Facilitating wound bed preparation

Properties and clinical efficacy of octenidine and octenidine-based products in modern wound management

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Declaration of interest

The following are all independent contributors who received a fee for their contributions: Ojan Assadian, Zoe Boulton, Sharon Hunt, Matthew Pilcher, Juliet Price, Deborah Simon, Steven Jeffery. José Neves Paulos Antunes, Gilbert Hämmerle, Bernd von Hallern and Elisabeth Lahnsteiner did not receive payment for their contributions.

How to cite this document

This document should be cited as Assadian, O., Pilcher, M., Antunes, J.N.P., Boulton, Z., von Hallern, B., Hämmerle, G., Hunt, S., Jeffery, S., Lahnsteiner, E., Price, J. Simon, D. Facilitating wound bed preparation: properties and clinical efficacy of octenidine and octenidine-based products in modern wound management. J Wound Care 2016; 25: 3, S1–S28.



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Published on behalf of schülke by MA Healthcare.

Publishing director: Anthony Kerr Editor/associate publisher, Medical Education: Tracy Cowan Editorial project manager: Camila Fronzo Sub-editors: Peter Bradley and Camila Fronzo Designer: Lindsey Butlin Published by: MA Healthcare, St Jude's Church, Dulwich Road, London SE24 0PB, UK Tel: +44 (0)20 7501 6732 Email: anthony.kerr@markallengroup.com Web: www.markallengroup.com

Octenidine dihydrochloride: chemical characteristics and antimicrobial properties

Abstract

The empiric use of antibiotics is being restricted due to the spread of antimicrobial resistance. However, topical antiseptics are less likely to induce resistance, owing to their unspecific mode of action and the high concentrations in which they can be used. One such antiseptic, octenidine dihydrochloride (OCT), can be used either prophylactically or therapeutically on the skin, mucosa and wounds. Evidence to support its use comes from *in-vitro*, animal and clinical studies on its safety, tolerability and efficacy. This article summarises the physical, chemical and antimicrobial properties of OCT in the context of wound care.

Key words: Octenidine dihydrochloride • biofilm • antimicrobial efficacy • wound antisepsis • cytotoxicity • biocompatibility index • contraindications

n the past decade, the increase in antibiotic resistance has restricted the selection and use of systemic antibiotics.¹ In general, antiseptics have a broader spectrum of activity than antibiotics, and, while antibiotics tend to have specific intracellular targets, antiseptics have multiple targets on and in bacterial cells.² Furthermore, antiseptics can be applied at higher concentrations directly onto the skin, mucous membranes and wounds, and so are unlikely to induce resistance in microorganisms to the extent that do antibiotics. However, if applied frequently over longer periods (months to years), many antiseptics can cause contact dermatitis³ and hypersensitivity; others can have strong antimicrobial efficacy but also high cytotoxicity against human cells. Therefore, selection of antiseptics is guided by the anatomical region and the clinical indication for prophylaxis or therapeutic use.

As antiseptics can be administered topically but not systemically, it is reasonable to treat systemic wound infection with antibiotics and local infection or critical bacterial colonisation with topical antiseptics. However, this will only be effective if the underlying wound aetiology is addressed and the principles of wound bed preparation are adhered to. Debridement (the removal of necrotic or severely damaged tissue) is an essential part of wound bed preparation.^{4,5} Supplementing this with topical antiseptics may help support the wound healing process directly by eliminating pathogens and indirectly by reducing the risk of wound infection. However, at present, the lack of well-designed randomised controlled trials means that the selection of antiseptic agents is based on efficacy and tolerability data from predominantly non-comparative clinical evaluations and in-vitro studies.

Antiseptics can be divided into six large classes (Table 1). Selection of the various compounds depends on their chemical and physical properties, and the clinical indications for which they will be used. In general, there are no 'good' or 'bad' antiseptics, only appropriately or inappropriately used compounds. Due to their distinct chemical features, their antimicrobial efficacy against the relevant microbial spectrum, and their varying efficacy in the presence of blood or exudate,⁶⁻⁸ most clinically available wound antiseptics belong to the class of guanidines. This class includes widely used wound antiseptics such as polyhexamethylene biguanide (polyhexanide; PHMB), chlorhexidine (CHX) and the pyridine octenidine dihydrochloride (OCT). This article focuses on the chemical and antimicrobial properties of OCT, and compares them with other wound antiseptics.

Chemical and physical characteristics

Octenidine dihydrochoride (CAS-number 70775-75-6) (N,N'-(1,10 decanediyldi-1[4H]pyridinyl-4-ylidene) bis-(1-octanamine) dihydrochloride) is a cationic, surface active antimicrobial compound (Fig 1). OCT differs from guaternary ammonium compounds (QACs), such as benzalkonium chloride, and other guanidines, such as CHX, by the lack of an amide- and ester structure in its molecule, which results in lower toxicity due to possible metabolites. Therefore, 4-chloroaniline, a toxicologically critical part of QACs and some impure CHX preparations, cannot be liberated from the OCT molecule. OCT is stable and remains antimicrobially active at an extremely broad pH range (1.6–12.2), which is particularly important in wound care, as the wound pH changes during the healing process. Therefore, the antimicrobial efficacy of OCT is not measurably altered in acutely infected or healing wounds. In comparison, CHX is antimicrobially active at a pH range of 5-79 and PHMB at pH 6–7.10 OCT can be sterilised

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Table 1. Overview of antimicrobial compounds used as disinfectants or antiseptics in health care								
Alcohols	Aldehydes	Oxidatives	Phenols	QACs	Guanidines			
Ethanol	Formaldehyde	Ozone	Phenol	Benzalkonium chloride	Polyhexanide			
Isopropanol	Glutardialdehyde	Peroxides	Pentachlorophenol	Benzethonium chloride	Chlorhexidine			
n-propanol	Glyoxal	Peroxicarbon acid	Cresol	Mecetronium ethylsulfate	Alexidine			
Methanol	Methenamine	Hydrogen peroxide	Chlorocresol	Cetrimide				
Butanol	Propenal	Sodium perborate	Thymol	Cetylpyridinium chloride	Pyridines			
Chlorobutanol	Piperonal	Hypochlorous acid	Eugenol	Benzoxonium chloride	Octenidine			
Glycerol	Dimethylol dimethyl hydantoin	Benzoyl peroxide	Biphenyl	Tetrazolium chloride	Dipyrithione			
Benzyl alcohol	Hexamethylenetramin	Halogens	Bisphenoles		Na-Pyrion			
2-phenoxyethanol	Chloroallyl chloride	Chlorine	Chlorophene		Zinc pyrithione			
Bronopol		Hypochlorites	Hexachlorophene		Pyrimidines			
		lodine			Hexetidine			
OAC - quaternary ammonium compounds								

by steam up to 130°C in aqueous solutions and stored at room temperature, making it suitable for long storage times.¹⁰

