

Bacterial-binding dressings in the management of wound healing and infection prevention: a narrative review

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Abstract: The aim of this review was to present the clinical data on the use of the family of bacterial-binding dressings (Sorbact; dialkylcarbamoyl chloride-coated) in the treatment of a variety of acute and chronic wounds. The findings are discussed in terms of the effectiveness of the bacterial-binding dressings on bacterial bioburden reduction, infection prevention, initiation/progression of wound healing and cost-effectiveness. The evidence in support of

the bacterial-binding dressings is strongest in the area of infection prevention in surgical wounds, with several controlled trials showing the prophylactic benefit of the dressing in these wounds. Wound bioburden management in chronic wounds is supported by a number of clinical studies. In total, 29 published clinical studies (with a total of 4044 patients) were included in this review.

Declaration of interest: This work was funded by ABIGO Medical.

bacterial bioburden • chronic wound • dialkylcarbamoyl chloride (DACC) • infection • Sorbact • surgical site infection

A wound occurs when the integrity of the skin is broken. This injury usually heals via a series of four distinct but overlapping phases: haemostasis, inflammation, proliferation and granulation/remodelling.¹ However, skin wounds that are slow to heal, do not heal or recur become chronic and may be more susceptible to infection.^{2,3} This presents a significant clinical challenge^{4,5} and bacterial contamination and infection can further delay healing.^{6,7} Any wound can become colonised by microorganisms and this may lead to infection, but some wounds are more prone to the risk of infection than others. Patients with 'high-risk' wounds tend to have other concomitant factors, such as, old age, poor nutritional status, comorbidities or immune deficiencies that compromise the patient's ability to combat pathogenic bacterial infiltration/proliferation that results in infection.⁸⁻¹⁰

Surgical site infections

Surgical site infections (SSIs) are the most common type of hospital-acquired infection and can be defined as occurring at a part of the body where surgery has taken place within 30 days of the procedure or within one year of the procedure if a prosthetic surgical device was implanted.¹¹ Europe-wide, SSIs account for up to 20% of all hospital-acquired infections,¹² with figures from England suggesting that SSIs are the third most common health-care-associated infection.¹³ The incidence of SSIs varies according to the type of operation, with the

highest percentage in colon surgery (9.6%) and the lowest in knee prosthesis procedures (0.8%).¹⁴ The presence of an SSI, at least in part, is related to one in three postoperative deaths.¹⁵ The presence of an SSI can lead to additional costs, as highlighted in a recent systematic review across six European countries that investigated the impact of SSIs on health-care costs and patient outcomes.¹⁶ The results of the review demonstrated that SSIs:

- Were consistently associated with elevated costs, compared with patients without infection
- Patients required prolonged hospitalisation, reoperation and readmission
- Were associated with increased mortality rates.

Chronic wounds

In developed countries, it is estimated that 1–2% of the population will experience a chronic wound in their lifetime,¹⁷ although other studies suggest chronic wounds have a prevalence of as high as 6%.¹⁸ Older adults are at the highest risk of chronic wounds due to a combination of slowing wound healing with age^{19,20} and an increase in the incidence of cardiovascular disease and diabetes (associated with an increased incidence of chronic wounds).²¹ In addition, chronic wound infections are also responsible for considerable morbidity and significantly contribute to the escalation in resource use and costs.^{22,23} Infection is the likeliest single cause of delayed healing in chronic wounds.²⁴ In a recent evaluation of the impact and cost of chronic wounds in Medicare beneficiaries, Nussbaum et al. reported almost 15% of Medicare beneficiaries had at least one type of wound or infection.²² After surgical infections, diabetic wound infections were the next highest prevalence category (3.4%). Venous infections had a prevalence of 2.3%.

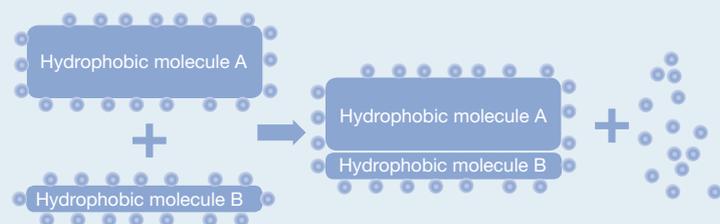
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Treatment of wound infection is generally undertaken using a combination of topical antiseptics, such as silver, and/or systemic antibiotics. Antiseptics, such as iodine, honey and silver, have a disruptive or biocidal effect on bacteria, fungi and/or viruses, with multiple sites of antimicrobial action on target cells, and therefore have a low risk of bacterial resistance. Topical antiseptics are non-selective and therefore may be cytotoxic, causing damage to the many cell types involved in healing, thereby impairing the healing process.²⁵ The use of topical antibiotics, for example topical metronidazole gel, silver sulphadiazine and Mupirocin, is controversial in the context of the global concern regarding antibiotic resistance. The use of topical antibiotics for wound management should only be considered in infected wounds under very specific circumstances.²⁵ A holistic approach to those with, or at risk of, wound infection is best practice in prevention and management²⁵ and is particularly important in relation to antibiotic resistance. The development and use of treatments for wound infection that do not involve the use of antibiotics is essential. Both antiseptics and antimicrobials are used to kill or reduce the level of bacteria by 'active' mechanisms such as damaging the bacterial cell wall.²⁶ Alternatively, the use of regimens that rely on a physical mode of action has also proved to be effective in wound bioburden management and there is no risk of bacteria developing resistance.²⁷ Dialkylcarbamoyl chloride (DACC), a fatty acid derivative, is an example of a physical mode of action for reducing wound bioburden. This review explores the clinical evidence that supports the use of a bacterial-binding dressing (Sorbact, ABIGO Medical, Sweden) as an alternative to active treatments in the management and prevention of wound infections, and reducing wound bioburden.

