Safe bioburden management

A clinical review of DACC technology

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Contents

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Safe, long-term management of bioburden that helps promote healing Evidence review of DACC technology

Unlike common antimicrobial dressings, the Cutimed Sorbact range does not kill pathogens, but instead binds them to its surface, so they can be safely removed at dressing change. As a result, it can be used long term with minimal risk of side effects. This supplement describes the evidence base on the efficacy of DACC technology

The purpose of this supplement is to review the evidence on the use of Cutimed Sorbact in the treatment of chronic wounds. The evidence comprises laboratory tests and clinical studies including comparative studies, case series and case reports. It is generally accepted that clinicians need to ensure that wound management is evidence based,[1] although, in general, little comparative data is available on the efficacy of modern wound management devices. Most randomised controlled trials (RCTs) usually measure the effect of a treatment/product on wound closure, whereas the use of endpoints that record intermediate aspects of healing, such as a viable wound bed or the elimination of infection,[1] are generating increasing interest and gaining in popularity. Such endpoints may be more relevant to clinicians, who often choose a product/treatment that will achieve an intermediate goal on the way to the final outcome of a healed wound. To close this gap, case series and case studies can provide valuable evidence that is of direct clinical relevance. This supplement contains a wide selection of data, including a large number of case series and case studies, many of which focus on reduction of infection as well as healing.

Bioburden: a cause of wound chronicity

A critical component of wound healing (and thus an important intermediate endpoint) is the management of wound surface bioburden. All wounds have bacteria on their surface. The presence of free-floating, non-replicating planktonic microorganisms on the wound surface is referred to as contamination. This is essentially a benign state where transient microorganisms do not induce a host response or delay healing.[2] These planktonic bacteria evaluate the local environment and may attach to the wound bed and/or each other, or continue in a planktonic state. Following confirmation that the local environment is able to sustain microbial growth, irreversible attachment occurs. The bacteria divide and form larger groups of multiple species of microorganisms on the wound surface and a state of colonisation is reached.[2] This represents microbial habitation and replication, which is largely unrecognised by the host and does not delay healing.

Microbes within the colony attach to the wound bed and anchor themselves to the tissues. They then begin to secrete an extracellular polymeric substance (EPS) that surrounds and protects the colony from the host's immune system and extrinsically applied antimicrobial agents. Once the microbial colony reaches a certain critical mass or quorum, the cells begin to secrete 'quorum-sensing molecules' that attract other microbes to the biofilm. As the biofilm grows, it begins to expand into a multispecies community by including other microorganisms on the wound surface. A critical point is reached when the biofilm triggers a local inflammatory event from the host's immune system.[3] Exudate is produced in the wound bed and provides the biofilm with a source of fluid and nutrients.[4] Once the biofilm's microbial population has reached a certain size or density, individual bacterial cells escape from the colony where they revert to a planktonic phenotype and float away from the main biofilm (Fig 1). These small entities may reattach at another location and form new biofilms of their own. At this time, they are most susceptible to topical and systemic antimicrobials.[5]

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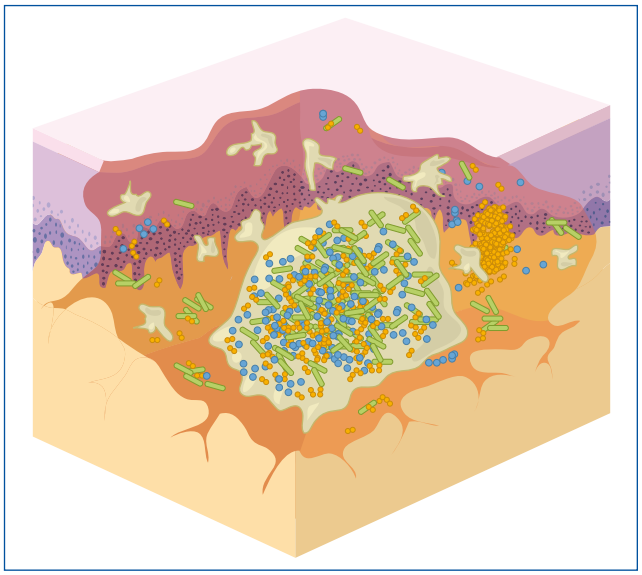
Microbes bind to both each other and the host extracellular matrix to protect themselves from marauding neutrophils and macrophages. While these predatory cells can engulf and destroy individual planktonic bacteria, they have difficulty penetrating the surface of a mature biofilm. Bacteria within a biofilm decrease their rate of cell division and invasive exotoxin production, and thereby conserve energy. The biofilm will gradually increase in size and constantly stimulate an inflammatory response from the host in order to provide a steady flow of fluids and nutrients to the colony. In this way, the biofilm ensures its survival and remains a constant threat to the host.[6]

Characterisation of biofilm is currently at an indeterminate stage, despite the recognised and underlying prolonged inflammation associated with wound biofilm infection.[7]

When the mature biofilm releases planktonic bacteria into a host environment, these microorganisms revert to a more aggressive form of behaviour: they divide rapidly and emit exotoxins that allow the microorganisms to spread within the host and form new biofilms. Alternatively, if large enough numbers of these bacteria are released into the bloodstream, they can cause an acute infection, where the host immune system responds with the generation of the classical signs of infection: pain, fever, swelling (oedema) and redness (erythema). Ascending cellulitis from the site of the wound is a potential development as the bacteria and their exotoxins migrate along lymphatic channels in a proximal direction.[8] At this point, fever, chills, night sweats and a general malaise will quickly overwhelm the patient, who will become very ill.

A number of therapeutic interventions is available to address biofilm infection and help create an environment, whereby the wound can progress towards granulation tissue formation and epithelialisation. However, bacteria have adapted to overcome our attempts to reduce their numbers by developing innate and induced resistance to antibiotics and the ability to form biofilms that are impervious to topical antiseptics.[9,10]



Peter Lamb

Fig 1. Biofilm in the wound bed: individual bacterial cells escape from the colony and revert to a planktonic phenotype.

Cell surface hydrophobicity: a key component of biofilm formation

A surface is hydrophobic if it repels or does not mix with water. A hydrophobic effect occurs when non-polar substances aggregate in aqueous solution and repel water molecules. A common, everyday example of this is the separation that soon occurs after water and oil are mixed together. The difference between polar and non-polar is described in Box 1.

Hydrophobic reaction plays an important role in biofilm formation. It is well known that bacteria flourish in a moist environment, e.g. biofilm formation on water pipes, indwelling catheters, and wound colonisation.[11,12] When

Box 1. Difference between polar and non-polar molecules

Polar

Molecules with a partial positive electrical charge at one end and a partial negative charge at the other. Water is a polar molecule

Non-polar

The electrons are distributed more symmetrically because asymmetrical distribution would lead to partial charges and polar molecules. A rule is that substances dissolve in like substances. Therefore, non-polar substances such as oil cannot dissolve in water as it is a polar molecule

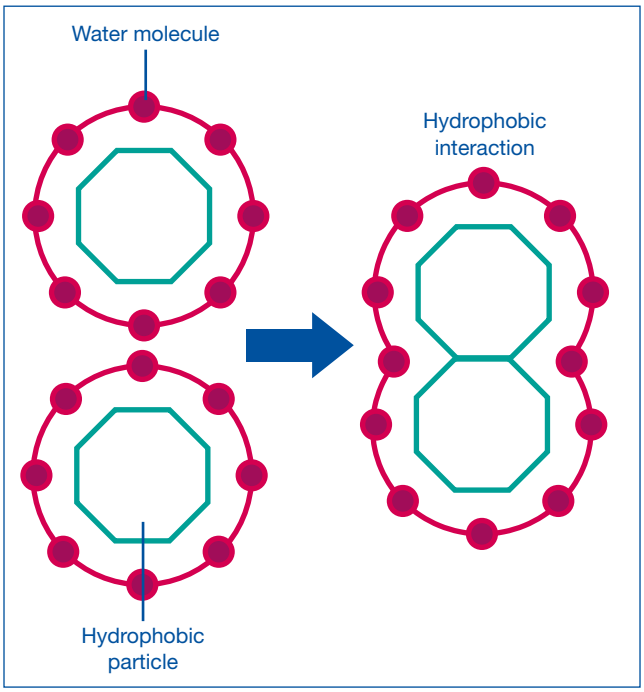


Fig 2. The principle of hydrophobic interaction.

in wet surroundings, many pathogenic microorganisms use hydrophobic interaction to attach to a surface, such as damaged wound tissue or other bacteria, as part of the process of biofilm formation.[11,13,14] These hydrophobic interactions take place when cells exhibit cell-surface hydrophobicity (CSH). The cells, which are located on the extracellular matrix (ECM) of the damaged tissue, bond together and expel water molecules. In this way, the cells aggregate and are held together by the surrounding water molecules (Fig 2). Pathogenic bacteria that exhibit CSH rely on these hydrophobic properties to attach to the wound bed, form colonies[15] and initiate the infective process.[16] Aerobic bacteria such as *Staphylococcus aureus*, including the meticillin-resistant types, and *Streptococcus* spp, anaerobes such as *Peptostreptococci*, and numerous fungi and yeasts all exhibit varying degrees of CSH.[17-19] The extent of CSH varies between bacterial species, as well as between members of the same species. There is also evidence that bacteria within a wound may respond to various environmental conditions by altering their degree of CSH, as well as their toxin production.[20]

The chronic wound with its biofilm, poor wound-bed circulation and subsequent lack of adequate oxygenation provides the ideal environment for the development of CSH in many wound pathogens.[20] The risk of systemic antibiotic toxicity and/or the increased risk of selection for resistance means that antibiotic therapy should be reserved for the treatment or prevention of systemic infection. This, and the cytotoxicity commonly seen with many topical antiseptics, encouraged the development of a new technology to address the problem.[21]

Introducing a new paradigm

As more became known about CSH of bacteria, the possibility of using this characteristic against pathogens became attractive. The use of CSH to bind bacteria to dressing fibres and then remove them from the wound at dressing change introduced a paradigm shift in wound bed management. It was clear this might not only make it possible to prevent biofilm formation, but also to reduce inflammation by eliminating the endotoxin release triggered by the cell-wall disruption of bacteria killed by the use of antiseptics and antibiotics. Common antiseptics and antibiotics work in several ways to kill bacteria. After the bacterial cell wall is ruptured, intracellular antigenic material and cell wall endotoxins are released into the wound fluid. Following the deaths of millions of bacteria, the wound fluid becomes decidedly inflammatory. Trapping bacteria onto a hydrophobic material therefore becomes an attractive way of managing wound bioburden and improving healing.

Hydrophobic dressings that bind bacteria are not commonly referred to as antimicrobials because the microorganisms are not killed by the hydrophobic interaction, but instead are simply collected for removal. The use of a highly hydrophobic dressing material that reduces the microbial load offers an attractive alternative to non-antibiotic treatments or can be used as an additional measure when reducing antibiotic usage in superficial infections.[16,22]

DACC technology

The Cutimed Sorbact range of dressings contains dialkylcarbamoyl chloride (DACC), which is a synthetically produced derivative of a naturally occurring hydrophobic fatty acid found in a spider's web. (Spider silk is partly hydrophobic, which explains why cobwebs cannot be wetted, but instead form droplets of water on their surface.) Cutimed Sorbact dressings are coated with DACC, which mediates the irreversible binding of bacteria that exhibit CSH (Fig 3).

Large numbers of adherent or 'trapped' bacteria can then be removed from the wound at each dressing change (Fig 4). They are removed without disrupting the bacterial cell wall, thereby avoiding the resultant increase in inflammation observed with traditional antibiotics or antiseptics.[22]

Numerous bacteria and fungi that exhibit CSH have been shown to attach to the DACC-coated material, including *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Enterococcus faecalis*, *Candida albicans* and the dermatophyte *Trichophyton rubrum*.[16,23,24] DACC-coated dressings rapidly and effectively bind *Staphylococcus aureus* and *Pseudomonas aeruginosa* within 30 seconds of contact and continue to exhibit effective binding of bacteria for 2 hours.[16,23] Once bound to the DACC coating, bacteria exhibit a decreased rate of replication, slower metabolism, and decreased production of bacterial toxins.[16]

The passive 'trapping mechanism' exhibited by DACC-coated dressings avoids the risk of microbial resistance seen with antibiotics and some antiseptics, which gives it a significant advantage over common antimicrobial dressings. They also avoid release of large amounts of antigenic, inflammatory, intracellular contents into the exudate commonly seen with use of antibiotics and antiseptics.

Cutimed Sorbact differs from silver, iodine, or PHMB-impregnated dressings in that it does not release chemicals into the wound to kill bacteria or kill bacteria absorbed into the dressing. Because there is minimal risk of sensitisation, allergy, systemic absorption, cytotoxicity, microbial resistance, or skin or wound discolouration, The dressing range can be used on patients who are sensitive to other wound dressings and can be safely used for microbial prophylaxis on a long-term basis or until there are no clinical signs of infection and the wound is granulating. It is also safe to use on infants, children, adolescents and the elderly.

In vitro and clinical experience of Cutimed Sorbact: the evidence base

In the previous chapter, Keith Cutting and James McGuire explored the link between infection and wound chronicity and explained how Cutimed Sorbact can be used to promote healing in chronic wounds. The following sections summarise the existing evidence for the Cutimed Sorbact range of dressings

Laboratory evidence

The previous chapter has provided an overview of the causes of local infection and wound biofilm, as well as an insight into how the cell surface hydrophobicity of a microorganism can help the wound healing process and where the Cutimed Sorbact range fits into this picture. The coming sections will review (but not critique) the available evidence on the use of Cutimed Sorbact to reduce bacterial bioburden and stimulate wound healing. While this review will cover clinical evaluations in a later section, it will begin here with the early laboratory evidence of antimicrobial properties and the principle of hydrophobic interaction on which Cutimed Sorbact rests.

Early studies

One of the earliest animal studies on the hydrophobic principle compared the efficacy of a 'hydrophobised' wound dressing with that of an active charcoal dressing and a hydrophilic dressing on *Staphylococcus aureus* wound infections in pigs.[25] The researchers created wounds measuring 2x2cm with a dermatome following a thermal injury in 4-week-old piglets and inoculated these wounds with the *Staphylococcus aureus* strains, with infections developing within a few days. Treatment with the hydrophobised dressing resulted in signs of healing, such as an elimination of inflammation around the wounds, on days 3 and 4, and all traces of infection were removed by days 5 and 6. In contrast, wounds treated with active charcoal dressings or hydrophilic dressings continued to show signs of infection. The authors concluded that active removal of *Staphylococcus aureus* cells with the hydrophobised dressing likely decreased the number of multiplying bacteria, resulting in a rapid onset of wound healing. This study provided early evidence on the efficacy of the hydrophobic principle in reducing wound bioburden, albeit using a porcine model.