Antimicrobial efficacy

Mode of action

OCT has two non-interacting cationic active centres in its molecule, which are separated by a long aliphatic hydrocarbon chain (Fig 1). It therefore binds readily to negatively charged surfaces, such as microbial cell walls and eukaryotic cell membranes. *In-vitro* experiments¹¹ demonstrated a strong adherence to bacterial cell membrane components (e.g. cardiolipins), which may explain why, despite its high antimicrobial efficacy, it does not adversely affect human epithelial or wound tissue.¹² Like other cationic antiseptics, such as benzalkonium chloride, CHX, and PHMB, OCT's main target appears to be glycerol phosphates in the bacterial cell membrane.¹³ On attachment, OCT interacts with polysaccharides in the cell wall of microorganisms and cytoplasmic bacterial



Fig 1. Chemical structure of octenidine dihydrochloride

enzymatic systems,^{14,15} resulting in leakage of their cytoplasmic membrane and cell death.¹⁶

Spectrum of activity and antimicrobial efficacy

Due to its unspecific mode of action, strong adsorption and interaction with cell wall and cell membrane structures, OCT has a broad antimicrobial spectrum, including Gram-positive and Gram-negative bacteria, chlamydiae, mycoplasma and fungi.¹⁷⁻¹⁹ For example, OCT was found to be superior to CHX and alexidine in inhibiting plagueforming enzymes of Streptococcus mutans in the oral cavity.²⁰ Generally, the *in-vitro* antimicrobial efficacy of OCT is 3 to 10 times higher than that of CHX.¹⁹ However, they differ in their effects on Gram-positive and Gram-negative bacteria: CHX is very active against Gram-positive bacteria, whereas OCT shows balanced activity against both (Table 2). Minimum inhibitory concentrations (MICs) reported for OCT range from 1 µg/ ml to 4.9 µg/ml against Gram-positive and Gram-negative organisms and from 1.5 µg/ml to 3.0 µg/ml against different yeasts (Candida albicans, Candida tropicalis and Candida pseudotropicalis).^{19,21} The residual effect of OCT

Table 2. Comparison of the minimum inhibitory concentrations (MICs) of different antiseptics on bacterial growth after 5 minutes of contact time. (MICs expressed as ug/mL)¹⁹

Organism	ОСТ	СНХ	РНМВ	TCS				
Staphylococcus aureus	1	0.2	0.1	0.1				
Escherichia coli	1	0.5	5.0	0.3				
Klebsiella pneumoniae	2	3.9	5.0	0.5				
Proteus mirabilis	2	15.6	10.0	5.0				
Pseudomonas aeruginosa	4	15.6	25.0	1000				

OCT = octenidine dihydrochloride; CHX = chlorhexidine; PHMB = polyhexanide; TCS = triclosan

Table 3. Biocompatibility scores for antiseptic substances after 30 minutes of contact with MEM cell culture medium containing 10% fetal bovine serum. (Adapted from Müller and Kramer³⁵)

Active compound	Cell line / test organism			
	L929 / E. coli	L929 / S. aureus		
Octenidine dihydrochloride	1.73	2.11		
Polyhexanide	1.51	1.36		
Povidone-iodine (PVP-I)	1.00	0.95		
Chlorhexidine digluconate	0.83	0.98		
Benzalkonium chloride	0.63	0.79		
Elementary iodine (I_2)	0.68	0.68		
Triclosan	0.23	0.46		
Silver protein	0.22	0.11		
Silver nitrate, silver sulphadiazine	<0.0001	<0.0001		
MEM= minimum essential medium				

and its ability to attach to cells are similar to CHX, which allows an antimicrobial depot effect on skin or wound tissue.²²⁻²⁴

The minimum bactericidal concentrations (MBCs) of OCT range from 1 µg/ml to 32 µg/ml, depending on the target organism. Results obtained from suspension tests show a fast antimicrobial efficacy after 1 minute against *Staphylococcus epidermidis*, *Staphylococcus aureus*, *Proteus mirabilis*, *Streptococcus pyogenes*, *Klebsiella pneumoniae*, *Escherichia coli*, *Pseudomona aeruginosa* and *Candida albicans*, even in the presence of blood or wound exudate.²⁴

Inactivation of biofilms

OCT has been demonstrated to be highly active, *in vitro*, against biofilms from species isolated from hospitalised patients with catheter-related infections and orthopaedic implant infections.^{25,26} Furthermore, compared with the antibiotic gentamicin, OCT

demonstrated higher efficacy against biofilms on medical implants.²⁷

Resistance

To date, microbial resistance to OCT has not been detected or induced *in-vitro*. Based on its unspecific mode of action and the high concentrations used in clinical practice, bacterial resistance is not anticipated.²²⁸⁻³¹

Indications and clinical use

At present, OCT is approved in several European countries as a skin, mucous membrane and wound antiseptic. For skin antisepsis, OCT is always combined with aliphatic alcohols (e.g. propan-1-ol and propan-2-ol) or with detergents for use as a wash lotion. For wound irrigation or antisepsis, OCT is currently used either without any further active compounds (e.g. octenilin Wound Irrigation Solution, Schülke & Mayr GmbH, Germany) or in combination with phenoxyethanol (e.g. octenisept, Schülke & Mayr GmbH, Germany). The former is mainly used as an irrigation solution for wound cleansing. The latter is used primarily for its antimicrobial activity. Hence, if a wound needs to be cleansed and moistened to prevent the development of infection, use of OCT as single product would be sufficient. However, if a local wound infection needs to be treated, OCT with 2% phenoxyethanol would be the formulation of choice.²¹

In a prospective clinical trial involving patients with advanced cancer and neoplastic ulcers (but which did not include wound infection as an inclusion criteria), *S. aureus, S. epidermidis* and *P. mirabilis* were eradicated from the wounds of all patients after 3 weeks of treatment with OCT and phenoxyethanol, while reductions in necrotic tissue, exudate levels, erythema, and oedema were also observed.³²

In animal studies involving experimental superficial aseptic wounds in pigs, OCT and phenoxyethanol was shown to be as effective as Ringer's solution in promoting wound closure.^{33,34}

Cytotoxicity and tissue tolerance

All antiseptics can exhibit cytotoxicity against human tissue cells depending on their concentration and application time. Therefore, the ideal wound antiseptic should demonstrate antimicrobial efficacy in the presence of blood or exudate with negligible cytotoxic effects. An in-vitro test that simultaneously screens antimicrobial compounds for their antimicrobial and cytotoxic action can be used to calculate their biocompatibility index (BI).³⁵ The BI compares the microbicidal activity and cytotoxicity of different wound antiseptics. An antiseptic with a BI greater than 1 has a high antimicrobial efficacy and low cytotoxicity. In contrast, an antiseptic with a BI less than 1 has a low antimicrobial efficacy and high cytotoxicity. This makes it possible to rank the suitability of wound antiseptics (Table 3).