Bacterial-binding dressing

When two water-repellent (hydrophobic) surfaces come into close proximity, they bind with one another by hydrophobic interaction and expel water molecules (Fig 1). This is despite there being no force or attraction between the surfaces. DACC is a highly hydrophobic substance that, coupled with the hydrophobic nature of bacterial cell walls, mediates the irreversible binding of microorganisms to DACC-coated dressings. When applied directly to the wound bed, this results in binding of bacteria and fungi to the dressing surface.²⁸ The bound microorganisms are subsequently removed at dressing change resulting in a decrease in wound bioburden.²⁸ Rather than killing the bound microorganisms (as would happen with antibiotics or antiseptics), the physical binding means that their cell walls remain intact avoiding release of endotoxins. The binding of microorganisms from the wound bed makes the development of resistance unlikely as no absorption of DACC into the wound environment is known to occur, and clinical studies have reported an excellent safety profile when using Sorbact dressings.²⁹⁻³¹

Fig 1. The principle of hydrophobic interaction involved in DACC-microorganism interaction (modified from Ljungh et al.²⁸)



Two hydrophobic molecules (A and B) (such as a DACC-coated dressing and microorganisms) come into contact with each other and associate with one another via a hydrophobic interaction and water molecules are expelled

Methods

Searches of internet reference databases MEDLINE and Cochrane Library were undertaken to identify published articles describing clinical data relating to the use of DACC-coated dressings or Sorbact in the treatment of infection and support of healing in surgical, acute wounds (for example, burns) and chronic wounds. The following search terms were used: bacterial bioburden, chronic wound, acute wound, burn wound, dialkylcarbamoyl chloride, DACC, Sorbact, surgical site infection, SSI. The search was from January 1970 to November 2018. In addition, manual searches of relevant journals not indexed in online reference databases were performed. All articles investigating the use of the bacterial-binding dressings in wound care with primary and/or secondary outcomes related to infection and or healing were reviewed.

This overview takes the form of a 'narrative overview' that summarises the data from each reviewed article.³² Data from both randomised and non-randomised trials, cohort studies and case series reports were included. Only full text reports on human subjects and in the English language were included. Articles of case series with fewer than three cases were also excluded.

Results

The key articles are summarised in Tables 1 and 2.

Surgical site infections

SSIs have been consistently identified as the third most common healthcare-associated infection in the UK (after pneumonia and urinary tract infection) and are associated with considerable morbidity, mortality and costs.^{16,33,34} A recent systematic review confirmed that a significant number of SSIs occurred following various surgical procedures in European countries.¹⁶ The incidence of SSI was as high as 36% in one of the studies reviewed, demonstrating that infections constitute a persistent complication of surgery and a financial burden.³⁵ Furthermore, it has been reported that, in England, the mean total cost of orthopaedic and trauma surgery in those who developed an SSI was about 2.9 times higher than the costs associated with patients who did not.³⁶ At least 5% of patients undergoing a

Table 1. Key peer-reviewed clinical evidence for use of bacterial-binding dressings on acute wounds