Over a decade later, Bowler et al.[26] investigated the ability of different dressings to sequester and retain microorganisms associated with wound fluid. This compared the ability of a Hydrofiber dressing, two alginate dressings and a hydrophobic dressing (Cutimed Sorbact) to sequester and bind *Staphylococcus aureus* and *Pseudomonas aeruginosa* in a simulated wound fluid. A suspension of maximal recovery diluent (MRD) and foetal calf serum was used as it maintained stable bacterial populations over the 4-hour test period. While the Hydrofiber and two calcium alginate dressings all successfully sequestered the challenge organisms from the simulated wound fluid, the hydrophobic and Hydrofiber dressings absorbed and retained significantly more of the *Staphylococcus aureus* and *Pseudomonas aeruginosa* within their dressing matrix than did the alginate dressings ($p<0.05$). The hydrophobic and Hydrofiber dressings retained approximately 60–80% of the bacterial challenge concentrations, whereas the alginates retained only about 10% of the *Staphylococcus aureus* and 30–40% of the *Pseudomonas aeruginosa*. Of the dressings, the hydrophobic one was the most effective in retaining *Pseudomonas aeruginosa* (mean percentage retained: 79% versus 70% for the Hydrofiber dressing and 41% and 32% for the two alginates). The author speculated that this was because the CSH of *Pseudomonas aeruginosa* is three times that of *Staphylococcus aureus*, with the former bacteria therefore binding aggressively to the hydrophobic dressing.

In vitro evidence on irreversible binding of bacteria to DACC-coated wound dressings

Over the next few years, Ljungh undertook scientific research into levels of CSH exhibition in bacteria and fungi, as well as the factors that influence this. They acknowledged that CSH expression can vary between bacterial species, and that variations can occur even within the strains of the same species.[16] In 2006, Ljungh et al. set out to quantify the numbers of different types of bacteria and fungi that bound to Cutimed Sorbact during an *in vitro* test. The aim was to predict the likelihood of binding *in vivo*.[16]

The investigators measured the numbers of bacteria and fungi (*Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Enterococcus faecalis*, *Bacteroides fragilis*,

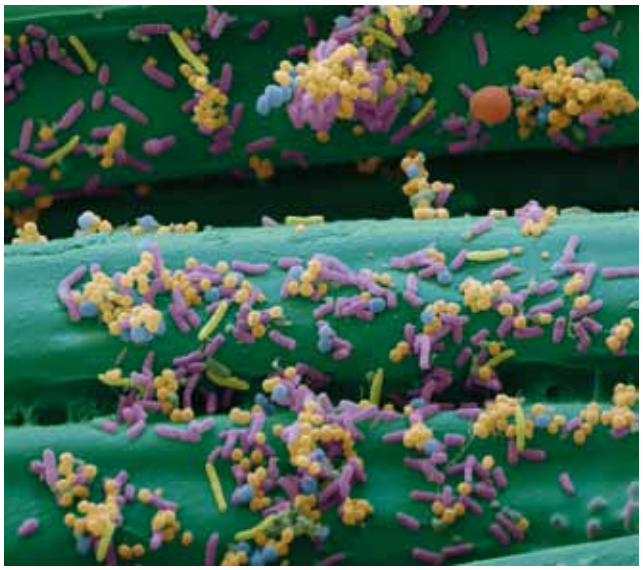


Fig 3. Binding action of Cutimed Sorbact: *Staphylococcus aureus* (yellow), *Pseudomonas aeruginosa* (purple), *Enterococcus faecalis* (blue), *Klebsiella spp.* (green) bound to the dressing and each other. x4000 magnification. (Colours are false)

Fusobacterium nucleatum and *Candida albicans*) that bound to the surface of a 1cm^2 single layer of Cutimed Sorbact in a simulated wound environment over a time period ranging from 0.5 minutes to 20 hours. They used bioluminescence (the production and emission of light by a living organism) and the species-specific standard curve to quantify the microbial adenosine triphosphate (ATP) of the microorganisms. (ATP is a molecule found in living cells, and is a direct measure of bacterial density and health. ATP bioluminescence can be used to quantify the extent of bioburden present, as the result is directly proportional to the amount of ATP in the sample.)

Results showed high levels of binding for all of the microorganisms, indicating that it is likely to be able to bind >10^8 (or >100,000,000) of *Staphylococcus aureus*, >$10^{6.7}$ of *Enterococcus faecalis*, >10^6 of *Bacteroides fragilis* and $10^{7.5}$ of *Fusobacterium nucleatum*. Complete saturation (where no more microorganisms could bind to the dressing) was achieved only for *Candida albicans*. The test showed that binding increased after 10 minutes and peaked at 2 hours. When observing a mixed culture, the researchers observed that as well as binding to the dressing, the microbes co-aggregated and bound to each other (Fig 4).

Ljungh et al.[16] undertook a second *in vitro* test to determine whether irrigating the wound with disinfectant or antiseptic or applying a lidocaine cream (Emla) before applying a dressing would affect the CSH levels expressed by the microbes and, therefore, the action and efficacy of Cutimed Sorbact. Suspensions of bacteria were washed and incubated with each of the eight substances at room temperature for 15 minutes. The salt aggregation test (SAT) was used before and after incubation. Only the Emla

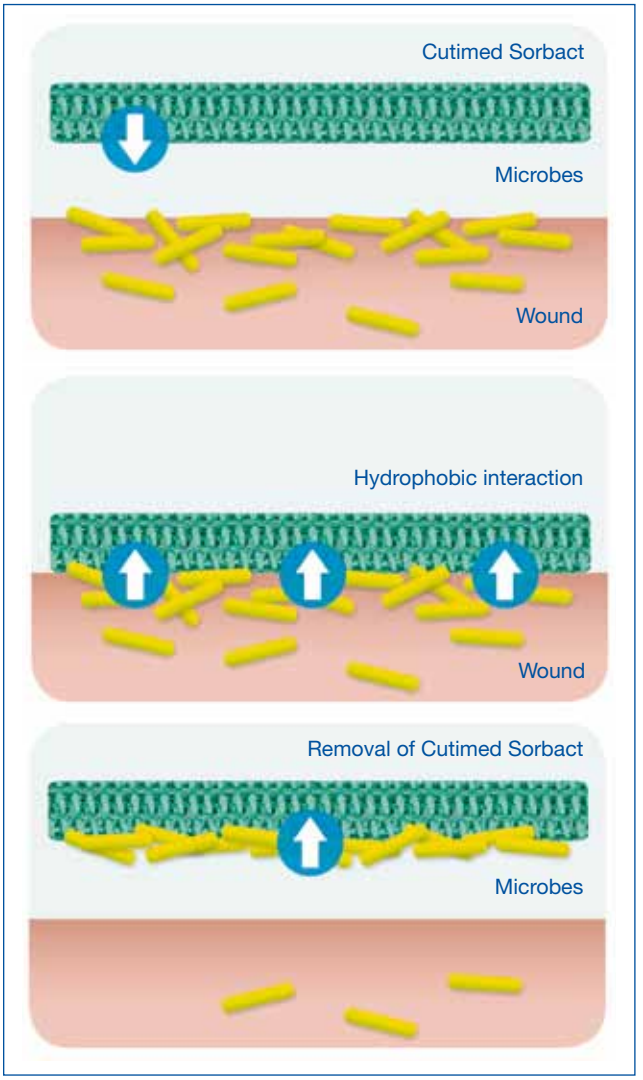


Fig 4. Cutimed Sorbact's action on hydrophobic microorganisms

abolished expression of CSH; however, as expected, the modified starch polymer with glycerol (Askina Hydrogel) also decreased CSH expression, rendering hydrophobic dressings less effective. This study indicated that Emla and Askina Hydrogel should not be used concurrently with Cutisorb Sorbact (Cutimed Sorbact). However, as will be seen later, hydrogels are frequently combined with Cutimed Sorbact with satisfactory or positive results.[27,28]

Nearly 10 years later, Ronner et al.[29] undertook *in vitro* experiments to determine the binding capacity of the DACC-coated dressing. The aim was to demonstrate comparable binding of *Staphylococcus aureus* and multiple MRSA strains to the dressing.

The group used 11 isolates from different inpatient and outpatient wounds, as well as a known MRSA strain obtained from the culture collection at University of Gothenburg (CCUG 35603) as a control. To study the binding of bacteria to the dressing surface, an inoculum of each strain was added to the wound dressing and a bioluminescence technique was used to quantify the

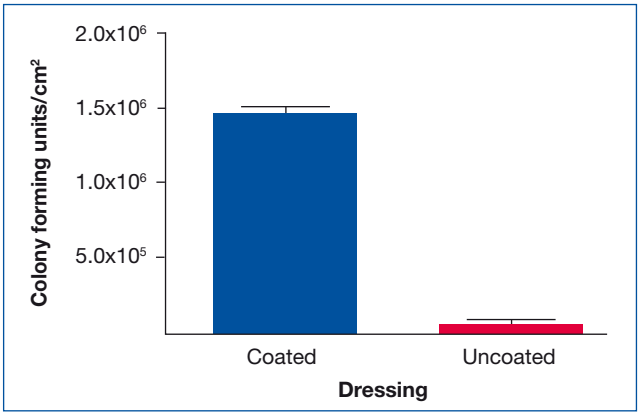


Fig 5. Adhesion of *Staphylococcus aureus* to a DACC-coated dressing material (n=3) and an uncoated control (n=3)[29]

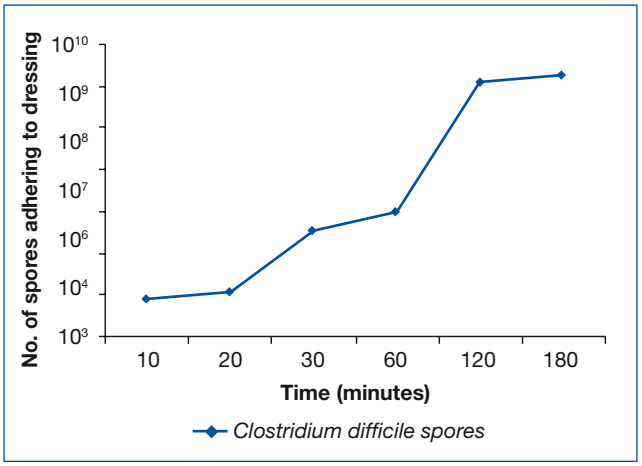


Fig 7. Marked hydrophobic bonding was achieved with *Clostridium difficile* spores[30]

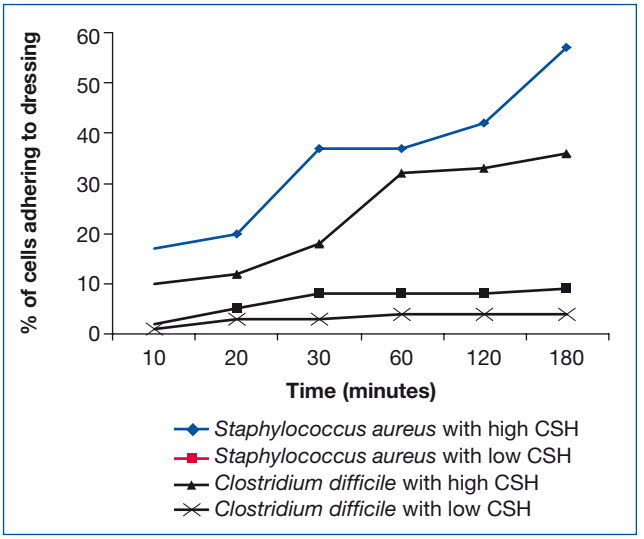


Fig 6. Exposure of high CSH was associated with greater hydrophobic attachment at 3 hours[30]

bacterial ATP levels against a reference standard curve. The binding capacity for all 11 strains of *Staphylococcus aureus,* including MRSA, was in the same range: 0.7–2.9 x 10^6 colony forming units (CFU)/cm^2. The antibiotic-resistance properties of the nine MRSA strains appeared to have minimal effect on this binding capacity. Comparison of the binding capacity of *Staphylococcus aureus* to a DACC-coated dressing vs. an uncoated control showed that the DACC-coated material bound significantly more bacteria: mean 1.5x10^6 vs. 6.8x10^4 CFU/cm^2 ($p<0.0001$; Fisher's exact test) (Fig 5). The authors stated that this is preliminary evidence that Cutimed Sorbact is effective against antibiotic-resistant pathogens.