Adverse effects and contraindications

OCT should not be used for joint irrigation as even a concentration of 0.005% OCT is toxic to cartilage tissue,³⁶ and therefore should not be used for intra-articular irrigation. In addition, it must not be used for pressure irrigation of stab wounds or wound cavities when the free outflow of the compound cannot be guaranteed. As OCT is not absorbed, any residue in the tissue can lead to oedema and tissue damage owing to mechanical pressure. Finally, OCT should not be used for peritoneal lavage or to irrigate the bladder or the tympanic membrane until detailed safety and efficacy data are available for these indications.

Conclusion

Topical OCT is well tolerated on skin, mucosa and wounds, and does not induce bacterial resistance.^{2,21} In contrast to systemic antibiotics, it can be easily be applied in a high concentration at the wound site. It is easy and safe to handle, chemically stable, not inflammable and low toxic to man and the environment alike.²¹ OCT is an established antiseptic that can be used both prophylactically and therapeutically on the skin, mucous membranes and wounds.

The *in-vitro* biocompatibility index, which represents the ratio of fibroblast cytotoxicity against antimicrobial efficacy towards *E. coli* or *S. aureus*, is > 1 only for OCT and PHMB, and lower still for povidone-iodine and CHX. This is supported by favourable clinical^{12,37} and experimental studies,^{19,21,38,41} which found OCT to be well tolerated and associated with improved wound healing when compared with the controls.

On wounds, OCT acts faster than PHMB; it achieved a 3-log reduction of bacteria within 30 seconds, whereas PHMB required a contact time of 2–20 minutes, depending on the pathogen.^{19,21} However, this difference is only relevant if rapid antibacterial reduction is required, and may be less relevant on wounds, where contact times can be much longer. However, when selecting antiseptics, it is important to bear in mind that there are no good or bad antiseptics. The selection depends on the current condition of an individual wound, whereby the wound will dictate which requirements are important.

There is a need for further research on OCT, particularly in relation to its interaction with various tissue cells, other anti-infective compounds, new methods of application, and its cost-effectiveness.

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Wound cleansing: a key player in the implementation of the TIME paradigm

Abstract

The concept of wound bed preparation can be implemented using the TIME paradigm. Chronic wounds are mostly characterised by prolonged inflammation and increased bioburden. Removal of wound biofilm and devitalised tissue, which is an ideal environment for bacterial growth, can help address the I in TIME. Wound cleansing aims to remove contaminants, debris, dressing remnants and superficial slough from the wound. Some wound cleansers contain surfactants, which reduce the surface tension of a liquid, enabling it to spread further over a surface. This article describes how these solutions can be used to debride the wound surface without damaging healthy cells.

Key words: biofilm • wound bed preparation • devitalised tissue • wound bioburden • wound cleansing • surfactants

ith an estimated 200,000 people experiencing a chronic wound in the UK at any given time, representing an annual cost to the NHS of approximately £4bn,¹ it is critical that wound care is both clinically effective and costeffective.^{2,3} One of the major approaches to the management of chronic wounds is the concept of wound bed preparation, which can be implemented using the TIME framework.⁴⁵ This will enable health professionals to optimise the conditions within the wound bed to promote healing. This article describes the role played by wound cleansing in wound bed preparation.

Infection/inflammation control

The TIME acronym summarises the four main components of wound bed preparation:

- Tissue management
- Infection/Inflammation control
- Moisture balance
- Epithelial advancement at the wound edge.⁵ Given the increasing number of antibiotic-

resistant strains of bacteria, which is being exacerbated by the overuse of antibiotics, the identification and management of wound infection, as stipulated in the TIME paradigm, is becoming ever more important.⁶ Patients can be at risk of wound infection if their host reaction to pathogens is less than optimal. This includes patients with poorly controlled diabetes, poor tissue perfusion, a poor nutritional intake, and/or who smoke and drink too much alcohol.⁷

As every wound is different, the number of pathogens and variety of bacterial species in it will vary, which will in turn provoke a different host reaction. The varying levels of host reaction are characterised as contamination, colonisation, critical colonisation/localised infection and spreading/systemic infection.⁷ This range is known as the infection continuum (Table 1). All wounds contain bacteria but they may still heal normally. It is only when the microbial activity and bacterial count increase above an indeterminate threshold that the bacteria can become detrimental to wound healing. In such circumstances, interventions are required to reduce the bioburden.⁸

Cutting et al.⁹ identified the characteristics of wound infection, which can be generalised as follows:

- Cellulitis/erythema
- Unexpected pain
- Friability of the tissues
- Wound malodour
- Wound breakdown
- Abnormal discharge
- Discolouration.

Wound biofilm

Many regard the formation of biofilm as a precursor to infection.¹⁰ A wound biofilm is a colony of multiple bacterial species that is coated with a protective matrix (extracellular polymeric substance (EPS)), which can attach itself to a living or non-living surface. It can take only 4–6 hours for a biofilm to form sufficiently to provide a degree of protection from topical agents, with full maturity occurring within 2 days.¹¹ Fig 1 shows a biofim comprising meticilin-resistant Staphylococcus aureus (MRSA). Biofilms are microscopic and so cannot be detected by the naked eye, although if left to mature, they may show some pigmentation, which can enable identification.¹² Phillips et al.¹¹ postulated that biofilm production stimulates a chronic inflammatory response, with cells releasing high levels of matrix metalloproteases (MMPs) and reactive oxygen species (ROS) in an attempt to dislodge the biofilm. These MMPs and ROS may also damage the extracellular matrix (ECM) and other healthy cells. Biofilms have been identified in up to 60% of chronic wounds compared with only 6% of acute wounds.¹³ The majority of biofilms are located in eschar or devitalised tissue,¹⁴ highlighting the importance of wound bed preparation in removing them from the wound.

