) (Figs 22 and 23), the wound had reduced to 2x1cm and the amount of granulation tissue present had increased to approximately 80%. The exudate level was low and the periwound skin was still healthy.

The NPWT dressing was changed one week later (week 8). The exudate level remained low and good stimulation of peripheral re-epithelialisation was observed. Figs 24 and 25 show the wound at this point.

The patient's overall satisfaction with the single-use NPWT system was 'very high', as she found it comfortable, and it did not affect her ability to perform daily activities. She was also pleased to see the continuous improvement in the wound. No adverse effects were reported.

NPWT was discontinued after 2 weeks' of application and replaced with a silver-containing Hydrofiber dressing. This was prescribed because the patient was considered at risk of infection, as she was receiving systemic steroids for RA. Meanwhile, the compression bandages were replaced with class 2 compression stockings, which were worn until complete healing occurred one month later.

The device seems to have had an excellent impact on the progression of a stalled wound that had failed to respond to standard of care.

Fig 20. Case study 3: the wound at week 6 when Avelle was first applied

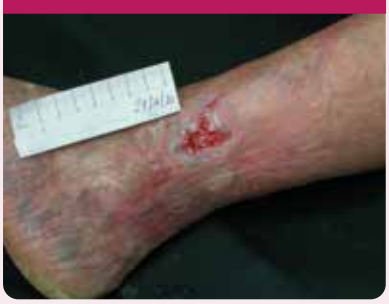
Fig 21. Case study 3: Avelle in place

Fig 22. Case study 3: the wound after seven days of treatment with Avelle

Fig 23. Case study 3: the wound after seven days of treatment with Avelle

Fig 24. Case study 3: the wound after 14 days of treatment with Avelle

Fig 25. Case study 3: the wound after 14 days of treatment Avelle



Case study 4: mixed-aetiology leg ulcer

Diego Mastronicola, Dermatologist, and **Paola De Bellis**, Clinical Nurse Specialist, both at Outpatient Wound Healing Centre, Local Health System, Frosinone, Italy

A 78-year-old woman presented with a mixed-aetiology ulcer on the right lower extremity of approximately 4 years' duration. She had been diagnosed with venous insufficiency four years previously by vascular surgeons at another centre. Comorbidities were diabetes, hypertension and peripheral arterial disease of the lower limbs, for which she had undergone recanalisation surgery on the left superficial femoral artery 3 years previously. The wound had failed to respond to treatments given at a different centre (enzymatic debridement, and hydrocolloid and alginate dressings).

A subsequent biopsy taken for histological examination was negative for neoplastic pathology.

At presentation, the wound measured 5x5cm and was 0.5cm deep. The wound bed, which comprised 70% granulation tissue and 30% fibrin, was dystrophic (irregular and dark red). It was producing a moderate volume of serous exudate. Clinical signs of local infection included induration, heat, oedema and periwound erythema, along with stalled healing. The patient stated that the wound was causing her moderate pain.

Following vascular assessment with Eco Doppler, the ankle brachial pressure index (ABPI) for the right leg was 0.75 and that for the left leg was 0.65, which is indicative of mixed-aetiology ulceration.

The wound was cleansed with a polyhexamethylene biguanide (PHMB) solution, after which it was debrided with a curette, and then a silver-containing Hydrofiber dressing (Aquacel Ag + Extra, ConvaTec) and a four-layer inelastic compression bandaging that applied 10mmHg to the ankle during rest and 40mmHg at exercise were applied. The dressing was changed two to three times a week, depending on the exudate level.

After 2 weeks of this treatment, the amount of granulation tissue on the wound bed had increased to 80% and the exudate volume was now low. There were no longer any clinical signs of infection (Fig 26). The wound edges and periwound skin were healthy.

Given the wound duration at presentation, it was decided to apply a single-use NPWT system (Avelle) (Fig 27) in combination with the same inelastic, multi-layer bandaging system to accelerate healing). The wound continued to be debrided with a curette at dressing changes.

The wound was assessed on day 5, when the NPWT dressing was changed (Fig 28). It had reduced to 2.5x2.0cm and now comprised 90% granulation tissue (Fig 29). The exudate level was now low and the patient no longer experienced wound-related pain. The periwound skin was healthy. The improvement in the condition of the wound increased the patient's wellbeing.

At the next NPWT dressing change on day 9, the wound had reduced to 2.5x1.5cm. The Hydrofiber dressing was controlling the exudate well (Fig 30).

On day 13, an initial stimulus to peripheral re-epithelialisation (30%) was observed (Fig 31). On day 17, the wound measured 2.0x1.5cm, a 50% reduction since presentation, and was now shallow. There was an excellent granulation tissue base, with the amount of epithelial tissue increasing to 40%. Fig 32 shows the wound at day 25.

The patient commented that she had mild or no pain at dressing removal and application, and found the portable device very comfortable.