Author	Study design/ sample size	Aetiology	Intervention	Outcome measures	Main findings
Stanirowski et al. ⁴³	Single-blinded randomised, controlled pilot study n=142	Emergency or elective cesarean section surgery	Intervention: bacterial-binding dressing Control: standard surgical dressing	Superficial or deep SSI within 14 days after c-section	SSI rates of 2.8% with the bacterial-binding dressing versus 9.8% in control (p=0.08)
Stanirowski et al. ⁴²	Single-blinded randomised, controlled study n=543	Emergency or elective cesarean surgery	Intervention: bacterial-binding dressing Control: standard surgical dressing	Superficial or deep SSI within 14 days after c-section. Cost-effectiveness of dressing to prevent SSI	SSI rates of 1.8% with the bacterial-binding dressing versus 5.2% in control (p=0.04). Total cost of SSI prophylaxis and treatments was greater in control group compared with the bacterial-binding group Only in the bacterial-binding group was there no use of systemic antibiotic treatment or hospital readmission
Bua et al. ⁴⁵	Prospective, non-randomised comparative study n=200	Non-implant vascular surgery	Intervention: bacterial-binding dressing Control: standard/conventional dressing	Primary outcome: presence of SSI Secondary outcome: included evidence of healing	Rate of SSI at five days was significantly lower in the bacterial-binding dressing group compared with control (1% versus 10%, p<0.05). There was no difference in the rates of SSI at 30 days
Choi et al. ⁵⁰	Case series n=7	Skin grafting on clean surgical wounds	Skin graft dressed with bacterial-binding dressing	Wound infection	No wounds became infected
McBride et al. ⁵¹	Prospective, randomised controlled study n=101	Clean donor site wounds	Intervention: bacterial-binding dressing Comparator: calcium alginate dressing or ointment-impregnated gauze	Primary outcome: days to re-epithelialisation Secondary outcome: includes cost and pain management	The bacterial-binding dressing was as effective as the calcium alginate dressing regarding re-epithelialisation, pain management and cost
Meberg and Schøyen ⁵⁷	Prospective randomised controlled study n=2441	Umbilical cord stump wounds	Intervention: bacterial-binding dressing Control: daily cleansing with 0.5% chlorhexidine in 70% ethanol	Infection in the newborn	No significant difference in either overall rate of infection
Bateman ⁶¹	Non-comparative evaluation n=10	Various infected wounds including DFU, SSI	Use of the bacterial-binding dressing as wound contact layer with NPWT	Wound size and characteristics	Exudate reduction and negative microbiology in all patients by week two. Wound size reduced for all patients
Bateman ⁹⁹	Non-comparative evaluation n=3	Surgical site infection wounds	Use of bacterial-binding dressing as wound contact layer with NPWT	Wound size and characteristics	All three patient's wounds progressed by week two, with no evidence of slough, malodour or necrosis
Bullough et al. ¹⁰⁰	Non-comparative evaluation n=4	Infected abdominal wounds	Bacterial-binding dressing used instead of NPWT on infected wounds	Wound infection	All signs of wound infection had resolved by day 14 of treatment; 3/4 wounds healed
Jeffrey ⁶⁰	Case series n=7	Various surgical wounds	Bacterial-binding dressing used as wound contact layer with NPWT	Wound improvement and quality of life benefits	Wound improvement with complete wound healing in several wounds

surgical procedure develop SSI, adding on average three days hospital stay and additional cost.³⁷ The annual incidence of infected chronic wounds in the UK has been reported to be up to 500,000 cases per year³⁸ with incidence of SSIs reported as being at least 16%.¹³ In the US, SSIs contribute to patients spending more than 400,000 extra days in hospital at a cost of an additional US\$ 900 million per year.³⁹ Table 1 summarises the key

clinical evidence in support of the bacterial-binding dressing in the treatment of SSIs.

Caesarean surgery

SSI is one of the most common complications following caesarean section and has an incidence of 3–15%.⁴⁰ It significantly affects the mother's well-being and is a weighty financial burden on the health-care system.⁴¹

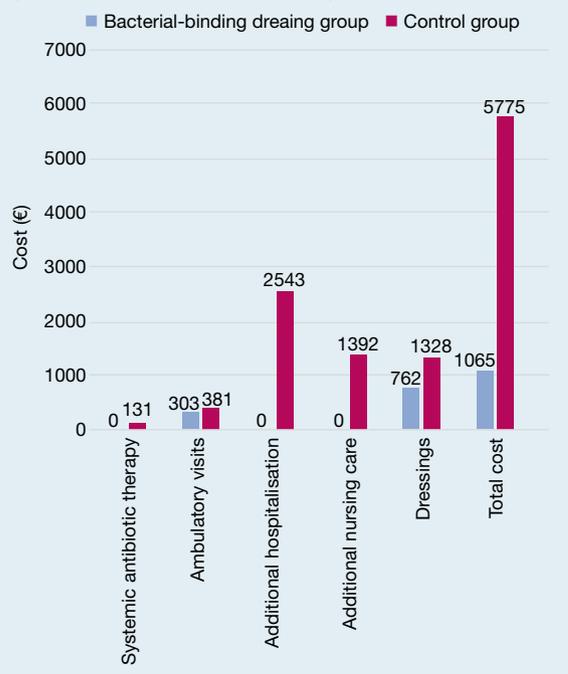
Table 2. Key peer-reviewed clinical evidence for use of the bacterial-binding dressing on non-healing wounds