Role of debridement

Chronic wounds often contain a degree of devitalised tissue, increasing the risk of bacterial colonisation and biofilm formation, which will impair healing. If the wound is to

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Table 1. The infection continuum ^{23,24}									
	Contamination	Colonisation	Critical colonisation/ localised infection	Spreading/systemic infection					
Description	Presence of non- multiplying bacteria in the wound	Presence of multiplying bacteria in the wound with no response from the immune system	Immune system is compromised and the patient is no longer able to control the multiplication of bacteria	Multiplying bacteria overwhelm the immune system resulting in clinical signs and symptoms					
Symptoms	The wound is healing normally and the patient has no symptoms	The wound is healing normally and the patient has no symptoms	Includes slight odour, increased/new pain, increased exudate and localised erythema. Wound healing is delayed	Includes fever, malodour, excessive exudate, severe pain and spreading erythema. The wound is breaking down					

have any chance of healing, the wound bed must resemble that of a healing acute wound. This can be achieved by debridement.¹⁵ In essence, debridement refers to the removal of devitalised and necrotic tissue in order to encourage healthy granulation tissue.¹⁶ Debridement and wound cleansing can also facilitate the physical removal of biofilm. As such, the debridement process should be considered an important aspect of wound care. The removal and management of biofilm formation has become an increasingly important aspect of wound management. However, repeated and targeted topical treatments and debridement, as required, are usually necessary to achieve the desired result.¹⁷ Repeated treatment is required due to the rapid onset of biofilm formation following contamination, as illustrated in *in-vitro* studies.

Wound cleansing as a management tool

Wound cleansing, which has been a routine part of wound management for centuries, aims to remove contaminants, debris, dressing remnants and superficial slough from the



Fig 1. Microscopic view of meticillin-resistant Staphylococcus aureus biofilm

wound. However, for many years it has been performed in a ritualistic manner, with a minimal evidence base on its clinical efficacy.¹⁸ A literature review on the limited research, published in 2001, found that none of wound cleansing solutions used at that time—ranging from sterile saline, distilled water, tap water to povidone-iodine solution—were associated with a difference in wound infection rates.¹⁹ Despite this, wound cleansing followed by regular debridement is considered a basic principle of wound bed management.²

The use of physical techniques, such as swabbing/scrubbing techniques, during wound cleansing has been shown to cause trauma to the tissue and therefore to delay healing. Wound irrigation has become more accepted, as it is more likely to preserve new granulation and immature epithelial tissue, although there is little consensus on the pressures required to effectively irrigate without causing wound trauma.¹⁹

Octenidine

The indiscriminate use of antiseptics for cleansing and within topical dressings in



Fig 2. Octenilin contains the surfactant-type molecule ethylhexylglycerin

wound bed preparation has been shown to be detrimental to wound healing. Antimicrobial dressings should be applied only when required and as indicated, in accordance with the manufacturer's instructions. For example, silver dressings should only be used on wounds with localised or spreading infection and their use reviewed after 2 weeks. It is therefore important to limit the use of antiseptics to when bacterial levels are posing a problem.

One alternative to antiseptics is the use of products based on octenidine, which is available in the form of octenilin Wound Irrigation Solution and Wound Gel (Schülke & Mayr GmbH, Germany). Octenilin Wound Irrigation Solution, which contains the preservative octenidine dihydrochloride, is a safe and effective cleansing solution.¹⁷ Octenilin Wound Irrigation Solution contains ethylhexylglycerin, which is a surfactant-type molecule. A surfactant is a substance that reduces the surface tension of a liquid, so that the liquid can spread further over a surface. By lowering the surface tension of the solution, octenilin increases the wetting effect (that is, it moistens the skin and loosens biofilm and devitalised tissue). Another wound cleanser containing a surfactant is Prontosan (B Braun); the surfactant found in Prontosan Solution and Wound Gel is called betaine.

Octenilin has a much lower surface tension compared with Ringer's solution and Prontosan solution (Table 2).²¹⁷ An *in-vitro* study showed that octenilin prevented biofilm formation, and appeared to have the potential to remove mature biofilms.¹⁷ A RCT investigating the use of an octenidinedihydrochloride hydrogel on skin graft donor sites found that it can be used as an effective barrier dressing, preventing any wound contamination, while its markedly low toxic effect on healthy cells makes it safe to use in all stages of the wound healing process.²⁰

The effective management of biofilm formation and tissue management could have a significant effect on aspects of the wound, such as its pH level. A non-healing chronic wound is likely to have a higher (alkaline) pH. This enables MMPs, whose number increases when the wound is in a state of chronic inflammation, to break down the ECM and wound proteins, which in turn increases the metabolic load, creating higher levels of tissue hypoxia.²¹ It could be argued that removing the cause of the inflammation will reduce the number of inflammatory mediators and cytokines, which will in turn reduce the wound pH to a more neutral or acidic level. Even a change in pH of 0.6, which will make the wound more acidic, can increase the oxygen perfusion into the wound.21

Conclusion

The contamination of a wound by either planktonic or biofilm bacteria can cause chronic inflammation, resulting in nonhealing/poor healing wounds. A key aspect of wound management is to remove all necrotic and devitalised tissue from the wound bed, and eradicate as far as possible any biofilm formation.

While antiseptic dressings can help to reduce the bioburden within the wound, they can also have detrimental effects on the healing tissue if not used in accordance with best practice guidelines and the manufacturer's instructions for use.²² Use of octenilin Wound Irrigation Solution (for wound irrigation) and octenilin Wound Gel (which helps decontaminate and supports the healing process) not only manages immature biofilm production but has also demonstrated the potential to disrupt established biofilms. Its low toxicity to healthy cells allows for its use throughout all stages of the wound healing

Table 2. Results of a comparison of the surface tension of three wound cleansing solutions¹⁷

Solution	Surface tension (mN/m)
Ringer's solution	71.7
Prontosan	44.4
Octenilin	30.6

Surface tension was measured in the laboratory using the pendant drop method. The difference in surface tensions between octenilin and Ringer's/ Prontosan was statistically significant (p<0.001)

process. The rest of this supplement comprises case studies demonstrating the efficacy of octenilin Wound Irrigation Solution and Wound Gel on a variety of wound types.