In 2009, Hastings investigated the effects of CSH levels and exposure time on the hydrophobic interaction of *Staphylococcus aureus* and *Clostridium difficile* cells with Cutimed Sorbact.[30] The number of cells from a suspension that bound to the dressing was estimated using ATP luminometry. The result, presented in a poster, showed that the expression of high CSH was associated with greater hydrophobic attachment by the 3-hour mark (Fig

Table 1. Summary of *in vitro* evidence on hydrophobic interaction and dressings

Study	Comparators	Outcome measures	Main results
Bowler et al.[26] (1999)	One Hydrofiber and two calcium alginate dressings	Ability to sequester and bind potentially pathogenic microorganisms via simulated wound fluid	Hydrophobic and hydrofiber dressings have a superior ability to absorb and retain *Staphylococcus aureus* and *Pseudomonas aeruginosa*
Ljungh et al.[16] (2006)	N/A	Effect of microbes' CSH levels on their ability to bind to a hydrophobic dressing	Microbes expressing CSH are likely to bind to hydrophobic dressings; hydrophobic dressings should be used on wounds with medium/high exudate
Hastings[30] (2009)	N/A	Ability of hydrophobic dressing to bind *Clostridium difficile* cells/spores, *Pseudomonas aeruginosa*	Pathogens with high CSH bind to hydrophobic dressings in higher numbers
Cooper and Jenkins[31] (2013)	N/A	Ability of Cutimed Sorbact to bind MRSA and *Pseudomonas aeruginosa* biofilms; efficacy of DACC	Cutimed Sorbact effectively binds biofilms and DACC enhances this process
Ronner[29] (2014)	DACC-coated dressing vs. uncoated control	Binding capacity of *Staphylococcus aureus* vs. MRSA	DACC-coated dressing bound significantly more bacteria ($p<0.0001$)

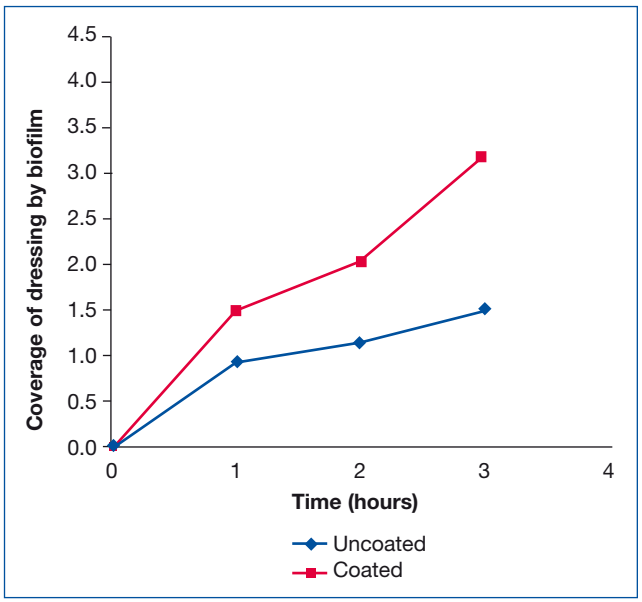


Fig 8. Binding of MRSA biofilm to a DACC-coated dressing material and an uncoated control[31]

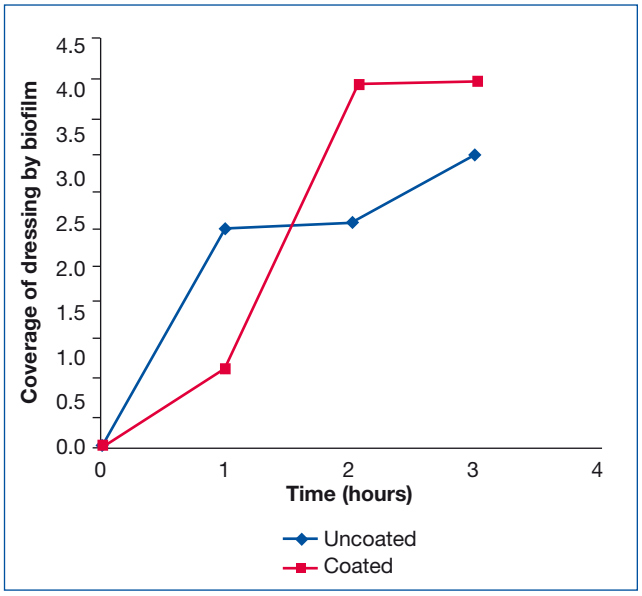


Fig 9. Binding of *Pseudomonas aeruginosa* biofilm to a DACC-coated dressing material and an uncoated control[31]

6). Marked hydrophobic bonding was also achieved with *Clostridium difficile* spores (Fig 7). Hastings observed that removal of *Clostridium difficile*, particularly spores, might prove advantageous for patients who are susceptible to this infection.

Effects on MRSA and *Pseudomonas aeruginosa* biofilms

While Ljungh et al.[16] and Hastings[30] have demonstrated the efficacy of Cutimed Sorbact in binding planktonic bacteria, Cooper and Jenkins[31] describe, in a poster, an *in vitro* test measuring its ability to bind biofilms of methicillin-resistant *Staphylococcus aureus* (MRSA) and *Pseudomonas aeruginosa*. This was the first *in vitro* study to an attempt to bind Cutimed Sorbact to bacterial biofilms.

Isolated cultures of MRSA and *Pseudomonas aeruginosa* (from patients with chronic leg ulcers) were cultivated for 24 hours in 24-well plates. Using sterile samples of Cutimed Sorbact with and without DACC coating, dressing samples were examined at intervals of up to 3 hours. SEM images showed that biofilms of MRSA and *Pseudomonas aeruginosa* irreversibly bound to a greater extent to the coated dressing samples than the uncoated ones. The *Pseudomonas aeruginosa* biofilms demonstrated a higher affinity to Cutimed Sorbact than did the MRSA biofilms (Figs 8 and 9), based on an arbitrary scoring system. The authors concluded that Cutimed Sorbact effectively binds to biofilms and the DACC coating enhances this process.

These *in vitro* studies are also summarised in Table 1.

Clinical evidence

This section outlines all of the existing clinical evidence available on Cutimed Sorbact. Peer-reviewed evaluations with sufficient sample sizes are described in the text below. The rest of the evidence is summarised in Tables which appear at the end of this supplement.

Leg ulcers

Using molecular diagnostics to measure the bacterial load

A non-comparative double-blind pilot study by Gentili et al.,[32] which set out to measure the reduction in bacterial burden in chronic leg ulcers treated with Cutimed Sorbact, found that the hydrophobic dressing resulted in positive clinical outcomes in 15 out of 20 chronic leg ulcers treated (75%), as well as a marked decrease in the bacterial load in ten (50%) of these cases.

As standard culture tests are unable to isolate and quantify the full range of bacterial species in a wound, Gentili et al. used a molecular alternative — panbacterial real-time polymerase chain reaction (RT-PCR) technique — which is able to determine the total bacterial load. Twenty chronic leg ulcers (arterial or venous) of 19 patients were rinsed with 0.9% sodium chloride saline solution before being surgically debrided and treated with Cutimed Sorbact for 4 weeks. Patients also received compression therapy. Dressings were changed and wounds rinsed twice a week. Punch biopsies were taken at the beginning and end of the 4-week follow-up period. A sample of superficial wound fluid and tissue debris was obtained from the Cutimed Sorbact dressing at each dressing change. Data were recorded on the wound size and amount of necrotic, granulation, fibrin and epithelial tissue present, as well as pain levels. Wounds were photographed at each weekly dressing change. Quality of life was assessed using the standardised SF36 questionnaire.

Quantitative real-time PCR was used to determine the total amount of bacteria from both the biopsies and swabs.

Of the 20 wounds treated with Cutimed Sorbact, there was a significant improvement in seven (77.5% average area reduction), two of which healed completely, and eight wounds improved (>50% reduction; mean reduction: 38.3%). Of the remaining five wounds, four increased in area (mean increase of 34.5%) and one was static.

The panbacterial RT-PCR showed a significant reduction in the bacterial load in 10 of the 15 (66%) healing chronic wounds. There was a 58% mean reduction in area in these wounds and, based on the biopsy results, a statistically significant (p=0.0243) 254-fold decrease in the total bacterial load. However, analysis of swabs from these same wounds, which were collected weekly for 4 weeks, showed no significant variation in bacterial load.

Five of the above 15 healing wounds (mean reduction: 50% of affected area) saw only a non-significant 5.3-fold reduction in bacterial load, based on biopsies, despite their positive clinical outcomes. Like the other 10 wounds, there was no change in bacterial load according to the swabs.

The remaining five static/deteriorating wounds (mean wound area increase of 27%) saw a non-significant 5.2-fold decrease in bacterial load according to the biopsies and no significant change in bacterial load based on the swabs.

While there is no explanation for the inconsistent PCR swab results, the authors warn of other reports that demonstrate inconsistent swab results.[33] The authors note that chronic wounds at an advanced stage of healing may still be colonised by a high number of bacteria at the surface, even though deep-tissue infection has been eradicated and recommend that, when carrying out PCR studies, analysis must be carried out with biopsies.[32]

Reduction in clinical signs of infection

Bruce found that use of Cutimed Sorbact Hydroactive resulted in a reduction in the clinical signs of infection in almost all of the 14 wounds they surveyed.[34] She evaluated the efficacy of Cutimed Sorbact Hydroactive in reducing signs of infection, as well as its effect on exudate management and healing, in a small multicentre evaluation undertaken in the UK and Ireland. The sample comprised 13 patients (7 males) with a mean age of 70 years (range 52–87). Thirteen wounds were chronic (had remained unhealed for >6 weeks), and the mean baseline wound duration was 12 months (range: 2 weeks to 33 months). All wounds exhibited clinical signs of infection, although the paper does not specify if antibiotics were required. Wound types comprised VLUs (VLUs) (n=9), traumatic wounds (n=4) and a mixed arterial ulcer (n=1). The VLUs had been treated with compression therapy. The clinicians were encouraged to use Cutimed Sorbact Hydroactive for 28 days or until signs of infection had reduced.

At the end of the treatment period, only two wounds were still classified as infected. These wounds had the shortest treatment periods, of 2 and 4 weeks, in contrast with the 8-week mean treatment length. The effect of the dressing on clinical signs of infection is depicted in Table 2.

In terms of progression towards healing, 11 wounds (79%) reduced in size, six (43%) by 75%. There was an associated reduction in signs of inflammation, with the baseline figure of 11 inflamed wounds (79%) reducing to four (29%) by the end of the evaluation. This was accompanied by an increase in epithelial tissue in five wounds. All but one wound had 'copious' or moderate baseline exudate levels, reducing to five wounds at the end of the evaluation, with five other wounds now producing light exudate levels and four no exudate. Similarly, all but two wounds were initially 'significantly' or 'moderately' malodourous, whereas by the end of the treatment period nearly the same proportion (79%; n=11) experienced only 'light' or 'no' malodour. Slough was present in six wounds at the start of the evaluation reducing to two at the end. Only three patients had a healthy periwound skin at baseline but this increased to seven, owing to the dressing's ability to vertically absorb and trap exudate. All of the clinicians found Cutimed Sorbact Hydroactive easy to apply and remove. Only one patient had pain at dressing removal, and then it was 'bearable'. Asked to score on a range of 0 to 10 how comfortable the dressing was under compression, patients gave it a mean score of 6, where the lower the score, the more dissatisfied the patient).

Table 2. Effect of Cutimed Sorbact Hydroactive on the clinical signs of infection (n=14 wounds)[34]

Clinical sign	Baseline No. of wounds (%)	Endpoint No. of wounds (%)
Erythema	9 (64%)	0 (0%)
Heat	6 (43%)	0 (0%)
Oedema	8 (57%)	1 (7%)
Pain	12 (86%)	2 (14%)

Reducing the need for antibiotics

Newer literature from Brambilla et al.[35] contained data showing that use of Cutimed Sorbact reduced the need for antibiotics in patients with clinical signs of infection. The 63-patient multicentre study, conducted in centres across Germany, Italy and Austria, involved patients with VLUs of less than 1 year's duration. Mean baseline wound surface area was 5.1 ± 12.0cm^2. The patients' ages ranged from 41 year to 92 years. Of the wounds, 82% showed signs of inflammation, 4% were covered with necrosis and 59% by slough. Most patients had either heavy (24%) or moderate (76%) exudate levels. Almost all (93%) had pronounced erythema around the wound margins.

The treatment protocol, which lasted for 6–12 weeks, comprised one week of short-stretch compression bandages (Comprilan or Tensoplast) to control oedema, followed by Cutimed Sorbact if the wound was infected, and, once the oedema had resolved, application of Jobst UlcerCare compression therapy. Initially, dressing changes took place daily but this frequency decreased when the signs of infection reduced.

Following treatment, 85% of the wounds either healed (full closure) or reduced in size (by 43.8–92.4%). There

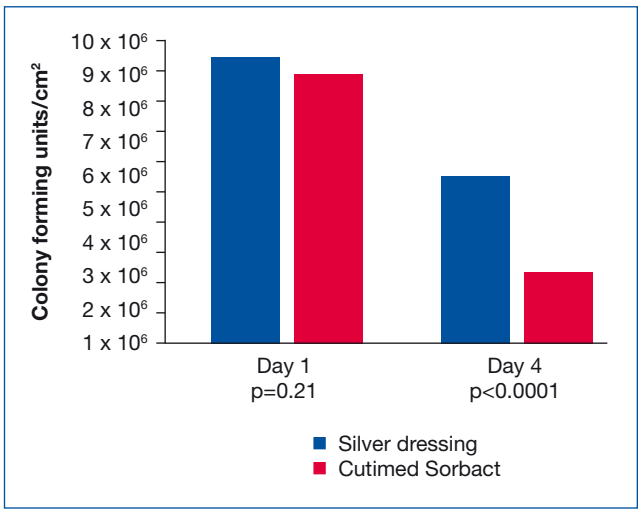


Fig 10. Comparison of bacterial loads at day 0 and day 4[36]

was also an improvement in wellbeing. Cutimed Sorbact was applied to 48% of patients with clinical signs of infection (erythema, itching, pain and malodour). In none of these cases were antibiotics required, although two other patients did develop an infection that had to be treated systemically. An overall reduction of redness was also noted. Patients experienced a substantial improvement in wellbeing and, as a result, patient adherence was high.

Comparative trial of DACC technology vs. silver

The only published comparative study on the use of Cutimed Sorbact in patients with chronic leg ulcers yielded results that favoured the hydrophobic dressing.[36] The investigators compared the efficacy of Cutimed Sorbact with Aquacel Ag (ConvaTec) in controlling the bacterial load in patients with critically colonised or locally infected chronic leg ulcers prior to skin grafting in a hospital in Italy. A silver dressing was chosen as the comparator because of persistent concerns about silver's potential toxicity and the risk of bacterial resistance.[37]

The patients (n=40) were randomised to the two groups (n=20 in each one). The grafting procedure took place after an observation period of 4 days, during which time the allocated dressing was changed daily. With the exception of dressing used, the treatment protocol was the same for both groups. Swab samples were taken to quantify the bacterial load at inclusion and on the final day of the observation period. No antibiotics were used.

The two groups were comparable in terms of age, sex, leg ulcer aetiology, wound size and duration, and bacterial load. Thirty patients had VLUs and 10 had arterial leg ulcers. All ulcers had an ABPI of >0.6. On entry, the mean wound surface area was 50cm^2 and the mean wound duration was 32 months. All patients completed the evaluation. Results showed that while the mean bacterial load was similar in both groups at inclusion, after 4 days of prophylactic dressing use it had reduced by a significantly greater proportion in the Cutimed Sorbact group than in the silver group: mean 73% vs. 42%, respectively ($p<0.00001$) (Fig 10). Both dressings were reported to be easy to apply and remove, and neither caused any adverse events. Ulcer-related pain scores were similar in both groups. Two patients in the silver group reported intense burning after dressing application, which lasted for a few hours and then disappeared without further problem.