Treatment with the single-use NPWT device stopped at week 5 (day 32), as its use was no longer considered necessary (Fig 33). From here on, treatment comprised a silver-containing Hydrofiber dressing (Aquacel Ag+ Extra, ConvaTec) and a class I knee-high elastic sock only. The dressing was selected due to its antibiofilm properties, given the wound's long history of non-healing. It was changed twice weekly. Full healing occurred one month later with this treatment regimen.

In this case, use of a single-use NPWT device and a silver-containing Hydrofiber silver dressing stimulated formation of healthy granulation, reduced the wound depth and promoted stable re-epithelialisation from the wound edges, with excellent capacity to manage mild to moderate amounts of exudate.

Fig 26. Case study 4: the wound before initiation of Avelle

Fig 27. Case study 4: Avelle in place (day 1)

Fig 28. Case study 4: the Avelle dressing (day 5)

Fig 29. Case study 4: the wound on day 5 of treatment with Avelle

Fig 30. Case study 4: the wound on day 9 of treatment with Avelle

Fig 31. Case study 4: the wound on day 13 of Avelle

Fig 32. Case study 4: the wound at week 4 of treatment with Avelle

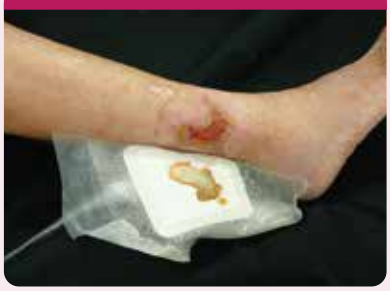
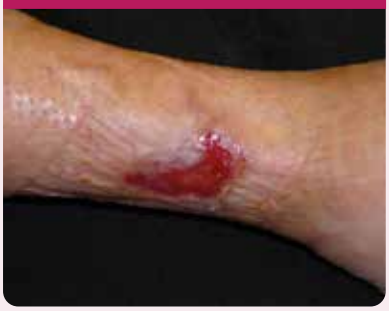


Fig 33. Case study 4: the wound at week 5 of Avelle



Case study 5: dehisced wound

Endika Nevado Sánchez, Medical Doctor, Department of Plastic and Reconstructive Surgery, Burgos University Hospital, Burgos, Spain

A 46-year-old woman presented with a dehisced donor site following excision of a vascularised flap from the left fibula for use in a segmental mandibulectomy. The patient, who had been diagnosed with a non-metastatic left mandibular squamous cell carcinoma with lymphadenopathy, required surgery to remove an ulcerated intraoral tumour and affected teeth. Subsequent 3D reconstruction was performed with the vascularised fibula flap, a reconstruction plate and the skin paddle from the leg. The postoperative pathological outcome was moderately differentiated squamous cell carcinoma with disease-free margins of excision. For 1 month after surgery, the patient had required nutritional support through a nasogastric tube, as well as protein shake to avoid hypoproteinaemia. Following chemotherapy and radiotherapy, the patient remained disease-free at her one-year follow-up.

The patient, who was a cigarette smoker (10/day), had no other relevant medical history.

Before surgery, a CT angiogram had identified that the three vascular arteries (posterior tibial, anterior tibial and fibular artery) were patent, indicating that it was safe to use the vascularised fibula flap for reconstruction. The patient's ankle brachial pressure index (ABPI) was 1.20, with no significant peripheral arterial disease (PAD) that would rule out compression therapy.

Following surgery, a postoperative Hydrofiber dressing was applied to promote healing by primary intention. This was not lifted for 72 hours. Negative pressure wound therapy (NPWT) was not used during this time. On the third postoperative day, grade 3 dehiscence (Sandy classification) of the flap donor site, with exposed paratenon, slough and fibrous tissue, was observed (Fig 34). The wound measured 9x4cm (length x width) and was producing a moderate volume of non-malodorous exudate. The patient's self-reported visual analogue scale (VAS) pain score was 8 out of 10 (where 10 is worst pain possible). There was no periwound erythema or any clinical signs of infection.

The dehiscence was caused by two factors: mechanical stress, resulting from tension during wound closure, and impaired healing due to the patient's poor nutritional status.

Fig 34. Case study 5: the dehisced wound on the third postoperative day

The patient's quality of life in relation to the dehiscence was measured using the validated Wound-QoL-17 scale (www.wound-qol.com/about).[1] The result—2.9 out of 5.0—was indicative of a moderate reduction in quality of life, due to the ulcer-related pain and problems with sleeping and performing activities of daily living, such as walking. She also felt very uncomfortable about the wound malodour and leakage, which was staining her clothes.

A microbiological culture test of the wound tissue and swab was performed, which ruled out the presence of infection.

In our clinic, donor sites on which we have used NPWT have been mostly micrografts of skin taken from the thigh, where it is used to promote healing and improve the graft harvest rate.[2,3] However, we have ruled out micrografting in patients at high risk of infection, undergoing chemotherapy and at risk of malnutrition, to minimise the risk of complications in the new donor site and avoid infection.