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Case 1: chronic infected donor site

Following a coronary bypass surgery, a vein donor site became infected and failed to heal despite use of antibiotics and a variety of topical treatments. Octenilin Wound Gel not only helped to promote healing, but also increased the patient's ability to tolerate dressing changes

57-year-old man with type 2 diabetes mellitus who was also morbidly obese underwent an urgent triple coronary bypass following an acute myocardial infarction. After surgery, the radial artery donor site wound on the left forearm failed to heal: the sutures dehisced and there was erythema on the wound margins. The other donor sites (veins taken from the left lower leg) healed without complication.

Initial treatment of the donor sites comprised povidone-iodine and a dry gauze dressing. This was changed every 3–4 days. The forearm donor site wound was found to be infected with *Staphylococcus aureus*. In accordance with the hospital's treatment protocol, oral systemic antibiotics (sultamicillin and trimethoprim/ sulfametrole) were administered on the 16th postoperative day (Fig 1). As the wound had not improved by postoperative day 35, the antibiotic treatment was replaced with topical treatment comprising a silver-impregnated Hydrofiber dressing, which was changed daily (Fig 2).

There was still no improvement by day 39, so this was replaced with a honey dressing and a silver-impregnated foam dressing with a soft silicone contact layer. However, due to a continued lack of improvement, on day 41 the topical regimen was changed to octenilin Wound Gel, plus the same silver-impregnated foam dressing with a soft silicone contact layer. The patient preferred this to the previous dressings as the octenilin Wound Gel had a cooling effect on the wound and was less sticky. Previously, the stickiness had resulted in adherence, which caused the patient pain at dressing removal.

On day 49, the wound had improved, with reduced dehiscence and erythema. Staff continued using the octenilin Wound Gel, which was covered with a polyurethane film dressing and gauze, until complete wound closure occurred on day 62 (Fig 3).

Due to the simple administration of octenilin Wound Gel, the patient's acceptance of dressing changes increased. The total treatment duration with octenilin Wound Gel was 22 days. The patient did not experience any ongoing wound pain due to thorough pain management with oral paracetamol.



Fig 1. Wound on postoperative day 16: the suture has dehisced and there is erythema on the wound margins. Antibiotic treatment was initiated



Fig 2. Wound on postoperative day 35: there is no improvement in the wound status. Topical treatment was switched to a silver Hydrofiber dressing



Fig 3. Wound on postoperative day 62 (after 22 days of topical treatment with octenilin Wound Gel): the wound has closed

Case 2: amputation site and infected toe on the diabetic foot

Severe infection resulted in the amputation of one toe and surgical debridement of necrotic tissue on another toe in the same diabetic foot. The postoperative wounds healed quickly and uneventfully following use of octenilin Wound Gel and a foam dressing



Fig 1. Wounds at admission: there is extensive gangrene of the second toe and necrosis on the hallux

78-year-old man with type 2 diabetes mellitus and diabetic foot syndrome developed diabetic gangrene and osteolysis in the second toe, and an infection, with necrotic tissue, on the hallux (big toe) (Fig 1). The diabetes was controlled with oral medication, and he did not have any other documented comorbidities.

Due to the extent of the necrosis, the second toe had to be amputated. However, it



Fig 2. Wounds following amputation of the second toe and surgical debridement of the big toe: topical treatment with octenilin Wound Gel was initiated

was possible to remove the necrotic tissue on the hallux with surgical debridement (Fig 2), leaving connective tissue and muscle. Exudate levels were low.

The postoperative wounds were treated with octenilin Wound Gel and a foam dressing, which was changed every 2–3 days. No oral antibiotics or antimicrobial dressings were used. On postoperative day 21, the amputation-site wound had fully healed and



Fig 3. Postoperative day 21: the amputation site has healed fully and the wounds on the hallux are healing well

the wound on the second toe was progressing well, with granulation tissue covering the wound bed and epithelial tissue at the wound margins (Fig 3). As the patient had diabetic neuropathy, pain management was not necessary.

The patient was satisfied with this fast and simple postsurgical wound management.

Case 3: chronic venous leg ulcer

A non-healing, sloughy venous leg ulcer quickly responded to topical treatment including octenilin Wound Gel and octenilin Wound Irrigation Solution. Full healing occurred within 6 weeks

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70-year-old woman with chronic venous insufficiency developed a venous leg ulcer despite wearing compression stockings. Her general practitioner and home care service treated the wound with a simple foam dressing. After one year, the wound still had not healed, so the patient was referred to a wound clinic. At this point, the wound bed comprised a very small



Fig 1. The wound at admission

amount of dry granulation tissue covered with fibrinous slough (Fig 1).

A new treatment protocol was initiated: the wound was cleansed with octenilin Wound Irrigation Solution, followed by application of octenilin Wound Gel and a non-woven compress and compression bandaging. The wound gel is a hydrogel, which was applied to moisten the dried granulation tissue and



Fig 2. The wound after 2 weeks treatment with octenilin Wound Irrigation Solution and octenilin Wound Gel. The wound has improved significantly, with the formation of healthy pink granulation tissue

loosen the dried-in fibrinous slough.

The wound began to improve, with growth of healthy granulation tissue and epithelial tissue at the wound margins within 2 weeks (Fig 2). Full healing was achieved within 6 weeks (Fig 3).

The patient tolerated the dressing well, stating that the octenilin Wound Gel was pleasantly cooling at dressing changes.



Fig 3. Full healing occurred at 6 weeks

Case 4: using octenilin Solution with the schülke WoundPad

This case study demonstrates the use of a debridement pad with octenilin

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Fig 1. Postthrombotic ulcer with mildly sloughy fibrin strands

his case demonstrates the synergistic use of octenilin Wound Irrigation Solution and Schülke WoundPad. A 64-year-old patient presented with a postthrombotic ulcer with mildly sloughy fibrin strands (Fig 1). It was decided to perform a splitthickness skin graft. To prepare the wound bed for this, presurgical debridement was performed using the Schülke WoundPad (one blue and one red pad) in combination with octenilin Wound Irrigation Solution.

Schülke WoundPads are elastic, polyurethane pads with a coarse texture and rough surface intended for wound cleansing by mechanical debridement. The single pad differs in its texture: the red pad has a coarse structure and a rough surface; the blue pad has a medium coarse structure and a rough surface; the white pad has a fine texture and is well tolerated.

Despite the patient's high pain sensitivity, the procedure was very well tolerated. Two minutes

of thorough mechanical debridement resulted in a clean wound bed that was ready to be grafted without anaesthetic surface preparation and under ambulant conditions (Fig 2).