Pressure ulcers

Case-control evaluation

While there is extensive evidence on Cutimed Sorbact in patients with pressure ulcers (PUs), most of it is anecdotal. However, a small Italian randomised clinical trial involving patients with infected pressure ulcers found that Cutimed Sorbact helped improve the wound bed characteristics, and significantly reduced periwound oedema and erythema. This case-control trial (n=33), conducted by Mussi and Salvioli,[38] set out to compare reduction of signs of infection between patients treated with Cutimed Sorbact and a control group, as well as to note comparative effects on autolytic debridement. Patients had at least one infected PU (n=36 PUs); the categories were not specified but are referred to elsewhere in literature as severe.[39]

Patients were randomised (method not specified) into either the control group (n=14) or the Sorbact group (n=19). The two groups were similar in terms of patient demographics and morbidity. The control group received specific therapy according to local guidelines; this included mobilisation, appropriate nutrition, broad-spectrum systemic antibiotics, topical treatment with 'povidone-iodine' solution, collagenase and medicated plasters. In the Sorbact group, the hydrophobic dressing was used as a topical medication instead of the plaster. It is not clear whether the povidone-iodine and collagenase were also used with the Sorbact, which could be seen as a limitation. Medication was changed, on average, once a day.

Treatment with Cutimed Sorbact improved the colour of the wound bed (95% of Sorbact patients vs. 72% of control patients; p=0.034), significantly reduced periwound oedema and erythema (79% vs. 57%; p=0.028), aided debridement and resulted in a faster healing time (9 ± 2 days vs 11 ± 2.1 days; p=0.041) (Fig 11). While there was a small increase in granulation tissue formation, as well as a decrease in ulcer volume in the Cutimed Sorbact group, this was not significant.

Diabetic foot ulcers

Reducing signs of infection

The efficacy of Cutimed Sorbact in the treatment of infected or at-risk chronic diabetic foot ulcers (DFUs) was demonstrated in a case-series evaluation, in which most of the wounds saw a reduction in the number and severity of signs of infection and all wounds decreased in size. This non-randomised case series, undertaken by Haycocks and Chadwick in the UK, set out to examine the dressing's ability to reduce signs, symptoms and risk of infection in 19 patients with 29 DFUs.[40]

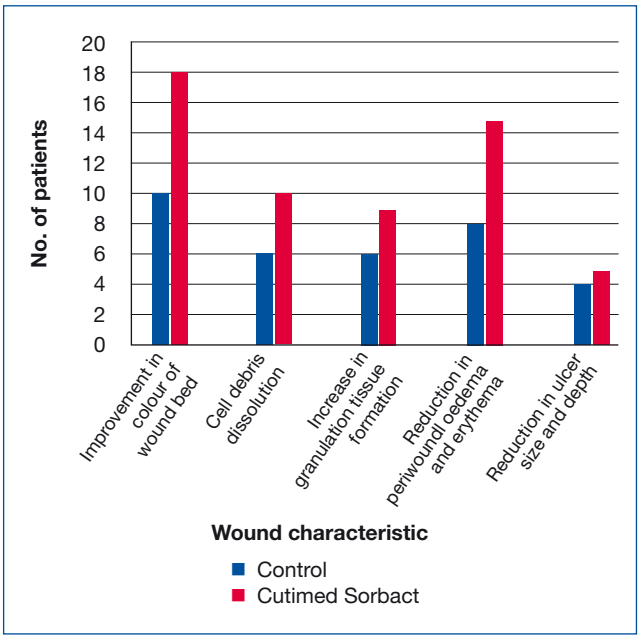


Fig 11. Improvements in infected pressure ulcers: Cutimed Sorbact vs. a control[38]

Participants in this single-centre open evaluation had active DFUs (mean duration: 11 months) that were treated with Cutimed Sorbact over a 4-week period (or until the ulcer healed). The patients, who had peripheral neuropathy, had a vascular supply that could support healing, as evidenced by at least one palpable foot pulse. On entry, the mean ulcer duration was 11 months (range: 3 weeks – 9 years) and the mean wound size was 4919mm^3 (range 34,500–12mm^3). Participants received appropriate debridement and offloading.

On entry, 22 of the 29 DFUs had two or more signs of infection (erythema, heat, oedema, pain, malodour, high exudate levels)[41] and most (n=21; 95%) were being treated with systemic antibiotics. At the end of the 4-week treatment period, all of the signs of local infection had resolved, with the exception of only one sign (high exudate level) in one wound. Nevertheless, this wound still reduced in size, while there was also an improvement in the quality of its margins. There was a similar improvement in terms of maceration, with seven of the eight macerated wounds resolving at week 4. However, it should be noted that a large proportion of patients also received systemic antibiotics.

Of the 29 wounds, eight (27.6%) healed completely, 10 reduced by>75% (34.5%), 10 reduced by >50% (34.5%) and one reduced by 25%. All patients (or carers) rated the dressing as 'excellent' in terms of comfort, acceptability and ease of use, and all clinicians considered its ease of use to be 'excellent'. Patients and clinicians regarded it as an uncomplicated and comfortable method of treating DFUs.

Fungal skin infections

An alternative to pharmaceutical treatment

In 2009, Johansson et al.[24] found that Cutimed Sorbact Ribbon Gauze is a potential alternative to pharmaceutical treatments for interdigital fungal infections in the diabetic foot. Unlike pharmaceutical treatments, however, Cutimed Sorbact is not associated with adverse effects and antibiotic resistance.

The sample in this non-randomised open pilot study comprised 20 consecutive patients with a topical interdigital fungal infection who were attending a diabetic foot clinic in Sweden. All patients had experienced previous fungal infections for which they had received topical pharmaceuticals. The investigating podiatrist applied Sorbact ribbon gauze (2x50cm) at the first visit. Patients were instructed to wash and dry their feet, apply the dressing and change their socks daily for 10 days. The patients attended the clinic on days 1, 5 and 10 when the investigating podiatrist assessed whether the lesion had deteriorated, remained unchanged, improved or healed. A blinded observer with no connection to the investigator or patient also assessed photographs of the lesion. A significant change was defined as an increase or decrease in wound size of >50%, and healing as intact skin with no localised reaction. Patients self-assessed on the days they did not attend clinic. Culture swabs were taken before inclusion and on days 1, 5 and 10 for fungal screening.

The sample comprised 20 patients (14 male; 6 female) aged 26 –74 years. By day 10, 50% (n=10) of the wounds had healed, 25% (n=10) had improved, 20% remained unchanged (n=4) and 5% (n=1) deteriorated. By day 10, 55% (n=11) of patients had no fungal growth; of these, 82% (n=9) either improved or healed, demonstrating a strong correlation between no growth and improved healing.

No adverse reactions were reported. This is noteworthy considering that, in the only comparable study[42] on the treatment of fungal infections in patients with diabetes (in this case with antifungal agents), local skin reactions occurred in 4–5% of the sample (n=429) despite excellent healing rates. However, the difference in size between Schopf's[42] and Johansson's[24] study means it is difficult to make a fair comparison.

The blinded observer's assessment supported the clinical observation about the number of healed digits, but differed in terms of the percentage that had improved or remained unchanged (10% and 35% respectively). The authors said this discrepancy could be owing to the poor quality of the photographs taken.

Three quarters of the patients found the dressing 'very easy' or 'easy' to use, with only three patients finding it 'difficult'. The investigator considered the dressing 'very easy' or 'easy' to use in all patients. The investigators commented that use of an independent assessor helped to validate their results (Table 3).

Multiple wound types

Early evaluation on effect on *Staphylococci*

One of the first clinical evaluations was conducted by Friman in the late 1980s.[43] This was a non-comparative study investigating the ability of Cutimed Sorbact to eliminate signs of local infection in 31 patients, the majority

of whom were immunocompromised and/or had poor blood perfusion (68%). Results showed that the infection reduced in just over two thirds of the wounds.

At the start of the evaluation, 32 wounds of varying aetiologies were deemed to be infected based on the presence of pus. The wounds were treated with Cutimed Sorbact and assessed at least twice a week. Treatment continued until wounds had either healed, as determined by no signs of local infection, or until treatment was considered unsuccessful. The median treatment period was 9 days.

Infection improved in 22 of the 32 wounds (69%), with the highest rate of improvement occurring in the first week. The remaining wounds deteriorated or remained unchanged. Cultures taken at the start of the evaluation showed that seven wounds grew only *Staphylococcus aureus*. A final culture taken at the end of the evaluation showed that this bacterium was still present in six of these seven wounds, but none of them showed signs of clinical infection. However, culture from wounds that had shown mixed bacterial flora on entry now revealed that the *Staphylococci* had been eradicated. Nursing staff found the dressings easy to apply and noted that they were effective in softening even sticky debris. No serious adverse effects were observed.

Early evaluation

In 2004, Von Hallern et al.[44] investigated the efficacy of Cutisorb Sorbact (as the dressing is referred to in this paper) in reducing infection in 36 patients with 'multiple types of infectious and secondary healing wounds' (wound aetiologies were not specified). No antiseptic solutions or ointments were used, and surgical debridement and irrigation with Ringer's solution was only performed if necessary. Swabs taken at the start of treatment deep inside the wounds and from wound margins revealed the presence of *Staphylococcus aureus*, *Pseudomonas*, coagulase-negative *Staphylococcus*, beta-hemolysing *Streptococcus*, *Enterococcus faecalis*, *Escherichia coli* and *Klebsiella oxytoca*. Cutisorb Sorbact was covered with an absorbent compress or hydroactive dressing. Systemic antibiotics were required in only two cases (6%). Dressings were initially changed daily and then on alternate days in the first 2–4 days of treatment.

The researchers noted that, generally after 8–10 days, signs of local infection, which were not specifically described, completely subsided and the condition of the wound improved (no numbers were given). No tolerability issues or complications were reported.

Effect on bacterial strains

The following year, these results were supported by a large evaluation, which showed that Cutisorb Sorbact (again, as the dressing was termed in this paper) reduced bacterial counts, based on analysis of deep-wound swabs.[45]

A total of 418 patients with colonised and infected wounds treated with Cutisorb Sorbact were observed from June 2003 to March 2005. Wound types comprised:

Table 3. Results of the assessments made by the study investigator and the blinded observer (n=20 patients)[24]

	Day 5	Day 10*
Deteriorated	2	1 (1)
Unchanged (<50% reduction in size)	7	4 (7)
Improved (>50% reduction in size)	11	5 (2)
Healed	0	10 (10)

* Bracketed figures relate to the photo evaluations

traumatic wounds (27%), abscesses, furuncles (boils) and phlegmons (purulent inflammation and infiltration of connective tissue) (20%), postoperative wounds (18%), pressure ulcers (18%), leg ulcers (13%), and (preoperative) diabetic gangrene (5%). (Some of the traumatic wounds were contaminated.) The authors did not indicate how they defined colonised or infected wounds. Baseline wound durations ranged from a few hours to 48 months and treatment with Cutisorb Sorbact lasted from 2 to 53 days.

Wounds were irrigated with an antiseptic and Ringer's solution, any necrotic tissue was debrided, and the Cutisorb Sorbact dressing was applied. Signs of infection usually decreased markedly in the first 2–8 days of treatment. The investigators observed that, in some of the wounds (number not specified), a thin layer of fibrin was replaced by a fine layer of well-perfused granulation tissue within 2–3 days. After 10–12 days, it was usually possible to switch to a foam dressing. None of the patients discontinued treatment with Cutisorb Sorbact owing to a deterioration in the wound or intolerance to it.

The researchers also obtained deep-wound swab specimens (using brush biopsy) for bacteriological analyses from 9% of patients (n=38) with a variety of chronic (e.g. VLUs and PUs) and postoperative wounds (e.g. post-open forefoot amputation, fistula excisions and evacuation of infected heamatomas). On the initial swabs, presence of bacteria such as *Staphylococcus aureus*, MRSA, *Pseudomonas*, *Streptococci* and *Escherichia coli* was confirmed. While the frequency of biopsy swabs was not specified, the authors reported a quantitative decrease in bacterial strains and noted that, in some cases, microbes were detected on the Sorbact dressings that were no longer showing as present on the swabs. Cutisorb Sorbact was therefore found to result in microbial elimination, supporting the observed reduction in clinical signs of infection.

Efficacy on infected wounds

A non-randomised European multicentre evaluation, published in 2008, found that Cutimed Sorbact eradicated local wound infection in 84% of the multiple wound types assessed.[28]

A total of 116 patients attending four wound-healing centres in Germany, Austria and Switzerland were recruited into the evaluation. All patients had wounds that were infected or at high risk of infection. The participating clinicians were instructed to use Cutimed Sorbact as part of their normal therapeutic regimen for them. The centres

had historically shared the same treatment protocols.

The mean age of the sample was 63 years (range: 27–95), and 47% were female. Wound aetiologies comprised: diabetic foot ulcers (22%), postoperative wounds (18%), 'post-infectious' (16%), PUs (10%), arterial leg ulcers (9%), mixed aetiology leg ulcers (8%), VLUs (7%), traumatic wounds (5%), ulcers with other aetiologies (3%) and burns/corrosion (2%). Baseline wound duration ranged from 1 day to 54 months old (mean: 6 months).

Wounds were classified as either infected or non-infected (critical colonisation was not included as a diagnostic criterion). At the first assessment, 98 (84%) of the wounds were categorised as infected, based on the presence of the following clinical signs: skin irritation, erythema, oedema, pain, increased exudate and malodour. Following treatment with Cutimed Sorbact, the infection was eradicated in 79 (81%). (Systemic infection (<10%) was also treated with antibiotics.)

The mean treatment period was 37 days (range: 4–134 days). The mean dressing change frequency was 2.5 per week. After treatment with Cutimed Sorbact, 24 wounds healed (21%), 84 improved (72%), seven were stagnating (6%) and one had deteriorated (1%).

With regards to pain, which was assessed at dressing change, the percentage of patients reporting no wound pain increased from 52% at baseline to 84% by the end of treatment; there were reductions in mild pain (33% vs 15%), moderate pain (4% vs 1%) and severe pain (10% vs 1%). (Data were missing for one patient.) There were no reported side-effects, no discolouration of wounds and no product-specific odour during the treatment course. Most clinicians (97%) rated ease of use as 'good' or 'very good'. Results for the dressing's compatibility with other products indicated that hydrogel was the best secondary dressing. Interestingly, this runs contrary to *in vitro* findings reported by Ljungh et al.[16] earlier.

The authors deemed Cutimed Sorbact to be a cost-effective alternative to other antimicrobial products and noted that the variety of shapes and sizes allows for flexible treatment of different wound types.

Effect on healing outcomes

In a UK evaluation, Hampton[46] undertook an evaluation of 21 patients with recalcitrant wounds of different aetiologies at high risk of clinical infection. The results found that use of Cutimed Sorbact promoted healing in almost all (96%) of these non-healing wounds.