Author	Study design/ sample size	Aetiology	Intervention	Outcome measures	Main findings
Brambilla et al. ⁷¹	Multicentre case study series n=63	VLU	Where signs of infection were present the bacterial-binding dressing was used under compression	Healing and wound size	Reduction in wound size or complete healing in 85% of cases, improved QoL
Genili et al. ⁷²	Non-comparative, double-blind study n=19	Chronic arterial ulcers, VLUs	Wounds treated with the bacterial-binding dressing for four weeks	Wound healing and size; bacterial load	Positive clinical outcomes in 75% of cases and marked decrease in bacterial load in 50% of cases 66% of wounds reduced in size
Mosti et al. ²⁹	Randomised, comparative, single centre study n=40	Critically colonised or infected chronic leg ulcers	Intervention: bacterial-binding dressing Comparator: silver-containing hydrofiber	Reduction in bacterial load	After 4 days, average bacterial load reduction 73.1% with the bacterial-binding dressing compared with 41.6% reduction in comparator (p<0.05)
Kammerlander et al. ⁷³	Non-randomised, multi-centre evaluation n=116	Various wound types including VLUs, DFUs, post-operative wounds	Wounds were treated with the bacterial-binding dressing as part of therapeutic regimen	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 81% of wounds were successfully treated for infection. 21% of wounds healed completely
Hampton ⁹²	Observational study n=21	Various non-healing wounds including pressure ulcers, VLUs, surgical wounds	Wounds treated with the bacterial-binding dressing	Reduced bioburden, inflammation, exudate levels, malodour, wound size, pain	Healing progression in 95% of wounds; 29% of wounds healed after 4 weeks
Sibbald et al. ³¹	Non-comparative clinical evaluation n=16	DFUs, VLUs	Wounds treated with the bacterial-binding dressing	Resolution of superficial and deep infection; healing	Improved healing in 71% of patients; no significant difference in infection
Mussi and Salvioli ⁸³	Case-controlled study n=33	Infected pressure ulcers	Intervention: specific guidelines for infected pressure ulcers with the bacterial-binding dressing substituted for usual dressing Control – specific guidelines	Wound bed colour; oedema and erythema; effect on debridement; healing time	The bacterial-binding dressing improved wound bed colour, oedema and erythema, aided debridement and resulted in faster healing time
Haycocks and Chadwick ⁹⁰	Non-randomised single-centre open case series n=19	DFUs	Wounds treated with the bacterial-binding dressing as a wound contact layer	Wound size; pain; signs, symptoms, risk of infection; maceration; malodour; healing; ease of use	By study end, all 29 wounds had reduced signs of infection. 69% of wounds had reduced in size and 27.6% of wounds had healed
Kleintjes et al. ⁶⁷	Prospective, randomised pilot study n=13	Partial- or full-thickness burn wounds	Intervention: the bacterial-binding dressing Comparators: nanocrystalline silver and silver dressings	Wound status (wound colour, epithelialisation, healing); bacterial load	Wound areas dressed with the bacterial-binding dressing subjectively cleaner and had less bacterial growth
Kleintjes et al. ⁶⁸	Prospective descriptive study n=27	Partial-thickness burns	Wounds treated with the bacterial-binding dressing	Wound appearance; wound size	Most wounds appeared clean and pink; 27% of wounds appeared healed

Post-caesarean SSI is associated with a maternal mortality rate of up to 3%.⁴⁰ The use of caesarean section is increasing globally and it is probable that there will be a parallel increase in the occurrence of SSI.

Therefore, developing strategies to diagnose, prevent and treat SSIs are essential to reducing post-caesarean morbidity and mortality.⁴⁰ The use of the bacterial-binding dressing in reducing levels of infection in caesarean section surgery

Fig 2. Cost of treatment of SSI after caesarean section (modified from Stanirowski et al.⁴²)



has been reported. In a clinical study undertaken by Stanirowski et al.⁴² patients undergoing caesarean section were randomised to either the bacterial-binding dressing or standard dressings. The patients were followed-up for 14 days postoperatively and the presence of superficial or deep SSI was assessed. Initially the results, reported as a pilot study,⁴³ demonstrated an SSI rate of 2.8% (bacterial-binding dressing) compared with 9.8% (standard dressing) ($p=0.08$). Also, patients receiving a standard surgical dressing and who had an SSI required systemic antibiotic therapy significantly more frequently than those receiving treatment with the bacterial-binding dressing ($p=0.03$). The full randomised control trial (RCT) reported overall SSI rates of 1.8% with the bacterial-binding dressing compared with 5.2% in standard surgical dressings ($p=0.04$).⁴²

Stanirowski et al. further examined costs related to treatment in each of the two groups. The results clearly demonstrated that the total cost of SSI prophylaxis and treatment was greater in the control group versus bacterial-binding dressing-treated patients (€5775 versus €1065, respectively, Fig 2). Specifically, in the bacterial-binding dressing-treated group costs related only to ambulatory visits, had fewer outpatient visits, fewer hospital bed-days and no women required hospitalisation for infection. Whereas in the control group, total cost encompassed prolonged hospitalisation, additional nursing care and systemic antibiotic treatment.