Fig 2. Following repeated ambulant debridement with the schülke WoundPad and octenilin Wound Irrigation Solution, the wound bed is clean and ready for grafting

Case 5: non-healing traumatic wound colonised with MRSA

A traumatic wound colonised with MRSA failed to respond to topical antimicrobial dressings. Following the combined use of octenilin Wound Gel and octenilin Wound Irrigation Solution, the MRSA was removed in 4 weeks, the necrotic tissue was debrided and the wound started healing

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Fig 1. The wound at presentation

r J is a 61-year-old man with a complex medical history, who lives with his wife and family, who attend to his day-to-day care needs. Besides type 1 diabetes mellitus, following two cardiac arrests he had a cerebral vascular accident that left him with rightsided weakness and poor speech. He also has a history of sacral pressure ulcers. Following bowel surgery, he returned home with a category III pressure ulcer on his sacrum, which was treated with topical negative pressure therapy, and an unstageable pressure ulcer on his left heel. During his admission, he had also incurred a traumatic wound on his lower left leg. This case study concerns the traumatic wound.

This wound measured 8x4cm and was necrotic. Exudate levels were low and there was minimal odour. According to his medical notes, previous interventions had included iodine, honey, silver and hydrogel dressings. His ankle brachial pressure index (ABPI) was



Fig 2. The wound after 2 weeks of treatment with octenilin Wound Gel and octenilin Wound Irrigation Solution

1.9. This, combined with his medical history, indicated that there was calcification of the vessels in his left leg. The staff notified his GP with a view to referring him to a vascular/diabetic foot clinic. A recent swab identified that the wound was colonised with meticillin-resistant *Staphylococcus aureus* (MRSA), increasing the risk of serious complications. Due to the poor response to previous treatments and the presence of MRSA, octenilin Wound Gel was used to decontaminate the wound and promote debridement.

Octenilin Wound Irrigation Solution was used to soak off the previous dressings, which had adhered to the wound bed and were causing pain at dressing change. The octenilin Wound Gel was applied to the eschar and covered with a low-adherent dressing and a crepe over stockinette. The dressings were changed three times a week.

After 2 weeks of treatment, the eschar started to lift, the surrounding skin appeared less



Fig 3. The wound at week 4: the wound is covered with granulation tissue, with epithelial tissue at the edges

inflamed and the edges were more defined. There was no maceration on the surrounding skin. The dressing could now be easily removed, but the wound continued to be irrigated with the Octenilin Wound Irrigation Solution as the patient found this reassuring.

After 4 weeks of treatment, a wound swab showed that MRSA was no longer present. Although the overall wound size remained largely unchanged, the wound bed was fully debrided and covered with granulation tissue. There was also evidence of epithelial tissue at the wound edges.

The district nurses and tissue viability nurse specialist involved in this patient's care found the octenilin Wound Irrigation Solution and Wound Gel easy to use, while the patient and his family were reassured by the pain-free dressing changes. The patient, who had both a complex medical history and a complex wound, made excellent progress in a short period of time, and his wound is now well on the way to healing.

Case 6: amputation site on an ulcerated diabetic foot

A patient presented with diabetic gangrene on four toes and a moderately infected ulcer on the dorsum of the foot. Following amputation of the gangrenous toes, it was possible to salvage the remaining foot using a combination of antibiotics, octenilin Wound Irrigation Solution and Octiset

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71-year-old woman with a 14-year history of type 2 diabetes mellitus plus hypertension and dyslipidemia was admitted to hospital in February 2013 for bladder removal due to malignancy. During her stay, she developed a small pressure ulcer on the hallux (big toe) of the left foot, which became infected. The patient was discharged and received outpatient treatment including two courses of antibiotics. However, she was readmitted in early July due to pain, oedema in her leg and foot, a deterioration of the ulcerated area and uncontrolled hyperglycaemia. She was treated empirically with antibiotics and a silverimpregnated foam dressing with a soft silicone contact layer, with no improvement. Following a CT angiography, the vascular surgeon recommended major amputation, which the patient declined.



Fig 1. The wound at admission

The patient was subsequently admitted to hospital with diabetic gangrene in the first, second, third and fourth toes, and a moderately infected Wagner grade 4 ulcer (gangrene on the toes or forefoot) (Fig 1). Culture results isolated multiresistant *Pseudomonas aeruginosa* and *Klebsiella pneumoniae*, for which antibiotic therapy was initiated.

Another CT angiography was performed, which revealed a severe atherosclerosis of the popliteal segment and the distal lower extremities. An endovascular angioplasty was undertaken without any complications.

One week after the revascularisation (Fig 2), the gangrenous toes were amputated and the infected ulcer was debrided with instillation of saline rinsing solution and octenidine antiseptic solution (octiset, Schűlke & Mayr GmbH, Germany). Topical antiseptic treatment comprised gauze saturated with octiset, which was in turn covered with gauze (as the exudate level was low) in accordance with the local treatment protocol. This was applied every 2–3 days.

Two weeks postoperatively, the wound surface was covered with healthy pink granulation tissue (Fig 3). At week 6, the patient was discharged with epithelialising wounds and a functional foot, allowing her complete autonomy in the performance of daily activities (Fig 4). The patient did not report any significant pain symptoms.

Even though the patient had many comorbidities and uncontrolled glycaemia, which delayed wound healing, the clinicians considered that the treatment time with octenidine was shorter than they had observed in the past with other topical treatments on similar wounds. The patient was grateful to have avoided amputation.



Fig 2. The foot one week after revascularisation



Fig 3. Two weeks after amputation of the gangrenous toes and topical treatment with octiset-saturated gauze: the wound is covered with healthy pink granulation tissue



Fig 4. Six weeks after amputation: the wounds are epithelialising and the functionality of the foot has been preserved

Case 7: highly infected post-surgical wound

Following treatment with antibiotics and surgical incision, which resulted in the release of putrid exudate, the wound was rinsed thoroughly with octenisept and covered with an antimicrobial dressing. This regimen successfully eradicated the infection, with full healing occurring in 6 weeks

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Fig 1. The wound 14 days after the initial surgery: healing is impaired and the wound is highly inflamed

75-year-old man with type 2 diabetes mellitus (primarily insulin independent) and a history of essential hypertension, coronary heart failure and a prostate carcinoma presented with a highly inflamed postoperative wound in the right groin. The surgery had comprised crossectomies of both the right and left great saphenous veins. The postoperative wound was covered with a simple sterile surgical adhesive wound dressing and began to heal without complications. However, 10 days post-surgery the wound developed signs of local infection, and so was treated with povidone-iodine ointment and a simple gauze dressing. The patient presented at our wound clinic on the 14th postoperative day (Fig 1).