Patients with non-healing wounds (no signs of healing had been observed in the previous 3 months) were recruited into the evaluation. Wounds were debrided when appropriate. Clinical infection was an exclusion criterion. The sample comprised 21 patients (mean age: 83 years) with the following wound types: PUs (n=7); mixed aetiology leg ulcers (n=5); VLUs (n=4); sinus wounds (n=2); an arterial leg ulcer (n=1); a surgical wound (n=1); and a traumatic wound (n=1). Most wounds (70%) were covered with devitalised tissue (described as black, black/yellow, yellow, or yellow/red). Cutimed Sorbact was applied for 4–10 weeks, depending on the stage of healing reported at week 4.

During the first 4 weeks, six wounds (29%) healed, 14 (67%) were progressing towards healing, with granulation or epithelial tissue present, and the remaining patient remained static. There was a concomitant reduction in malodour and exudate levels: malodour was present in 5 wounds (28%) at day 1 compared with none at 4 weeks; the number of patients with high or moderate exudate levels fell from a baseline of 19 (90%) to 15 (73%) at week 4, with a reduction in all seven cases (33%) with high baseline exudate levels. Correspondingly, dressing change frequency decreased from an average of three times weekly to an average of one or two times weekly. The number of patients with a healthy periwound skin increased from 8 (38%) at enrolment to 14 (68%) at week 4. Pain scores also improved significantly over the test period. Fourteen patients agreed to a litmus strip measure; the pH level reduced to <7.4 in nine of these patients (64%), resulting in a more acidic environment conducive to healing. Baseline pH levels and the healing outcomes of the remaining five patients were not specified.

Effects on healing outcomes

A Canadian evaluation by Sibbald et al.[47] investigated the overall effect of Cutimed Sorbact in promoting healing in 14 patients with chronic DFUs (n=8) or chronic VLUs (n=6). Inclusion criteria were adequate blood supply to heal (ABPI >0.5), no uncontrolled systemic disease and the absence of medication that could prevent wound healing. The entire sample comprised 13 men and one woman with a mean age of 60.8 years (range 18–85). All wounds (n=14) were >1 month in duration. In all cases, the underlying aetiology was treated, standard wound care was provided, and wounds were debrided as necessary. The treatment period with Cutimed Sorbact was 4 weeks.

Of the 14 wounds, 10 improved. The remaining four wounds occurred in patients with independent factors thought to have delayed healing, such as complex coexisting diseases and poor adherence to a pressure-offloading device. The mean wound area of the entire sample reduced from a baseline of 1.74cm^2 to 1.15cm^2 at week 4 (p=0.337), showing a trend towards a reduction in size. In addition, mean pain scores, measured on a numerical scale (0–10), reduced from a baseline of 3 to 2.07 at week 4 (p=0.145). The dressings were found to be easy to apply and remove, and there were no serious adverse events.

Signs of superficial and deep infection were objectively assessed using the NERDS (Non-healing wounds; Exuding wounds; Red and bleeding granulation tissue; Debris on wound surface (yellow or black); Smell) and STONES (Size – bigger; Temperature – increased; Os (probe to or exposed bone); New or satellite areas of breakdown; Exudate, oedema, erythema; Smell) clinical criteria.[47] The authors noted that there was no difference in NERDS and STONE scores, although unfortunately they did not provide any supporting baseline and endpoint data.

Table 4. Summary of the key peer-reviewed clinical evidence on the Cutimed Sorbact dressing range*					
Author	Study design	Aetiology	Sample	Outcome measures	Main findings
Leg ulcers					
Gentili et al.[32] (2011)	Non-comparative double-blind pilot study	Chronic arterial ulcers and VLUs	n=20	Wound healing and size; bacterial burden	Positive clinical outcomes in 75% of cases and marked decrease in bacterial load in 50% of cases
Bruce[34] (2012)	Multicentre study	VLUs; traumatic; mixed arterial	n=14	Signs of infection; exudate; wound size	Reduced oedema, pain, odour, exudate; 79% of wounds reduced in size
Brambilla et al.[35] (2013)	Multicentre study	VLUs	n=63	Healing and wound size; QoL (survey based on Tübingen questionnaire)	Reduction in wound size or complete healing in 85% of cases; improved QoL
Mosti et al.[36] (2015)	Comparative study: Cutimed sorbact vs. Aquacel Ag	Critically colonised or infected chronic leg ulcers	n=40	Reduction in bacterial load prior to skin grafting	After 4 days, the mean percentage reduction was 73% vs. 42% in favour of Cutimed Sorbact
Pressure ulcers					
Mussi and Salvioli[38] (2004)	Case-control trial	PUs	n=33	Wound bed colour; oedema and erythema; effect on debridement; healing time	Sorbact improved wound bed colour, oedema and erythema, aided debridement and resulted in faster healing time
Diabetic foot ulcers					
Haycocks and Chadwick[40] (2011)	Non-randomised single-centre open case series	DFUs	n=19	Wound size; pain; signs, symptoms, risk of infection; maceration; malodour; healing; ease of use	100% of wounds reduced in size; all patients reported reduction in pain; reduced infection, maceration, exudate, erythema and malodour; all patients and carers rated dressing as 'excellent'
Fungal skin infections					
Johansson et al.[24] (2009)	Non-comparative non-randomised open pilot study	Interdigital fungal infections	n=20	Wound healing; fungal growth; ease of use	Day 10, 75% improved, 50% had healed; 55% had no fungal growth and 82% of these had healed or improved; patients and investigator found dressing 'very easy' or 'easy' to use
Multiple wound types					
Von Hallern et al.[44] (2004)	Pilot study	Multiple types of infectious/secondary healing wounds	n=36	Signs of infection and bacteria (swab)	Signs of infection subsided; marked improvement in wound conditions; progress in granulation and epithelialisation; no antibiotics needed in 94% of cases
Von Hallern and Laing[45] (2005)	Observational study	Varied infected wounds	n=418	Microbial count; pain; comfort; patient/nurse satisfaction	Microbial elimination supporting reduction in clinical signs of infection
Kammerlander et al.[28] (2008)	Non-randomised multicentre evaluation	Varied wound types	n=116	Inflammation; local infection;healing; tolerability; compatibility with other products; ease of product handling	Cutimed Sorbact improved 72% of wounds; 21% healed completely. Of infected wounds, 81% healed and 93% saw an improvement
Hampton[46] (2007)	Observational study	Varied non-healing wounds	n=21	Reduced bioburden; inflammation, exudate and malodour	Healing progression in 96% of wounds; complete healing in 29% wounds over 4 weeks
Sibbald et al.[47] (2012)	Non-comparative clinical evaluation	DFUs; VLUs	n=16	Eradication of superficial and deep infection; healing	Improved healing in 71% of patients; no significant difference in infection
* Von Hallern 2004[44] and 2005[45] were not peer reviewed					

Effect on autolytic debridement

In 2010, Stephen-Haynes et al. undertook a multicentred clinical audit of the use of Cutimed Siltec and Cutimed Sorbact Gel on 32 patients.[48] Only the results relating to Cutimed Sorbact are summarised here. The 14 patients treated with Cutimed Sorbact Gel presented with leg ulceration (n=8), PUs (n=2) and other wound types (n=4). The authors stated that the 'majority' of wounds had been present for >3 months but did not specify exactly how many this was. Baseline wound characteristics were also not described. While some success was noted with regards to its use on critically colonised wounds, the consensus among the clinicians who applied the dressing was that its main benefit related to its ability to autolytically debride sloughy tissue. Cutimed Sorbact Gel facilitated autolytic debridement in five wounds and supported granulation tissue formation and epithelialisation in a further four. Three wounds remained static and three deteriorated (one patient continually removed the dressing and the other two had high exudate levels, for which Cutimed Sorbact Gel is not indicated).

The results of all of the clinical evaluations described in this section are summarised in Table 4.

Negative pressure wound therapy

The benefits of negative pressure wound therapy (NPWT) in wound management are manifold. It is used to create moist conditions, drain exudate, reduce periwound oedema, increase granulation, reduce malodour and pain, stabilise wound margins, stimulate angiogenesis and, ultimately, achieve wound closure and prepare the wound.[48-50]

Foam or gauze dressings are most often used as wound fillers to deliver negative pressure to the wound bed and ensure equal distribution across its surface. Both fillers are seen to be of equal clinical efficacy in human studies,[51] but with different benefits and drawbacks. For example, foam is more absorbent but gauze is more malleable where a wound's margins or depth, for instance, require more flexible treatment. Clinicians are best placed to determine which option is best suited to each individual case.

Either of these options can also be impregnated with an antimicrobial such as PHMB or silver, although there is no evidence that NPWT reduces bacterial colonisation.[52]

Foam, however, has been reported to cause more pain during dressing change as a result of tissue ingrowth caused by its open pore structure.[53,54] A liner can be used to provide a wound contact layer which can avoid adherence, therefore promoting atraumatic removal and protection of vulnerable underlying structures. Cutimed Sorbact may be used as both a liner and an effective alternative wound filler and has been found to distribute negative pressure to the wound bed as effectively as gauze or foam.[55]

Animal study: Cutimed Sorbact versus foam and gauze: vascular effects

A porcine laboratory study by Malmsjö et al.[56] compared the effects of Cutimed Sorbact with those of gauze or foam as a contact layer in NPWT. In particular, it assessed their performance in relation to pressure transduction to the wound bed, fluid retention, wound contraction and microvascular blood flow.

Circular wounds, measuring 6cm in diameter, were created on the pigs' back, to which NPWT was applied for 72 hours. Each parameter was assessed on 8 pigs. The results showed that the three different types of wound filler all provided similar pressure transduction (measured at settings ranging from 20mmHg to 160mmHg), but wound contraction was more pronounced for foam (e.g. 89.7% ± 1.3% at -120 mmHg) than for gauze (94.6% 0.7%) and Cutimed Sorbact (93.1% ± 1.4%) ($p<0.05$), which the authors attributed to foam's open cell structure. (The reduction in wound diameter was calculated as a percentage of the area before negative pressure was applied.)

Cutimed Sorbact and foam were found to remove fluid from wounds more efficiently than gauze, with the two dressings retaining approximately 2000mg vs. over 6000mg for gauze.

In terms of microvascular flow, which was measured 1 minute after application of NPWT, blood flow decreased in the immediate vicinity of the wound edge (0.5cm away from it), only to increase 2.5cm from the edge, while remaining unaltered at a distance of 5cm, where it was not affected by the NPWT. The increase at 2.5cm was similar with all wound fillers, but the decrease at 0.5cm was greatest with foam: -33.0 ± 4.1% for foam, compared with -22.2 ± 4.5% for gauze and -21.4 ± 5.8% for Cutimed Sorbact (with microvascular blood flow being expressed as a percentage change relative to the baseline values).

The authors stated that the reduction in blood flow achieved with NPWT stimulates angiogenesis and granulation tissue formation, which can help promote healing,[57,58] but that there is a risk of ischaemia if the circulation is already impaired. They concluded that this early preliminary evidence indicates that foam may therefore help maximise hypoperfusion, thereby stimulating angiogenesis, while gauze and Cutimed Sorbact may be preferable when vascularisation of tissue is in doubt.

They also proposed that Cutimed Sorbact and foam were more effective than gauze at removing fluid from these porcine wounds during NPWT as a result of their hydrophobic properties.

Animal study: Cutimed Sorbact versus foam and gauze: tissue ingrowth

One year later, the same investigators[59] published further preclinical evidence, again using a porcine model (n=8), to compare the above three wound fillers, although this time the outcomes were the quality and characteristics of granulation tissue formation, as well as microdeformation and the ingrowth of tissue. The same methods of creating the wounds and applying the NPWT were used as before.[56] Biopsy and histological examination showed that Cutimed Sorbact produced more granulation formation, leucocyte infiltration and tissue disorganisation in the wound bed than gauze, but less than foam.

The quantity of granulation tissue formation in each case was assessed blindly by two surgeons using a grading scale of 0–5 (where 0 is no granulation and 5 is fully granulated tissue). The assessors graded Sorbact granulation at approximately 3, whereas foam was closer to 4 and gauze closer to 1. Leucocyte count was number per μm^2. This was >300 per μm^2 for Sorbact, <200 per μm^2 for gauze and >500 per μm^2 for foam. Tissue disorganisation was defined as the disruption of contacts between cells and differences in cell size. Depth of tissue disorganisation was approximately 400µm for Sorbact, nearer to 300µm for gauze and about 600µm for foam.

Histological analyses of the cross sections taken of the wound bed indicated that all three wound fillers caused an undulating wound bed. Such undulations are associated with microdeformation, which is thought to stimulate angiogenesis and granulation tissue formation.[60]

The histological images also showed ingrowth of tissue into foam, but not into gauze or Cutimed Sorbact. Correspondingly, considerable force was required to remove the foam, compared with little force for Cutimed Sorbact and gauze: 9.1 ± 1.3mN versus 2.1 ± 0.4mN and 1.0 ± 0.2mN, respectively. (These values were calculated by a custom-made force measurement device following removal of the filler at a constant speed of 4mm/second.)

The investigators concluded that Cutimed Sorbact compared favourably with gauze in terms of its ability to promote granulation tissue, but did not have the disadvantage of tissue ingrowth associated with foam.