Vascular surgery

Although a major source for vascular surgery infections is by bacteria transference with vascular graft tissue,⁴⁴ patients undergoing non-implant surgery — as with

most surgical procedures — are also prone to infection via the surgical procedure. In a recent (non-randomised comparative) study, the use of bacterial-binding dressings was shown to be an effective treatment in this indication.⁴⁵ In this study, the effect of bacterial-binding dressing on the incidence of SSI in non-implant vascular surgery patients was evaluated; two groups of patients ($n=100$ in each group) were treated postoperatively either with conventional dressings or bacterial-binding dressings. The results highlighted that rates of SSI at 5–7 days was significantly lower in the bacterial-binding dressing group compared with the standard dressing group (1% versus 10%, $p<0.05$). Only a single patient in the bacterial-binding dressing group required seven days of intravenous antibiotics, while in the conventional dressing group, all 10 patients with SSI at days 5–7 were treated with antibiotics: two of these patients required intravenous antibiotics and the other eight patients were treated with oral antibiotics.⁴⁵ There was no difference in the rates of SSI at 30 days.

Skin grafting

A skin graft is defined as removal of healthy skin from an unaffected area of the body and used to cover an area where the skin has been lost or damaged.⁴⁶ A split-thickness skin graft (STSG) involves only the epidermis and a very thin layer of underlying dermis as part of the graft, thus maximising the opportunity for healing of the new graft to occur.⁴⁷ In order that the graft will 'take' (that is, become incorporated into the host bed), the wound bed must be prepared so as to minimise the risk of infection.⁴⁸ However, infection is a significant problem that can cause graft failure and prevention or treatment of infection is a requirement for optimising graft take.⁴⁹ The use of bacterial-binding hydrogel dressings for fixation of grafts after surgery was assessed in a seven-patient evaluation.⁵⁰ After treatment with the bacterial-binding dressing and a tie-over dressing (fine cotton gauze to help secure primary dressing in position), the wounds were assessed for infection at five, 14- and 30-days postoperatively. No SSIs were observed.

In a parallel, three-arm prospective RCT ($n=101$),⁵¹ bacterial-binding dressing was compared with two other dressings, including a calcium alginate (the most commonly used donor site wound dressing),^{52–54} in treating non-infected donor sites in paediatric STSG. The investigators found that the three dressings performed equally well when compared.⁵¹ Donor sites dressed with bacterial-binding dressing had a mean time to re-epithelialisation of seven days which was not statistically different compared with the other dressings, including the alginate dressing ($p>0.05$). There was also no statistical difference between the three dressings in pain scores. The authors concluded that there was no evidence for a preference between dressings.

Umbilical cord care

During birth, the umbilical stump can become infected and, if not treated promptly, a more severe, systemic

infection can occur which may lead to death (estimated mortality rate between 7–15%).^{55,56} The use of aseptic techniques during delivery, proper cord care and the use of chlorhexidine as a topical agent has been shown to reduce the risk of cord infection.⁵⁶ In a prospective, randomised study in newborn infants there was no significant difference in the incidence of infections between the bacterial-binding dressing and the chlorhexidine-ethanol-treated group, 16.3 versus 14.6% respectively, $p>0.05$.⁵⁷

Negative pressure wound therapy (NPWT)

NPWT involves the controlled application of sub-atmospheric pressure to the local wound environment using a sealed wound dressing connected to a vacuum pump. It has been shown to be a very effective form of treatment in hard-to-heal or static wounds.⁵⁸ Generally, foam or gauze dressings have been used as wound fillers to help deliver negative pressure to the wound bed and to help distribute the pressure equally across the wound surface.⁵⁹ Liners have been used to help avoid adherence and to aid in the atraumatic removal of the fillers. In some instances, these liners may also have 'active antimicrobial agents aimed at reducing levels of infection in these wounds.'⁶⁰

Evidence to support the use of bacterial-binding dressings in conjunction with NPWT and as an aid to reducing infection in complex abdominal wounds has been reported by several authors (Table 1). Bateman⁶¹ investigated the use of bacterial-binding dressing as a wound contact layer in conjunction with NPWT in 10 patients with heavily infected, exuding wounds of various aetiology (including five surgical wounds). All wounds had previously been treated with NPWT but the wounds had not progressed. The bacterial-binding dressing was used to line the wound bed and the walls of any wounds with significant depth and the regular NPWT regimen was followed. The bacterial-binding liner remained *in situ* and was replaced every seven days. 'Negative microbiology' was reported in 60% (n=6) of patients at week one and in all patients (n=2) at week two. Wound exudate production also decreased by week two in all patients, and there was a mean reduction (40%) in wound size.

In a case series of seven patients with surgical wounds, Jeffrey⁶⁰ reported preliminary clinical evidence of the use of bacterial-binding dressing as an alternative to foam and gauze during NPWT. The author felt that there was a significant improvement of the wounds, such as progression to healing and in the quality of life (QoL) of the patients.