Microbiological examination revealed



Fig 2. After 28 days of treatment: the wound is free of infection and progressing towards healing

coagulase-negative *Staphylococci* and histology revealed purulent ulcerative dermatitis with an abscess. This led to a diagnosis of a necrotic post-surgical wound infection. Intravenous antibiotics were prescribed: cefuroxime (1.5g, three times daily) and metronidazole (500mg, twice daily). After 3 days, the antibiotic regimen was changed to oral moxifloxacin (400mg, twice daily), which was given for an additional 10 days.

The wound was opened surgically, and the putrid, malodorous exudate was completely removed. The wound cavity, which measured 6x2x2cm, was rinsed thoroughly with octenisept and filled with a dialkylcarbamoyl chloride (DACC) tamponade. Due to the high levels of a seropurulent exudate present, a superabsorbent dressing was used as a secondary dressing. During the next 2 days,



Fig 3. After 78 days of treatment: the wound has fully healed

the dressing was changed twice daily and rinsed with octenisept. After this, it was changed once daily as only a moderate amount of serous exudate was present (it continued to be rinsed with octenisept). On day 4, the signs of wound infection had resolved and granulation tissue had started to form at the wound base.

On day 16, the wound had completely granulated and epithelial tissue was starting to form at the wound margins. The treatment protocol was switched to irrigation with Ringer's solution and application of a DACCcoated wound contact layer, which was changed on alternate days. After 28 days (Fig 2) the wound was free of infection and healing without complications. Full healing occurred on day 42. Fig 3 shows the healed wound at a late follow-up visit (day 78).

Case 8: extremely painful, locally infected venous leg ulcer

This ulcer was so painful that the young patient concerned was unable to tolerate antimicrobial dressings and compression therapy. A treatment regimen including octenilin Wound Gel helped reduce the pain, giving the patient more control over her life. The wound healed after 6 months

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37-year-old woman presented to the wound healing unit with a non-healing venous ulcer, of 2 years' duration, located just above the right lateral malleolus (Fig 1). The wound had started to heal during the first 12 months only to deteriorate in the following 6 months, becoming increasingly painful. There were skin changes and varicosities on her leg that were consistent with a chronic venous ulcer.

The patient was a single mother of a 2 year old and worked full time in a coffee shop. She had no significant past medical history that would affect the wound's ability to heal. She was overweight falling into the obese category. Although mobile, her gait was impaired, mainly because of the ulcer pain and chronic inflammation.

Wound swabs showed *Streptococcus* group B, *Staphylococcus aureus*, *Pseudomonas* and anaerobes. The wound edges were very inflamed with spreading erythema (approximately 2–3cm), while exudate damage extended distally to the heel region. The wound bed had very little healthy tissue, with a thicker layer of devitalised tissue. The ulcer was so painful that the patient struggled to tolerate antimicrobial topical treatments or any form of physical debridement, but she was able to wear high levels of compression. Her pain, which was managed by her GP with opiate and non-opiate analgesics, was assessed regularly.

Octenilin Wound Gel was not the first choice of treatment, mainly because of the high exudate levels and the moisture damage on the skin. However, the patient was reluctant to use 'traditional' antimicrobial dressings (silver, honey, lodine) and so opted to try octenilin Wound Gel. A barrier cream was used to protect the periwound skin, while the octenilin Wound Gel was covered with a non-adherent wound contact layer and a superabsorbent to manage the exudate, followed by four-layer compression bandaging. There was no increase in pain at application.

Over the next few weeks, there was no reduction in the pain, and the patient required more frequent district nurse visits because of the high exudate volume, although the surrounding skin did not deteriorate. As the barrier treatment did not appear to be sufficient, it was replaced with a honey barrier cream.

After 5 weeks of treatment, the team considered that the anaerobes in the wound were becoming more of an issue and so replaced the octenilin Wound Gel with topical metronidazole. However, this appeared to increase the patient's pain, so the team resumed use of the octenilin Wound Gel.

As the treatment with the octenilin Wound Gel continued, the pain reduced and the wound improved (there was a reduction in size and the patient was better able to tolerate treatment). The patient felt happier and more in control of her life. After 6 weeks, treatment was switched to a dressing composed of collagen and oxidised regenerated cellulose, but the patient opted to continue using the octenilin Wound Gel as she felt this was more suitable for her needs and was the most comfortable. The wound healed after 6 months (Fig 2).

It is difficult to determine the dressing change frequency as the patient's working hours affected the regularity of the



Fig 1. Wound at start of treatment with octenilin Wound Gel



Fig 2. Wound after 6 months of treatment

community nurse visits. However, she initially required visits 3 times a week, which reduced to twice weekly after 4 weeks and then to once weekly as the wound became superficial.

The patient was extremely pleased with the outcome, which increased her sense of wellbeing.

Case 9: heavily exuding, malodorous, necrotic pressure ulcer

In this case, the necrotic tissue was so hard it was not possible to categorise the ulcer. Octenilin products were able to debride the necrotic tissue, so that the wound depth could be determined. After 4 weeks, the wound was covered with granulation tissue, improving the patient's quality of life

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r C is a 45-year-old man with spina bifida who was referred to community nursing services with a suspected deep tissue injury on his sacrum/hip. He had a history, many years previously, of pressure ulceration and osteomyelitis. He had been self-treating the current injury for 2 months but reported that it had deteriorated while on holiday when he had no access to pressure relief and endured a long flight delay on his return home. Other than a pressure-redistributing cushion, he had not received any equipment or interventions from community services.

Assessment revealed a pressure ulcer measuring 7.5x4.0cm. It could not be categorised because it was covered with hard and firmly attached necrotic tissue (Fig 1). Adjacent to this was a superficial wound caused by friction and adherence of a dressing that he had worn on holiday. This area measured approximately 4x4cm, and was superficial but sloughy. The patient had placed absorbent pads over the wounds, which were found to be saturated with exudate on removal.

Treatment options were discussed with the patient. He agreed to have a pressureredistributing mattress and spend a period of time in bed, with assistance from carers. However, he was concerned that, based on past experience, it would take several weeks to debride the pressure ulcer and the malodour would put people off visiting. Although there was erythema on the surrounding skin and the wound looked unhealthy, with increased exudate as well as malodour, a swab showed no significant growth, so it was thought to be critically colonised and not infected. Treatment aims were to fully debride the wound in order to assess its depth and, if appropriate, start negative pressure wound therapy.