Table 5. Summary of peer-reviewed evaluations and case studies on NPWT

Study	Comparators	Outcome measures	Main results
Evaluations			
Malmsjö et al.[56] (2012)	Gauze and foam vs. Cutimed Sorbact	Animal study: effects on pressure transduction to the wound bed, contraction, microvascular blood flow in the wound edge and fluid retention in porcine wounds	Results for all three dressings were similar for pressure transduction. Wound contraction was more pronounced for foam than for gauze and Cutimed Sorbact. Cutimed Sorbact and foam removed more fluid from the wound, compared with gauze. Foam decreased blood flow at 0.5cm away from the wound edge to a greater extent than did Cutimed Sorbact and gauze
Malmsjö et al.[59] (2014)	Gauze and foam vs. Cutimed Sorbact	Animal study: effects on granulation tissue formation and ingrowth of wound bed tissue into the wound filler in porcine wounds	Cutimed Sorbact was associated with more granulation tissue formation than gauze, but less than foam. There was ingrowth of tissue into the foam filler, but not into Cutimed Sorbact or gauze
Case series			
Study	**Sample**	**Clinical challenges**	**Outcome**
Bateman[62] (2013)	n=3 patients	**Non-healing surgical site infection (1):** wound infected with *Enterbacteria* and faecal flora; measured 23x15x5cm with 50% soft necrosis, thick slough, strong malodour, macerated periwound skin and high exudate levels **Non-healing surgical site infection (2):** wound infected with *Staphylococcus aureus*; wound measured 7x2x4cm and was sloughy, with mild malodour, minor soft necrosis, macerated periwound skin and moderate exudate levels **Non-healing surgical site infection (3):** wound infected with *Pseudomonas aeruginosa*; wound measured 8x8x5cm and was sloughy, with strong malodour and high exudate levels. All patients received systemic antibiotics, with NPWT plus Cutimed Sorbact as a wound liner	**Non-healing surgical site infection (1):** malodour disappeared and slough reduced in week 1; exudate volume reduced by 50% at week 2. NPWT and systemic antibiotics were discontinued at week 3. Wound measured 17x10x1cm at week 4 **Non-healing surgical site infection (2):** malodour disappeared within 4 days and slough within 1 week. NPWT was discontinued at 4 weeks, when exudate reach manageable levels. Wound measured 6x1x3cm at week 4 **Non-healing surgical site infection (3):** exudate level reduced by 50% in 2 weeks, by which time slough had also disappeared. NPWT and systemic antibiotics were discontinued at week 3. Wound measured 3x3x2cm at week 4
Bateman[61] (2015)	Non-comparative evaluation involving 10 patients with locally infected, non-healing wounds	Clinical study: to determine the clinical benefits of using Cutimed Sorbact as a liner for NPWT	All wounds reduced in size within 3 weeks (mean reduction: 40%). All patients had been receiving NPWT before entering the evaluation. Use of Cutimed Sorbact as the wound filler resulted in a reduction in the subsequent NPWT treatment period in seven patients, when compared with the NPWT treatment time before their entry into the evaluation

Jeffreys[63] (2014)	n=7 patients	**Reconstruction following sacral osteomyelitits:** reconstruction comprised large flaps to cover residual bony prominences and skin grafts to cover flap donor sites. Residual raw areas were left to heal by secondary intention **Surgery to open sinus on amputation stump:** granulation tissue present was curetted during surgery. **Facial reconstruction:** deep facial burns resulting in a significant soft-tissue defect. NPWT used to prepare the face for reconstruction **Reconstruction following flash burn to arm:** deep burns were excised and reconstructed with a dermal substitute, followed by immediate skin grafting. NPWT was then applied. **Evacuation of haematoma:** large volume of exudate expected **Deep flame burn on arm**: deep burn **Deep ankle wound caused by a cast following a fracture:** the wound extended from the malleolus to the extensor retinaculum (which is in front of the ankle joint). There was a 6x4cm area with full-thickness necrotic tissue All wounds were treated with NPWT plus Cutimed Sorbact as a filler and liner	**Reconstruction following sacral osteomyelitits:** Cutimed Sorbact conformed easily to the irregularities of the wound surface. As it is non-adherent, dressing changes were straightforward and there was no need for a liner. Wound healed in 3 weeks **Surgery to open sinus:** Cutimed Sorbact filled the irregular defect well and its non-adherent nature allowed for simple dressing changes. Healing progressed well and the patient was able to wear a prothesis in 3 months **Facial reconstruction:** Cutimed Sorbact used in order to prevent wound infection, splint the wound and facilitate outpatient dressing changes. After 1 week, the wound bed was ready for reconstruction with a dermal substitute. Four weeks later, the site was ready for grafting **Reconstruction following flash burn:** Cutimed Sorbact dressings were removed after 1 week, when the skin graft was observed to have taken well **Evacuation of haematoma:** dressing changes took place on the ward. Skin grafting took place 6 days after decompression surgery post-evacuation. Graft took very well **Deep flame burn on arm**: burn was excised, and a skin substitute was applied, followed by grafting. Cutimed Sorbact used with NPWT in order to splint the wound and prevent dislodgement of graft at first dressing change. Skin graft took well **Deep ankle wound caused by a cast following a fracture:** the dressing filled the cavity completely and its non-adherent nature enabled dressing changes to take place on the ward. Full healing occurred without need for skin grafting

Clinical studies

Clinical evidence relates to the use of Cutimed Sorbact as a wound liner with NPWT, and as both a filler and liner with this therapy.[61] Bateman described the use of Cutimed Sorbact swab as a liner in three patients with non-healing wounds complicated by SSIs.[62] After 3 weeks, microbiology swabs were negative and by 6 weeks the patients were being managed by conventional low-cost dressings in the community. More detail is given in Table 5.

More recently, Bateman[61] conducted a 10-patient case series, involving 10 patients, where a Cutimed Sorbact swab was also used as liner with NPWT. Patients had exuding, locally infected wounds that were not healing despite treatment with NPWT. Subsequent use of Cutimed Sorbact as a NPWT liner was associated with reduced treatment times and, therefore, cost savings.

The sample comprised an equal ratio of men and women, with a mean age of 51 years (range 28–68 years). Wound aetiologies were: surgical (n=5), burn (n=1), ulcer (n=2), trauma (n=2). Swab results showed that the wounds were infected with pathogens including *Staphylococcus aureus* (n=3), *Pseudomonas aeruginosa* (n=4), Strep A and B necrotising fasciitis (n=1) and *Candida albicans* (n=1).

Negative pressure wound therapy was used with gauze as the filler, which was changed twice a week, and Cutimed Sorbact as the liner, which was replaced weekly.

Wound size reduced in all patients within 3 weeks, with a mean reduction of 40% (median 38%, range 10–75%). After two weeks of treatment, there was a marked reduction in exudate levels, with the number of patients with highly exuding wounds falling from a baseline of eight to zero (Fig 12). Microbiology results were negative for 6 patients at week 1 and in all patients at week 2.

The mean treatment duration with Cutimed Sorbact as a NPWT liner was 27 days (range 14–56 days). In seven patients, the NPWT treatment period reduced after the first application of Cutimed Sorbact as a liner: mean 9 weeks (range 3–23) vs. mean 3 weeks (range 2–8) before and after this time point. This, in turn, yielded cost savings.

Finally, Jeffreys[63] described the first reported use of Cutimed Sorbact as both a filler and liner with NPWT. The sample comprised seven patients with complex pre- and postoperative surgical wounds, on whom Cutimed Sorbact was used because of its flexible shape and ease of handling and application. The dressing was found to be as good as gauze in terms of its ability to conform to irregular wound shapes, while eliminating the need for a separate liner saved time and money. There were no instances of dressing adherence or ingrowth of tissue into its structure. Jeffreys concluded that the patient outcomes were as good as would be anticipated with conventional wound fillers. More detail is given in Table 5.

Other evidence

In addition to the published evaluations summarised above, there is a wealth of non-peer-reviewed evaluations and case series on the use of Cutimed Sorbact in different settings and wound types. These are summarised in Tables 6–8.

Conclusion

While the evidence base on Cutimed Sorbact comprises mostly case series and clinical evaluations, it is large and covers most wound aetiologies. When viewed in its totality, it is compelling. The findings show that Cutimed Sorbact can be safely used on critically colonised and locally infected wounds for long periods of time, with no adverse events or toxicity issues. In addition, it has been found to reduce wound bioburden, evidenced by a concomitant reduction in signs such as exudate levels, slough, erythema and maceration of the surrounding tissue, malodour, ongoing pain and local warmth. This resulted in a progression towards healing in previously chronic, recalcitrant wounds, with many reducing in wound size or healing during the follow-up periods. By implication, this low-cost dressing has the potential to achieve cost savings. More comparative studies are needed to substantiate these findings, but based on clinical experience described in this supplement, it is fair to conclude that Cutimed Sorbact is a safe and effective alternative to antimicrobial wound dressings.

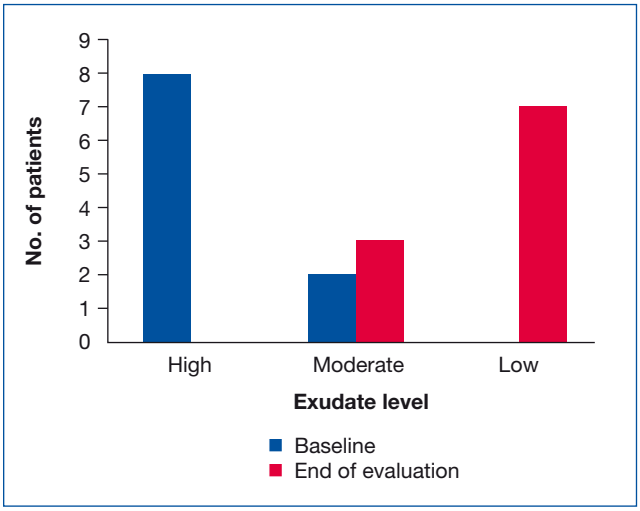


Fig 12. Reduction in exudate levels.[61]

Table 6. Summary of non-peer-reviewed evaluations on Cutimed Sorbact (poster presentations)

Study	Sample size	Design	Wound type	Outcome measures	Main findings
Traumatic wounds					
Corsi et al.[64] (2012)	n=440	Italian comparative, non-randomised evaluation: DACC vs antimicrobial dressings (eg, silver, alginates, PHMB) DACC: n=320 patients with 380 wounds Antimicrobial dress-ings: n=120 patients	Traumatic wounds (in emergency department)	Healed versus non-healed wounds at weeks 6–8	DACC group: 77% healed at 2-week follow-up. Of the remaining 23%, half had a high bacterial load at the first follow-up and half had an infection-free wound at 8 weeks. Control group: 18% presented with signs of infection within 2 weeks. Of the remainder, 78% had not healed at 8 weeks
Leg ulcers					
Will et al.[65] (2011)	n=29	German multicentre non-comparative evaluation	Chronic venous and mixed aetiology leg ulcers	Healing at 6–12 weeks	In 52% of cases, wounds healed completely. Others saw reductions in wound surface area of 44–92%. Of the infected wounds (proportion not specified), 48% saw a significant improvement in wound status or complete healing and 93% saw an improvement in reddening in wound edges, even in cases of chronic ulcers where patients had not seen any healing over extended periods
Brambilla et al.[66] (2014)	n=31	Italian case series	Large or multiple smaller chronic VLUs	Healing	68% of wounds healed completely or epithelialised almost fully within 3 months. Patient wellbeing and adherence improved considerably

Powell[67] (2014)	n=19	UK observational evaluation	Chronic VLUs	Healing	74% of the ulcers healed completely or epithelialised almost fully. Quality of life (QoL) and adherence improved substantially and there was an overall reduction in impaired mobility
Pressure ulcers					
Cassino et al.[68] (2011)	n=15	Italian observational study	Deep, narrow, infected PUs with moderate to heavy exudate	Progression towards healing at 8 weeks	40% of the PUs healed and 60% improved. The reduction in the depth ranged from 55% to 80%
Multiple wound types					
Lui et al.[69] (2008)	n=15	Italian non-controlled observational study	PUs: 6 VLUs: 9 All wounds had at least 3 clinical signs of infection	Reduction in signs of infection	Reduction in signs of infections, as illustrated by thee case studies
Corsi[70](2012)	n=80	Italian comparative evaluation: Cutimed Sorbact Gel vs silver dressings	Chronic wounds on the lower limb: n=40 Acute traumatic wounds: n=40 (75% burns)	Healing at 4 months. Signs of infection and pain levels	The average healing time in the Cutimed Sorbact group was 12 days versus 20 days for the silver group. No patients in the Cutimed Sorbact group developed signs of infection vs 12 in the silver group. There were lower pain scores for the Cutimed Sorbact group: mean visual analogue score (VAS): 4 vs. 8. Two patients withdrew from each group
Von Hallern[71] (2012)	n=100	European observational study	VLUs: 35% Arterial ulcers: 15% DFUs: 3% PUs: 13% Postoperative dehisced wounds: 24% Traumatic wounds: 7% Others (eg, skin tears): 3%	Reduction in levels of necrotic tissue and signs of infection. Healing	After a minimum of 10 days of treatment, signs of infection and the amount of necrotic tissue decreased in 53% and 56% of the wounds respectively. There was also decreased inflammation and increased proliferation
Lang et al.[72] (2013)	n=144	German observational study	VLUs: 31% Arterial ulcers: n=6% DFUs: 17% PUs: 21% Postoperative dehisced wounds: 1% Traumatic wounds: 6% Others: 18%	Wound healing. Reduction of signs of infection and healing	After 12 days of treatment, the number of wounds with signs of infection reduced from 41% to 24%. Wound completely or partially covered with granulation increased from 64% to 88% and those with complete or partial epithelialisation increased from 30% to 67%
By infection status (critically colonised, local infection, biofilm)					
Von Hallern et al.[73] (2007)	n=1934	German retrospective evaluation	Colonised and infected postoperative wounds: n=351 Colonised and infected VLUs: n=343 Contaminated, colonised and infected traumatic wounds: n=396 Abscesses, boils and phlegmones: n=335 Colonised and infected PUs: n=262 Infected diabetic 'gangrenes': n=247	Safety and tolerability	Only 8% of patients subsequently required antibiotics. Cutimed Sorbact resulted in a significant reduction in use of topical disinfectants and systemic antibiotics for wound management in the author's hospital

Grothier[74] (2013)	n=19	UK 4-week pilot audit of a clinical pathway designed to manage infection or prevent it in at-risk or high-risk patients. Cutimed Sorbact was included in the treatment pathway	Established infection: n=1 Critically colonised wounds: n=7 High risk of infection or recurrence: n=11	Effectiveness of the pathway	None of the high-risk patients developed an infection, despite many previous instances of infection recurrence. There was also an improvement in the symptoms of critically colonisation and infection, particularly pain. Within 6 months, incidence of wound infection decreased with a 20% savings in dressing costs
Cassino et al.[75] (2011)	n=72 patients	Italian observational study	Infected chronic wounds (aetiology not specified)	Effect on signs of infection	After 3 weeks, signs of colonisation were eliminated in >75% of cases and no allergic reactions were reported. Swab results revealed reductions in MRSA in 69% of patients (11/16), in *Pseudomonas aeruginosa* in 79% (22/28), in *Morganella morganii* in 83% (10/12) and *Serratia marcescens* in 100% (2/2)
Probst[76] (2013)	n=10	German pilot study	Wound biofilms treated with the regular protocol of either sharp (5/10) or ultrasonic (5/10) debridement, followed by Cutimed Sorbact	Healing. Reduction in wound biofilm	All patients showed a reduction in bacterial load and were progressing towards healing. This resulted in a change in protocol to sharp or ultrasonic debridement, followed by Cutimed Sorbact