Burn wounds

In 2004, the WHO Global Burden of Disease report estimated that approximately 11 million people per year had burn injuries that were serious enough to seek medical attention – placing burn injury as the fourth most common substantial injury.^{62,63} In the UK, it is estimated that each year about 250,000 people with

burn injuries present to primary care teams⁶⁴ and the number of burns-related deaths in the UK averages 300 a year.⁶⁵ Invasive infection in burn wounds is prevalent and a significant cause of mortality, and is now the chief reason for death and morbidity after burn injury, with it being responsible for 51% of the deaths.⁶⁶

In a randomised prospective study of 13 patients with partial- or full-thickness burn wounds, the effectiveness of the bacterial-binding dressing was compared with two silver-containing dressings.⁶⁷ The results showed no differences between the 'active' silver dressings and bacterial-binding dressings in terms of level of infection parameters assessed, but the investigators noted that burns dressed with the bacterial-binding dressing appeared subjectively cleaner and had less bacterial growth compared with the comparators. Based upon this study, and the finding that partial-thickness burn wounds appeared to progress under the bacterial-binding dressing, Kleintjes et al.⁶⁸ examined 27 patients with partial-thickness burns treated with the bacterial-binding dressing as a 'skin substitute'. Treatment was followed for up to 28 days and by final assessment wounds appeared clean (59%), dry (51%), pink (51%) and healed (27%). The authors concluded that the bacterial-binding dressing was a cost-effective skin substitute for treating burn wounds in their facility.

Chronic wounds

The failure of a wound to heal is the result of a complex series of abnormalities both in the patient's underlying aetiologies as well as within the wound bed. Infection is a major contributor to chronicity and wounds with a significant bioburden often show healing failure.^{69,70} The devitalised tissue within the chronic wound bed is a focus for bacterial colonisation and proliferation. As such, it can act as a nidus for infection which can be exacerbated if the patient also has an impaired host immune response. Treatment of infection in chronic wounds is therefore of great importance and generally includes thorough debridement to remove dead, devitalised tissue and the use of antimicrobial therapy, such as silver-containing wound dressings.² Table 2 summarises the key evidence in support of the use of bacterial-binding dressings in the treatment on chronic wounds.

Leg ulcers

Bacterial-binding technology has been shown to be effective in the treatment of chronic wounds. For example, in a multi-centre clinical evaluation, patients with venous leg ulcers (VLU; n=63) were treated with bacterial-binding dressing and changes in wound status and the wellbeing of the patients were evaluated.⁷¹ The results showed that after treatment with the bacterial-binding dressing 85% of wounds either healed or reduced in size (44–92% reduction). In addition, infections were suspected in 48% of patients and there was an overall reduction in the signs of infection (redness) with dressing treatment and no antibiotics were required.

Bacterial-binding dressings have also been shown to be effective in a non-comparative double-blind study in patients (n=19 patients/20 wounds) with infected arterial and VLU.⁷² In this study, bacterial load, wound size, wound condition and QoL were assessed. The wounds were surgically debrided and then treated with bacterial-binding dressings for four weeks. Punch biopsies of wounds were taken at the beginning and end of the assessment period and assessed for bacterial load. After the four-week assessment period, there was a significant improvement in seven wounds (77.5% average area reduction), two of which healed completely, and eight wounds improved (>50% reduction, mean reduction 38.3%). Bacterial burden decreased significantly in 10/15 (66.7%) healing chronic wounds and remained unchanged in 5/5 non-healing chronic wounds.

Mosti et al. reported a randomised, comparative study on patients with critically colonised or locally infected leg ulcers comparing bacterial-binding dressing with a silver-containing hydrofibre dressing group (n=20 in

each group).²⁹ The results showed that there was a significant reduction of bacterial bioburden on day four in both groups (compared with baseline) but that the bacterial-binding dressing-treated group demonstrated the more effective response with an average bacterial load reduction of 73.1% versus 41.6% in the silver-containing dressing group (p<0.00001) (Fig 3).

In a non-randomised, multicentre evaluation, Kammerlander et al. assessed the efficacy of the bacterial-binding dressing in the management of chronic wounds of different types.⁷³ Of the 116 patients enrolled on the study, 84% had signs of wound infection at the start of the study and after treatment with the bacterial-binding dressing, 81% of these wounds showed no signs of infection (Fig 4). The healing response was equally as positive. With the bacterial-binding dressing treatment, 21% of all wounds went on to heal by the end of the study, and there was wound healing improvement in a further 72%, with only 1% worse and 6% stagnating.

The authors were positive regarding results seen with the bacterial-binding dressing and stated that:

‘Despite initial scepticism, Cutimed Sorbact achieved a good level of efficacy as an antimicrobial product within a phased programme of wound care. Using Cutimed Sorbact in this study, 81% of wounds showing signs of infection at the start of treatment were healed and in 93% of cases there was an improvement in wound healing or a complete cure.’

Chronic wounds are associated with high treatment costs and data from Germany suggests that wound dressings are the main cost-drivers in VLU care.^{74,75} A budget impact analysis was performed comparing three different scenarios of the ‘intervention mix’ of antimicrobial dressings (including bacterial-binding, silver- and PHMB-containing dressings). A Markov model estimated VLU progression for one year which demonstrated that an increased use of bacterial-binding dressings reduced costs in both drug and dressing expenses, with the impact increasing over the course of 12 months.