Here, the objective was to manage the exudate output more effectively and promote healing by secondary intention. It was hoped that reduced lateral tension, improved lymphatic drainage and increased perfusion, as observed in studies on NPWT in surgical wound dehiscence, would promote healing.[2,4,5] Treatment, therefore, comprised cleansing with a PHMB cleansing solution and a single-use NPWT device (Avelle, ConvaTec) (Fig 35). The NPWT dressing was changed every 5–7 days, depending on the exudate level.

At the first NPWT dressing change (day 5 of this treatment), there was no reduction in wound size, but the exudate volume had decreased and the wound edges were not macerated. The wound bed had started to granulate on the peritenon. There was still some fibrous tissue on the wound edges, which was mechanically debrided with a scalpel.

At the second dressing change (day 12), the wound measured 4x2cm (a reduction of approximately 50%). Granulation tissue was present on the wound bed and the wound edges were starting to contract. The patient's VAS score had reduced to 3/10. Her adherence to this treatment was good: she was able to perform her basic activities of daily living with the portable device in place without impediment. It did not affect her mobility, which was good.

At the third dressing change (day 19), the wound measured 2x1cm and had almost completely epithelialised (Fig 36). The therapy improved the patient's QoL, with her Wound-QoL-17 score reducing to 0.4 out of 5.0, which should be comparable to that before the surgery.

At this point, the NPWT therapy was replaced with a hydrocolloid dressing, along with a class 1 (18–21mmHg) compression stocking. Complete epithelialisation was achieved at 22 days.

During the 3 weeks of NPWT therapy, no clinical signs of infection were observed or problems with the NPTW system encountered.

1. Conde Montero E, Sommer R, Augustin M et al. Validation of the Spanish Wound-QoL Questionnaire. [Article in English, Spanish.] Actas Dermosifiliogr. 2021;112(1):44–51. https://doi org/10.1016/j.ad.2020.09.007
2. Gupta S. Optimal use of negative pressure wound therapy for skin grafts. Int Wound J. 2012;9(suppl. 1):40–7.
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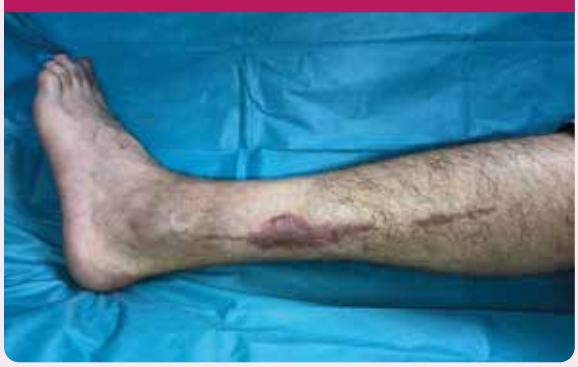
4. World Union of Wound Healing Societies. Consensus document. Surgical wound dehiscence. Improving prevention and outcomes. 2018. https://tinyurl.com/y2bw7ttf (accessed 16 December, 2021)
5. World Union of Wound Healing Societies. Consensus document. Closed surgical incision management: understanding the role of NPWT. 2016. https://tinyurl.com/ ycktpdmz (accessed on 16 December 2021)

Fig 35A. Case study 5: Aquacel dressing placed on the wound

Fig 35B. Case study 5: Avelle plus Aquacel on the wound bed

Fig 36. Case study 5: almost complete epithelialisation has occurred after 3 weeks' treatment with Avelle



Avelle™
Negative Pressure Wound Therapy System

The Hydrofiber® Difference

The Hydrofiber® Technology you trust, combined with the healing power of NPWT for up to 30 days.

SCAN ME

- Interactive Hydrofiber® Technology dressing gels on contact with wound fluid and locks in bacteria within it[1,2] to create a moist wound healing environment.[3]
- Single patient use pump with 30-day lifespan* delivers 80mmHg (±20mmHg) for continuous NPWT to the wound bed.

Experience the benefits of NPWT with Hydrofiber® Technology and see how the Avelle™ NPWT System can improve your clinical practice and enhance patient care.

www.avelle-npwt.com

POWERED BY
Hydrofiber® TECHNOLOGY

ConvaTec | Negative Pressure Wound Therapy

*Battery change may be required during pump lifetime 1. Assessment of the in-vitro properties Avelle™ Negative Pressure Wound Therapy Dressing. WHRI4520 MS128. Data on file. 2015. ConvaTec. 2. HFM-2015-017. Data on file. 2015. ConvaTec Inc 3. Bishop SM, Walker M, Rogers AA, Chen WYJ. Moisture balance: optimising the wound-dressing interface. J Wound Care. 2003; 12:125-128. Avelle is a trademark of ConvaTec Inc. AP-019824-MM