Table 7. Summary of peer-reviewed case series

Author	No. of patients	Clinical challenges	Outcomes
Von Hallern et al.[44] (2004)	n=3	**Complete separation of dermis following a serious injury:** patient had femoral fracture. Despite intensive antiseptic therapy, there was poorly perfused granulation tissue. **Open wound after excision of labial abscess:** Patient had poorly controlled type 2 diabetes. Deep incision extended to perineal region. Necrotic tissue extended to bone at time of surgery **Chronic pilondial sinus:** excision of sinus resulted in an open wound that produced pus when exposed to pressure	**Complete separation of dermis following a serious injury:** daily surgical debridement, following by application of Cutimed Sorbact, were used to prepare the skin for mesh skin transplantation. After 6 days, 'infection-free conditions' were observed, along with well-perfused granulation tissue **Open wound after excision of labial abscess:** the clean cavity wound was packed with Cutimed Sorbact after the sixth postoperative day. Seven weeks after incision the infection-free wound was sutured. No other dressing was used **Chronic pilondial sinus:** Cutimed Sorbact was used for 4 days, and then replaced with a foam dressing. The wound healed in 4 weeks
Hampton[46] (2007)	n=5	**Multiple painful arterial leg ulcers:** ulcer duration was 5 years. The patient frequently rated his pain as 10 on a VAS. Wound bed comprised red tissue and slough. Extremely malodorous **VLU:** painful wound of 3 years' duration covered with malodorous thick slough. Patient had metastatic breast cancer **Category IV PU:** high levels of haemoserous, extremely malodorous exudate. Wound bed comprised 25% necrotic tissue **Traumatic leg wound:** malodorous wound, with red shiny appearance but no signs of infection **Chronic leg ulcer:** had been inflamed and wet for many years	**Multiple painful arterial leg ulcers:** pain reduced to 0 on VAS within 1 week and the wound beds were granulating with epithelial tissue present within 4 weeks **VLU:** after 7 weeks, the wound was covered with 62% epithelial tissue **Category IV PU:** after 1 week the necrotic tissue was replaced with yellow slough. The odour resolved by week 5 and full healing occurred by week 18 **Traumatic leg wound:** after 9 days the wound had debrided and granulation buds were appearing. Within 4 weeks, the wound bed was clean with some contraction of the wound margins. The wound went on to heal **Chronic leg ulcer:** after 1 week there were signs of Pseudomonas colonisation. After 2 weeks, epithelial tissue was apparent and the redness had subsided

Pirie et al.[77] (2009)	n=3	**Traumatic critically colonised wound on the arm:** evidence of hypergranulation and bleeding when touched **Traumatic wound on the heel:** wound had local infection with yellow/red wound tissue and high exudate levels. Wound margins were macerated and the surrounding skin was red **Wound on leg on patient with cellulitis:** the patient had not responded to oral antibiotics. Wound tissue was dusky red (75%) and yellow (25%) with moderate exudate levels. Intravenous antibiotics were administered	**Traumatic critically colonised wound on the arm:** after 14 days, the wound reduced in size from 4x2cm to 3x1cm, with areas of epithelialisation across the wound bed. The hypergranulation resolved in 1 week **Traumatic wound on the heel:** after 20 days, the wound had reduced in size from 4x2cm to 2.5x1.5cm and the local infection had resolved. Only low viscosity exudate was present. Treatment with Cutimed Sorbact continued after discharge to a care home, where the wound reduced further to 2.0x1.0cm, with no slough present **Wound on leg on patient with cellulitis:** after 3 weeks, the wound reduced in size from 17.5x11cm to comprise three small areas, measuring 0.3x0.2cm, 0.2x0.2cm and 0.1x0.1cm, which were still leaking exudate. There were no signs of infection
Powell[67] (2009)	n=5	**Venous and mixed aetiology leg ulcers:** one patient with three highly exuding, malodourous chronic wounds; one patient with a highly exuding ulcer that had failed to respond to silver dressings; one patient whose painful ulcer was producing green exudate and some malodour **Fungating wounds:** abdominal and breast wounds, with the latter covered with 100% slough. Strong malodour **Pilonidal sinus:** two wounds, one with total wound breakdown and the other with painful, inflamed (sloughy) wound	**Venous and mixed aetiology leg ulcers:** the first two patients' wounds healed or almost healed in 7 months and 8 weeks respectively; the third patient's wound reduced in size after 4 weeks and was less painful. Dressing change frequency reduced from daily to twice weekly **Fungating wounds:** the malodour and exudate levels had reduced by day 3. The wound was de-sloughing and the surrounding skin had noticeably improved by 2 weeks. There was a significant reduction in wound size at 8 weeks **Pilonidal sinus:** the first wound healed in 15 days and the second one reduced in size with 100% granulation tissue after 1 week. (The first wound was treated for 7 days with silver dressings and then 8 days with Cutimed Sorbact)
Derby-shire[78] (2010)	n=2	**Arterial leg ulcers:** patient with heavily ulcerated legs with heavy slough, visible biofilm, debris from previous wound products and malodour. Wound edges were macerated **Leg ulcer:** wound aetiology not specified, but leg was heavily ulcerated. Large areas of engorged tissue and biofilm on wound bed. Dressing changes were very painful	**Arterial leg ulcers:** both legs improved significantly after 3 weeks, with clear signs of granulation. Maceration had resolved **Leg ulcer:** after 3 weeks, the wound was de-sloughed and the pain at dressing change and maceration had reduced. The wound was still exuding, but there was granulation tissue formation
Hardy[79] (2010)	n=2	**Chronic oedema with leg ulceration and lymphorrhoea:** extremely painful and inflamed circumferential ulcer. Malodour present **Chronic oedema with varicose eczema and lymphorrhoea:** varicose eczema on the (macerated) forefoot and toes	**Chronic oedema with leg ulceration and lymphorrhoea:** after 2 months the malodour had almost disappeared and the leg was almost pain-free. The leg was healing well **Chronic oedema with varicose eczema and lymphorrhoea:** reduction in bacterial load helped to treat the eczema, while there was also an improvement in fungal infection. No strikethrough reported
Stephen-Haynes et al (2010)[48]	n=1	**Pretibial laceration**: wound was not infected, but it was sloughy, malodorous and the exudate volume was increasing	**Pretibial laceration**: after 7 days the wound had reduced in size from 6x6cm to 3x5cm, with no slough present. The wound was showing signs of healing
Skinner and Hampton[80] (2010)	n=4	**Infected toe on diabetic foot:** painful, locally infected, non-healing wound of 4 weeks' duration **DFUs:** the wounds were not expected to heal owing to the patient's poorly controlled diabetes and arterial disease. Wounds were colonised, with an increase in exudate but little pain. Wounds treated with Cutimed Sorbact pads **Inflamed toe on diabetic foot**: non-healing, painful toe, with erythema and maceration. **Toe on diabetic foot at risk of infection:** deep wound with necrotic tissue. Following autolytic debridement, Cutimed Sorbact ribbon was used as prophylatic	**Infected toe on diabetic foot:** the wound started to heal within 7 days, and reduced in size by one third after 10 days. The pain stopped **DFUs:** the bioburden reduced, with the wound bed becoming clean and healthy. There was slight maceration of the wound margins but this was not a problem for the patient. Wound remained free of colonisation **Inflamed toe on diabetic foot**: erythema and pain reduced within 24 hours, and the wound had almost healed on day 11 **Toe on diabetic foot at risk of infection:** use of the dressing avoided colonisation, and the wound progressed towards healing

Gray et al.[81] (2011)	n=4	**Sacral PU:** severely disabled patient; critically colonised wound of 4 years' duration **Sinus plus cavity wound:** highly exuding, critically colonised wound of 2 months duration. Wound size: 4x2x2cm. Had not responded to a variety of antimicrobial dressings. **Puncture wounds on leg:** non-healing wounds producing blood-stained fluid. Had not responded to antimicrobial dressings **Leg ulcer:** patient history of rheumatoid arthritis. Sloughy wound, with inflamed edges, at risk of infection	**Sacral PU:** after 4 weeks, wound reduced in size from 4x2x1cm to 1x2x1cm **Sinus plus cavity wound:** after 4 weeks of treatment, the sinus had almost closed and the cavity had closed **Puncture wounds on leg:** after 2 weeks of healing the wounds either healed or reduced in size to a depth of <1mm. The patient did not develop an infection **Leg ulcer:** after 14 days the wound reduced in size from 12x12cm to 10x11cm, with epithelial tissue present. The risk of infection was considered to be greatly reduced
Haycocks et al.[40] (2011)	n=2	**Infected DFU**: the wound, which was over the right first metatarsal joint area, was blistering, with local warmth and erythema on the surrounding skin. Antibiotics were prescribed, along with Cutimed Sorbact and Cutimed Siltec **DFU with osteomyelitis**: heavily exuding open wound that was prone to Pseudomonas infection. Switched from silver dressing to Cutimed Sorbact (absorbent pad version), as silver dressings must be used with caution in renal patients	**Infected DFU**: the erythema resolved and the ulcer reduced in size after 2 days. The wound healed in 5 weeks **DFU with osteomyelitis**: the Cutimed Sorbact pad dressing managed the exudate and the Pseudomonas infection resolved. The dressing was used for 6 months until full healing occurred
Bullough[82] (2012)	n=4	**Complex open abdominal wounds:** all wounds were infected. They had exposed bowel, were close to a stoma and were at risk of developing a fistula. Cutimed Sorbact was used instead of NPWT for the duration of the patients' hospital stay. All patients received antibiotics	**Dehisced abdominal wound:** the wound infection resolved in 14 days in all of the patients. Wound size reduced by 6–10% per week throughout the treatment period. One patient healed, two progressed towards healing in the community and one patient died

Table 8. Summary of non-peer-reviewed case series and case reports (poster presentations)

Author	No. of patients	Clinical challenge	Outcomes
Meuleneire[83] (2007)	n=5	**Wet eczema on leg:** wet eczema **Infected VLU:** heavily exuding wound with *Pseudomonas aeruginosa*. **Open abdominal wound:** Cutimed Sorbact used with NPWT to prevent infection. Antibiotic resistance **Fistula:** heavily exuding, malodorous wound with MRSA infection **Infected lymphatic ulcer:** exuding, malodorous and painful wound with *Pseudomonas aeruginosa* infection	Clinician reported that 'almost every wound reduced in size'. Bacterial 'balance' observed in a short period of time. No patient reports of pain. No adverse events
Von Hallern[73] (2007)	n=4	**Infected postoperative DFU** infection occurred after opening a plantar abscess. Cutimed Sorbact and antibiotic therapy used **Postoperative DFU:** open resection of second toe and metatarsus resulting in a 2.5cm deep wound plus maceration **Infected PU:** this 8-day-old wound was surgically debrided but antibiotics were not administered. The wound was debrided and irrigated with a topical antiseptic solution on a daily basis. Cutimed Sorbact Ribbon was applied to the wound cavity, along with Cutimed absorbent pad **Infected dorsal foot ulcer:** wound, which measured 12x4cm, was partly necrotic, with hypergranulation	**Infected postoperative DFU:** the wound starts granulating within one week, with the patient walking again at 3 weeks. Wound closure occurs after 9 weeks **Postoperative DFU:** patient walking again by 4 weeks and the wound closed at 12 weeks **Infected PU:** wound was infection free after 14 days, and the cavity was almost filled with granulation tissue. Rotation flap was then performed **Infected dorsal foot ulcer:** the infection and necrotic tissue had disappeared after 12 days. The hypergranulation had reduced and the wound was ready for mesh graft transplantation

Baiano et al.[84] (2008)	n=1	**Infected amputation stump:** patient had a history of vasculitis	**Infected amputation stump:** dressing effected autolytic debridement of dry tissue
Del Prato et al.[85] (2008)	n=1	**Neonate with an abdominal and upper-extremity abscess:** infected wound in extremely premature baby. Treatment regimen included antibiotics, topical disinfectant and Cutimed Sorbact	**Neonate with an abdominal and upper-extremity abscess:** granulation tissue formed at 4 weeks and healing occurred at 6 weeks, although there was keloid scarring
Palazzesi et al.[86] (2008)	n=1	**DFU:** patient presented with infected phelgmon (diffuse inflammation with purulent exudate or pus) and fever. Culture revealed *Streptococcus agalactiae* infection. Wound was cleansed with superoxide solution	Cutimed Sorbact was applied daily until the infection ceased, after which the wound healed within 15 days
Sigona and Pecci[87] (2008)	n=3	**Non-healing ankle abscess:** wound infected with biofilm and surrounded by eczema. Cutimed Sorbact was applied along with zinc-oxide ointment to protect the edges **Chronic abscess on ball of foot:** the wound was infected, and surrounded by eczema **Chronic abscess on ball of foot:** wound was inflamed with signs of biofilm	**Non-healing ankle abscess:** After 3 weeks, the wound bed was clean with signs of granulation tissue formation, and there was also an improvement of the surrounding skin. After 5 weeks, the abscess had started to reduce in size **Chronic abscess on ball of foot:** the wound starts to progress towards healing after 4 weeks **Chronic abscess on ball of foot:** the wound bed was cleaner and signs of severe inflammation and biofilm reduced after one month
Haycocks and Chadwick[88] (2010	n=1	**Complex diabetic foot wound:** patient underwent surgical resection of bone infected with osteomyelitis and removal of the sesamoids. He was then prescribed antibiotics, followed by Cutimed Sorbact	**Complex diabetic foot wound:** the dressing managed the exudate well. The wound healed after 15 weeks with no episodes of infection or recurrence
Veneziano[89] (2010)	n=1	**Infected circumferential wounds on both legs:** wounds infected with *Staphylococcus aureus* and *Pseudomonas aeruginosa*, with risk of amputation. Patient had cryoglobulinaemia-induced vasculitis	**Infected circumferential wounds on both legs:** Wounds were visibly clean within 12 days. Both legs healed, with the right leg healing in 8 weeks (healing time not given for left leg)
Probst[90] (2011)	n=1	**Infected chronic VLU:** highly inflamed ulcer with signs of periwound maceration. Wound swabs were positive for *Pseudomonas aeruginosa* and *Proteus mirabilis*. Wound underwent repeated surgical debridement, followed by ultrasound-assisted wound irrigation and Cutimed Sorbact	**Infected chronic VLU:** wound swabs revealed a reduction of bacterial load throughout the course of treatment. The wound improved and granulation tissue formation occurred within 3 weeks, paving the way for skin grafting. Complete healing occurred in just over 10 weeks
Probst and Matthies[91] (2011)	n=1	**Arterial leg ulcer:** patient declined bypass surgery. Patient self-harm	**Arterial leg ulcer:** 6 weeks after debridement, wound was treated with collagen powder and Cutimed Sorbact. At 11 weeks, the wound had enlarged, but granulation tissue was present. After reports of an increase in pain and swelling, NPWT and Cutimd Sorbact were applied. Wound subsequently divided into two smaller wounds. One wound closed within 2 months. Wound re-opening resulted in bypass and wounds reduced in size within 9 weeks. Cutimed Sorbact and collagen powder used again. Wounds reduced in size within 3 months. New wounds occurred, for which a microbial cellulose dressing was used, with complete closure occurring one month later. After a further episode of self-harm, the wound finally closed. Total treatment time was 26 months.