The use of the bacterial-binding dressing in 50% of target patients leads to a higher number of healed ulcers and ulcers without wound infection within a year and lowering overall cost per patient.⁷⁶ Grothier and Stephenson audited a clinical pathway for identifying and managing wound infection in a community nursing service.⁷⁷ The audit data suggest that managing patients appropriately (e.g. with bacterial-binding dressings) and preventing infection reduces the use of expensive antimicrobials and other dressings. Hardy reported on the use of bacterial-binding dressings in the management of patients with lymphoedema, chronic oedema and lymphorrhoea.⁷⁸ The author describes that the implementation of the above products to achieve bioburden management resulted in improved wound healing, the patients’ QoL and significant reduction in

Fig 3. Comparison of bacterial loads on day 0 and day 4 in ulcers treated with wound dressings (modified from Mosti et al.²⁹)

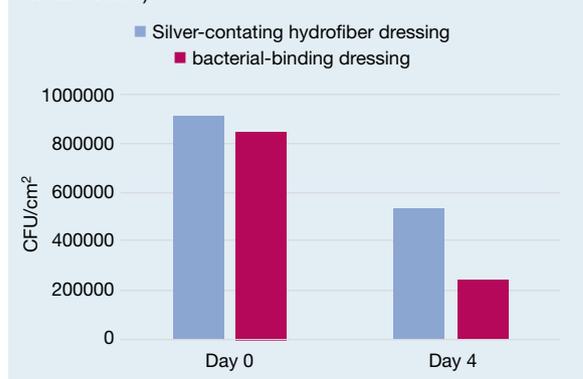
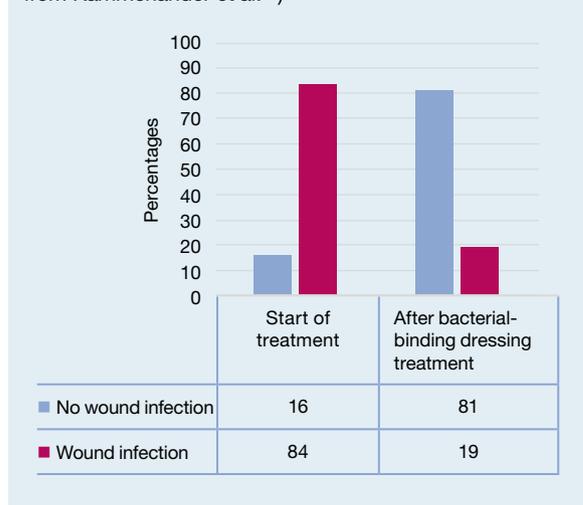


Fig 4. Percentage of wound infections at the start and end of treatment with the bacterial-binding dressing (modified from Kammerlander et al.⁷³)



the cost of care. Derbyshire reported on a series of three case studies that there were significant cost savings in the treatment of chronic wounds with bacterial-binding dressings.^{79,80}

Pressure ulcers (PU)

PU form when an area of skin is placed under constant pressure for a prolonged period and compression and/or shear forces results in local tissue damage.⁸¹ PUs are prone to infection⁸² and as with all chronic wounds, removal of infection is a priority for healing to progress.

Bacterial-binding dressings have been shown to be effective in the treatment of infected PUs as can be seen in a comparative study, whereby patients (n=33, with 36 PUs) were randomised into either the control group (n=14) or a bacterial-binding dressing group (n=19).⁸³ The study monitored wound bed colour, periwound oedema and erythema, autolytic debridement as well as changes in signs of infection. Both groups received the same treatment appropriate to local guidelines (control group) except for inclusion of bacterial-binding dressing in the test group. The results demonstrated a significant reduction in periwound oedema/erythema in patients treated with bacterial-binding dressing versus the control group (78% versus 57%, respectively, $p=0.028$). Wound bed improvements were seen in wound bed colour (95% versus 72%, bacterial-binding versus control group, respectively, $p=0.034$) and the bacterial-binding dressing also aided wound debridement and faster healing time (9 ± 2 days versus 11 ± 2.1 days, $p=0.041$).

Diabetic foot ulcers (DFU)

Foot disease affects nearly 6% of people with diabetes⁸⁴ and is linked to infection, ulceration or destruction of tissues of the foot.⁸⁵ It can significantly impair the wellbeing of patients affected and impacts on many social aspects of their lives including their day-to-day work.⁸⁶ Ulceration is common in patients with diabetes, with a prevalence as high as 25%, and as a result between 0.03% and 1.5% of patients will require an amputation.^{87,88} Most amputations start with ulcers but can be prevented with good foot care and screening to assess the risk of foot complications.⁸⁸ Despite this, infection is commonplace, occurring in up to 25% of patients and is costly.⁸⁹ Consequently, it is imperative to prevent and treat infection in DFUs effectively and quickly.

Evidence in support of the use of bacterial-binding dressings to treat DFUs has been reported in a (non-randomised, single-centre open) case series of infected/at-risk chronic DFUs.⁹⁰ In this study, patients (n=19, 29 wounds) were treated with bacterial-binding dressings to evaluate the dressing's ability to reduce the signs and symptoms of infection. At the beginning of the study, 76% (22/29) wounds (mean duration: 11 months) showed two or more signs of infection. These patients were treated over a four-week period (or until the wound had healed) and at completion of the study 100% of wounds demonstrated a reduction in size

and pain, with most wounds showing no signs of infection. There are also several case reports relating to the successful use of bacterial-binding dressings for the management of infection in wounds of the DFU⁹¹ and the use of Sorbact ribbon treating interdigital fungal infections in patients with diabetes.³⁰ Additionally, a number of reports have presented evidence on the successful treatment of infection and support of healing in a variety of chronic wounds (including DFU, VLU and PU) with bacterial-binding dressings,^{31,77,92-95}

Discussion

The aim of this review was to present clinical data reporting the use of bacterial-binding (DACC-coated) dressings in the prevention and management of wound infection and to reduce wound bioburden; two areas were the primary focus—SSIs and chronic wounds.

SSI is the most common type of hospital-acquired infection. Even with many precautions and protocols in place to prevent infection, any surgical procedure can lead to infection. SSI accounts for up to 20% of all hospital-acquired infection and occurs in at least 5% of all surgical procedures.¹⁵ Morbidity and mortality due to SSI can be devastating but could be preventable with appropriate strategies and policies in preoperative, intraoperative, and postoperative patient and wound care.¹⁵ A RCT reported a significant reduction in SSI rates in patients undergoing caesarean section when wounds were dressed with bacterial-binding dressings compared with standard surgical dressings.⁴² The use of bacterial-binding dressings for reducing SSI rates was also reported in a prospective comparative study in 200 patients undergoing non-implant vascular surgery.⁴⁵ Bua et al. comment that the maximal protective effect of the bacterial-binding dressings appears to be in the early postoperative period and suggest that this may be due to the prevention of ingress of bacteria into freshly created wounds by the dressing.⁴⁵

A significant proportion of chronic wounds has been shown to be clinically infected.^{96,97} The bacterial-binding portfolio of wound dressings can manage established wound infection and decrease bacterial load when used as part of the treatment regimen for a variety of infected acute and chronic wounds,^{29,67,72} and prevents infection in high-risk patients.⁷⁷ The management and resolution of already-established wound infections helps to optimise the wound environment and to aid the establishment of wound progression in previously static wounds. Removal of bacteria by bacterial-binding dressings improves the quality of the wound bed⁸³ leading to an improved healing response^{31,93} and promotes healing.⁹² Other benefits identified in the clinical studies include improvements, such as reduced pain experienced by patients treated with bacterial-binding dressings^{31,73,78,90-92,94} and a reduction in wound malodour.^{73,78,90,92,94} Reducing the level of microorganisms in the wound bed has a beneficial effect on the local wound environment, removing

barriers to healing progression and optimising the local environment.

The mechanism of action of the bacterial-binding portfolio of dressings for resolving infections by removing wound bacteria is beneficial for all types of wounds. The physical binding of microorganisms by these DACC-coated dressings avoid an active bactericidal action on microbes and relies instead on a physical mode of action to reduce bacterial load. This mechanism of bacterial load control makes the development of resistance unlikely. Unlike traditional antimicrobial dressings, bacterial-binding dressings do not release any chemically or pharmacologically active substances but rather uses a physical mode of action using the hydrophobic interaction of DACC to reduce bacterial load.²⁸ This suggests that the use of this dressing does not adversely affect the wound bed or cells involved in the various aspects of wound healing. Bacterial-binding dressings can be used prophylactically for wounds at risk of infection or re-infection because of their lack of damaging effect on wound-derived cells and processes. They can be used during all phases of the healing response.

Limitations

This review was not a systematic review of the literature and includes a larger number of lower quality studies than would be found in a systematic review. In RCTs, investigators can study a specific clinical question by exerting control over the treatment variable(s). Outside the control of RCTs, smaller-scale studies, case series and reports examine 'real world data' which reflects the actual

care received by patients in clinics and offers insights into the dressing's use.⁹⁸ With this in mind, our review is in general agreement with a recent systematic review of the use of bacterial-binding dressings in supporting the management and prevention of wound infection.²⁷

Conclusion

The bacterial binding portfolio of wound dressings have a unique 'passive' mechanism of action that can:

- Reduce levels of bioburden (without the use of an 'active' antimicrobial agent)
- Enable the progression of healing in static/chronic wounds.

In acute wounds such as clean surgical wounds, bacterial-binding dressings provides a reduced risk for the development of costly SSIs. The innovative approach to reducing microbial load means that they are effective against microorganisms that are resistant to antibiotics. The natural binding and removal of microorganisms prevents the release of endotoxins into the wound and no chemical agents are released into the wound. Therefore, bacterial-binding dressings may be used prophylactically for wounds at risk of infection or re-infection and during all phases of the healing response.

These wound dressings provide an important contribution to aiding the management and prevention of wound infection in a way that will not further exacerbate the resistance problems seen with the catastrophic overuse of antibiotics that has led to multiple resistant microorganisms. **JWC**

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