Probst and Steinhoff[92] (2011)	n=1	**Postoperative wound:** impaired healing following muscle removal in a patient who had undergone a mastectomy	**Postoperative wound:** NPWT, along with Cutimed Sorbact, was applied for 39 days. After this, Cutimed Sorbact and collagen powder only were applied in order to prevent infection. The wound improved over the next 6 weeks. Cutimed Siltec and collagen powder were then applied for approximately 1 month, resulting in a further reduction in wound size. Cutimed Sorbact was re-applied again, resulting in full healing 2 weeks later. The patient was pain-free throughout this treatment period
Probst and Steinhoff[93] (2011)	n=1	**Infected heel ulcer and ankle joint wound:** the heel ulcer was covered with dry necrosis and the ankle joint wound was infected with *Staphylococcus aureus.* The patient had arterial occlusive disease	**Infected heel ulcer and ankle joint wound:** the heel wound improved significantly after 31 days and healed in 95 days. The ankle wound initially improved following debridement, application of Cutimed Sorbact and skin grafting. However, it became infected with *Pseudomonas aeruginosa* and *Staphylococcus aureus* after 9 days, necessitating in surgical debridement and NPWT. Cutimed Sorbact was reapplied on day 72, together with a hydrogel for autolytic debridement and a collagen matrix. The wound had reduced in size by day 95
Riley[94] (2011)	n=2	**Infected heel PU:** patient was diabetic and developed osteomyelitis, for which antibiotics were prescribed. Risk of amputation **Dehisced forefoot amputation site:** patient had diabetes. The wound, which had a gaping suture line, had 60% slough, and was malodorous, with moderate to heavy exudate levels. There was also periwound maceration. Following NPWT, antibiotics and Cutimed Sorbact were prescribed	**Infected heel PU:** after 6 weeks the wound reduced in size from 4x2.5cm (with 1cm undermining) to 2.25x1.5cm, and was no longer considered at risk of amputation. By week 13, exposed bone was covered with granulation tissue, and by week 27 the wound had reduced to 0.75x0.5cm. The wound subsequently healed. **Dehisced forefoot amputation site:** after removal of sutures at 9 days, the wound dehisced, measuring 13.5cm with areas of dry necrotic tissue. Cutimed Sorbact pads replaced with Cutimed Sorbact swabs. By week 10, the wound had reduced to 10x2.5cm, and by week 20 it had contracted still further to 2.5x1cm. The wound subsequently healed
Turns[95] (2011)	n=1	**Non-healing DFU:** inflamed and painful ulcer accompanied by cellulitis and tracking up the foot. Antibiotics and Cutimed Sorbact were prescribed. Previously, the patient had undergone transmetatarsal amputation of the other foot	**Non-healing DFU:** within 4 weeks, the cellulitis had reduced, and the tracking resolved and the patient did not experience pain. There were no systemic symptoms
Weerasena and McGinnis[96] (2011)	n=1	**Neonate with critically colonised sternotomy wound:** dehisced wound, colonised with MRSA and covered with slough and necrotic tissue. Minimal local erythema and oedema were present. Patient had sepsis and was immunocompromised.	**Neonate with critically colonised sternotomy wound:** the MRSA colonisation was managed successfully and the wound healed
Cook[97] (2012)	n=2	**Dehisced amputation site on diabetic foot:** slough was debrided with a Hydrofiber dressing but the wound remained static, measuring 4x3cm. Wound bed was clean with fragile granulation tissue, but there was some malodour. Silver dressings were used with little effect. **Dehisced amputation site on diabetic foot:** at 10 weeks post-amputation, there was superficial slough, with moderate exudate levels and significant malodour. Wound edges were static. Use of cadexomer iodine appeared not to reduce bioburden	**Dehisced amputation site on diabetic foot:** the wound edges started to advance after 2 weeks and the wound had almost completely healed by 6 weeks **Dehisced amputation site on diabetic foot:** the wound improved within 2 weeks and full healing occurred at 6 weeks

Corsi[98] (2012)	n=4	**Wound following surgical diathermy for a non-cancerous skin lesion:** extensive dry or soft necrosis; pia mater exposed **Sacral PU:** extended to deep tissue with large areas of necrosis and biofilm **Forearm wound:** patient history of Behcet's disease and pyoderma gangrenosum. Silver dressings had resulted in an immediate recurrence and healing times of up to 12 months **Calf erysipelas following tattoo:** oedema of subcutaneous tissue and intense hyperaemia. Patient was feverish and in pain	**Wound following surgical diathermy for a non-cancerous skin lesion:** autolytic debridement of pia mater at 3 weeks; necrosis disappeared after 2 months; bone gap almost covered in just over 3 months. Antibiotics not used **Sacral PU:** necrotic tissue disappeared after 30 days; granulation tissue formation at 6 weeks. Healthy surrounding skin **Forearm wound:** epithelialisation almost complete at 3 months. Good scar formation **Calf erysipelas following tattoo:** symptoms disappeared after 8 days. No antibiotics used
Dursley et al.[99] (2012)	n=1	**Chronic VLU infected with MRSA:** this extremely painful, sloughy wound was producing high levels of exudate, despite administration of intravenous antibiotics. Cutimed Sorbact was used in conjunction with compression bandages	**Chronic VLU infected with MRSA:** wound size reduced significantly, with granulation and epithelial tissue visible, within 2 weeks. District nurse visits reduced from daily to twice weekly. The pain reduced and the patient's quality of life improved
McDonald[100] (2012)	n=1	**Infected traumatic leg wound:** patient had a history of leg ulceration, lymphoedema and vasculitis, and was at high risk of infection recurring. The wound was covered in 80% slough and producing high levels of exudate. Cutimed Sorbact was used with Cutimed Siltec	**Infected traumatic leg wound:** In 5 weeks, wound reduced from 4.6x1.9cm to 1.5x1.4cm, with 80% epithelial tissue and 20% healthy granulation tissue. There was no infection
McGuire[101] (2012)	n=1	**Dermal fungal infection complicated by secondary bacterial infection:** severe tinea pedis (athlete's foot) with secondary bacterial cellulitis. Had failed to respond to an antifungal agent, silver sulphadiazine cream and antibiotics. The wound was inflamed, painful and highly malodorous. Cutimed Sorbact was used in combination with oral antibiotics and fluoroquinolone	**Dermal fungal infection complicated by secondary bacterial infection:** the pain and malodour had almost resolved after one week. Itching and the interdigital ulceration resolved after 3 weeks, with only mild scaling remaining
Solit and Tobin[102] (2012)	n=1	**Infected chronic VLUs:** the patient had two infected wounds (one on pre-tibia and one on lateral leg) that had not responded to antibiotics and topical treatments. On presentation, she underwent radiofrequency ablation, followed by debridement, application of a skin substitute, and subsequent use of Cutimed Sorbact and compression therapy	**Infected chronic VLU:** no signs of infection were observed during the treatment period. Granulation tissue formation occurred in both wounds by week 2. The pre-tibial ulcer had healed fully by week 5, while the lateral leg wound continued to reduce in size
Suzuki[103] (2012)	n=3	**Chronic VLU:** the ulcer, which had a duration of 2 years, was large, malodorous and painful, with copious exudation. Periwound skin was inflamed and there were signs of mild cellulitis. The patient also had severe chronic oedema. Previous courses of antibiotics and gauze bandages were ineffective. Antibiotics, Cutimed Sorbact and compression therapy were applied **Chronic VLU:** 6-month duration. The wound was sharp debrided and irrigated, and Cutimed Sorbact was applied with compression therapy **Chronic VLU:** the ulcer had been recurrent over 2 years. The patient had type 2 diabetes mellitus. The wound was sharp debrided and irrigated, and Cutimed Sorbact was applied with compression therapy	**Chronic VLU:** the malodour resolved after one week, while the wound reduced in size, until full healing occurred after 16 weeks **Chronic VLU:** the wound healed in 13 weeks **Chronic VLU:** the wound healed in 15 weeks

Ambrose and Greene[104] (2013)	n=4	**Overgranulation of perianal abscess:** silver dressing and NPWT applied for 2 weeks, followed by Cutimed Sorbact **Overgranulation of groin abscess:** initial use of NPWT followed by silver dressing, which was discontinued when it had no effect on over-granulation **Overgranulation following toenail avulsion:** wound overganulated following application of a foam dressing because it was thought the wound bed was too moist **Overgranulation of traumatic wound on arm:** wound did not heal within 8 weeks (treatment not specified) most likely due to high bioburden	**Overgranulation of perianal abscess:** the overgranulation resolved, allowing the wound to heal **Overgranulation of groin abscess:** the overgranulation quickly diminished and the wound reduced in size **Overgranulation following toenail avulsion:** the wound healed in approximately 4 weeks **Overgranulation of traumatic wound on arm:** overgranulation resolved within 10 days, when Cutimed Sorbact was discontinued. Full healing occurred in one month
Calvin-Thomas[105] (2014)	n=1	**Chronic infected VLU:** ulcer duration was 10 years. Wound bed comprised 20% epithelial tissue, 20% granulation tissue and 60% slough. Malodour and green-tinged exudate were present, while the surrounding skin was inflamed. Patient would not wear compression bandages	**Chronic infected VLU:** the wound reduced from 3.5x2cm to 2x1cm in 4 weeks. The inflammation reduced and condition of the periwound skin improved. The amount of granulation tissue and epithelial tissue increased to 50% and 40% respectively, with slough reducing to 10%
Debono and Taliana[106] (2013)	n=1	**Traumatic wound with haematoma and popliteal cyst:** the wound was infected and very painful. Overgranulation and discolouration were present	**Traumatic wound with haematoma and popliteal cyst:** the wound started to reduce in size at 2 weeks, and healed completely at 17 weeks with minimal scarring
Derbyshire[107] (2013)	n=1	**Chronic leg ulcer:** aetiology not specified. Wound was covered with a thick layer of slough and was producing high exudate levels resulting in maceration of periwound skin	**Chronic leg ulcer:** after 2 weeks, exudate levels reduced and the wound showed signs of healing with 10% granulation tissue and 5% epithelial tissue
Espiritu et al.[108] (2013)	n=3	**Traumatic leg ulcer of over 4 weeks' duration:** ulcer measuring 4.0x3.5x0.1cm. Fibrin and necrotic tissue present on wound bed **Traumatic leg ulcer of over 6 weeks' duration:** two ulcers measuring 3.0x3.0cm and 1.0x1.0cm. Fibrin on wound bed **Traumatic leg ulcer of over 3 months' duration:** ulcer measured 6.5x3.5x0.1cm. Fibrin and necrotic tissue present on wound bed None of the ulcers showed evidence of malodour, purulent discharge or ascending erythema. Treatment regimen comprised porcine extracellular matrix plus Cutimed Sorbact	**Traumatic leg ulcer of over 4 weeks' duration:** complete epithelialisation occurred after 4 weeks **Traumatic leg ulcer of over 6 weeks' duration:** complete epithelialisation occurred after 6 weeks **Traumatic leg ulcer of over 3 months' duration:** complete epithelialisation occurred after 6 weeks
Fudge[109] (2013)	n=2	**Traumatic wound:** substantial laceration to leg complicated by an infected seroma, resulting in gangrenous ulceration. Patient received surgical debridement and NPWT with Cutimed Sorbact as the liner **Complex wound to the buttock and coccyx:** baseline wound size was 117.42cm^3. The wound was treated with NPWT and then Dakin's for 5 months before switching to Cutimed Sorbact	**Traumatic wound:** tissue improved within 3 days. Three weeks following this, the wound measured 89.54cm^2, decreasing to 68.4cm^2 within 14 days with no odour. Full healing occurred after approximately 20 weeks **Complex wound to the buttock and coccyx:** the wound had almost (99.3%) healed after approximately 10 weeks, although two small open tracks were still present
McGuire[110] (2013)	n=1	**Chronic VLU:** The 4-month old wound showed signs of haemosiderin staining as well as a *Pseudomonas* biofilm. Treatment included Cutimed Sorbact and compression therapy	**VLU:** there was a reduction in slough within 7 days, as well as rapid epithelialisation and a significant improvement in the periwound skin. The wound closed within 4 weeks
Probst et al.[111] (2013)	n=2	**Mycoses (fungal infection) in the abdominal skin fold:** intense infection with erythema and open exuding wounds **Mycoses in the inguinal fold:** erythema. In both cases, Cutimed Sorbact was changed daily and no additional antifungal medication was used	**Mycoses in the abdominal skin fold:** after 3 days erythema and signs of inflammation reduced, and after 6 days almost all of the open wounds had healed **Mycoses in the inguinal fold:** erythema and signs of infection had almost disappeared and the skin healed within 4 days

Rupert[112] (2013)	n=3	**Open abdomen with bowel discontinuity and necrotic fascia** **Complex surgical wound:** surgery included hernia and small bowel reduction, colostomy resiting, resection of necrotic abdominal wall and mesh placement for biological bridge of the fascia. Pseudomonas was present on the mesh **Amputation (hemipelvectomy) site with fistula:** heavy bioburden and periwound excoriation present NPWT and Cutimed Sorbact applied in all cases	**Open abdomen:** measures 6x1.5x1cm when Cutimed Sorbact first applied. After 2 weeks, slough, peri-wound maceration and infection disappeared, while healthy granulation tissue was present. Full healing occurred in just over 3 weeks **Complex surgical wound:** the wound closed after approximately 11 weeks of treatment with Cutimed Sorbact **Amputation site:** wound reduced from 190cm^2 to 45cm^2 in 37 days
Probst[113] (2014)	n=3	**Large ulcer on the gaiter region** (two patients) **Leg ulcer with abscess formation** All ulcers required wound bed preparation in advance of skin grafting. This comprised sharp debridement followed by application of Cutimed Sorbact	**Large ulcer on the gaiter area** (two patients: in first patient, mesh grafting was possible after 10 days of treatment with Cutimed Sorbact. In second patient (who had multiple other leg ulcers), the wound was ready for grafting after 4 weeks **Leg ulcer with abscess formation:** treatment protocol included NPWT. Wound was ready for skin grafting in 2 weeks

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