Following discussion, it was decided to use octenilin Wound Irrigation Solution to soak off the previous dressing in order to minimise further skin damage. Octenilin Wound Gel was used to debride the necrotic tissue, and a foam dressing with an adhesive silicone border was selected in order to minimise trauma during removal. The dressing was changed on alternate days. No other form of debridement was used.

After 2 weeks, it was possible to remove the foam dressing easily from the wound with no further trauma. The adjacent superficial wound had improved and wound edges were more defined (Fig 2). The octenidine solution was used to irrigate the wound and cleanse the adjacent skin. The wound dimensions were unchanged but the patient reported that the malodour had reduced. The wound was still producing moderate amounts of exudate, but this was well absorbed by the foam dressing. Treatment with octenilin Wound Gel and the primary foam dressing continued.

After 4 weeks, the wound had improved significantly. The superficial wound had healed and the surrounding skin was healthy. The main wound had fully debrided and now measured 4x2cm (Fig 3). It was now possible to probe the wound base and measure the depth, which was 7cm. The wound bed was now completely covered with granulation tissue, and it was decided to apply negative pressure wound therapy to speed up the healing process.

The nurses and the patient both reported that they were delighted by the speed at which the wound had been debrided, and thought that the dressing regimen had accelerated this. The patient was particularly pleased that he was



Fig 1. Pressure ulcer at presentation: it could not be categorised because of the hard necrotic tissue. There is a superficial wound nearby



Fig 2. After 2 weeks of treatment with octenilin Wound Gel and Irrigation Solution, the condition of the surrounding skin has improved



Fig 3. After 4 weeks, the superficial wound has healed, the necrosis has been fully debrided and the surrounding skin looks healthy

able to join his family at Christmas without being embarrassed by any malodour.

Case 10: venous leg ulcer that was significantly impairing quality of life

This heavily exuding, sloughy ulcer was so painful that the patient had difficulty tolerating any physical contact with it. After treatment, pain levels subsided, so that she was better able to tolerate dressing changes, could sleep in her own bed instead of a chair, and started compression therapy

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rs D is a 71-year-old woman who had been attending the treatment room service at a walk-in centre with weeping areas on the back of both legs. Her legs were extremely painful and she was referred to a leg ulcer clinic for assessment. While waiting for the appointment, she had only been able to tolerate low-adherent dressings covered with a layer of orthopaedic wool and crepe. Dressing changes were very painful and she was unable to sit with her legs elevated as any pressure on the back of the legs caused her significant pain. She therefore usually spent the night in a chair. She was prescribed morphine to take before dressing changes. When she attended the leg ulcer clinic, the staff were unable to measure her ankle brachial pressure index as she could not tolerate the cuff inflation. She was therefore referred for a vascular opinion.

Approximately one month later, her tissue viability nurse specialist and GP made a joint visit to her home. Mrs D's clinical appearance and past medical history, plus triphasic waveforms of the foot pulses, suggested that the leg ulcer was predominantly venous in aetiology. A diagnosis of venous disease with critical colonisation of the leg ulcer was made.

The wound measured 10x11cm, and the wound bed was covered with a thin layer of slough, although some dusky granulation tissue was visible (Fig 1). It was agreed that a vascular referral was not necessary.

The patient's main concern was the pain, followed by the high volume of exudate. At that time, all she wanted was for her pain to ease enough for her to spend Christmas Day, later that month, at her sister's. After discussion, she agreed to the following treatment regimen: octenilin Wound Irrigation Solution, to soak off the previous wool and crepe, and an ibuprofen-impregnated foam primary dressing, to reduce the pain and discomfort, plus a layer of orthopaedic wool and crepe. The dressing was initially changed daily owing to the high exudate levels; the wound was irrigated with the octenidine solution at each dressing change. While the patient found any physical contact with the wound surface very painful, she was able to tolerate gentle irrigation, which she described as 'cooling'.

The patient attended the treatment room service one week later. Even in the waiting area, she looked much more comfortable. She had been able to sleep in her bed and found the dressing changes much less painful as the octenidine solution gently loosened and lifted the foam dressing at each dressing change. The wound now measured 8x8cm. The wound bed remained wet but small islands of epithelialisation were visible. Slough was still present but the wound bed appeared healthier and was less dusky (Fig 2). The patient reported that she was optimistic her leg would improve. Dressing change frequency reduced to three times weekly.

After 3 weeks of treatment, the wound had reduced to 4x4cm in size. The octenidine solution continued to be used but, as the pain had reduced, the ibuprofen-foam dressing was discontinued. The wound bed looked much healthier (Fig 3). Meanwhile, the patient no longer required morphine and was able to elevate her legs and go to bed, although she still experienced some discomfort during dressing removal. It was now possible to undertake a full leg ulcer assessment, and as a result the patient started wearing compression therapy.

Without this treatment regimen, this patient would have been referred to hospital for a

vascular opinion, potentially delaying the initiation of treatment. She would not have been able to tolerate compression therapy, and dressing adherence would have added to her pain. This treatment regimen aided her comfort and promoted healing. Most importantly, she achieved her goal of spending Christmas with her sister.



Fig 1. The venous leg ulcer at presentation: it was covered with a thin layer of slough



Fig 2. After one week of treatment the wound bed looked healthier



Fig 3. After 3 weeks' treatment, the wound pain had reduced sufficiently for the patient to tolerate compression

Case 11: large, infected, necrotic mixed-aetiology leg ulcer

This painful and malodorous ulcer was covered with 40% necrotic tissue. Combined use of octenilin Wound gel and Wound Irrigation Solution gently debrided the necrotic tissue, and helped reduce the pain and malodour. Within 6 weeks, the wound was covered with granulation tissue

Juliet Price, Senior Nurse Tissue Viability, and Zoe Boulton, Inpatient Podiatrist, both at Royal Devon and Exeter Foundation Trust

his case concerns a 72-year-old woman with extremely painful mixed-aetiology leg ulcers of 18 months' duration. Her medical history included myocardial infarction, thrombophlebitis and deep vein thrombosis in her left leg. Other comorbidities included stage 3 chronic kidney disease, type 2 diabetes mellitus controlled by diet and metformin, and atrial fibrillation, for which she was prescribed rivaroxaban.

Due to the ulceration, the patient had been unable to sleep in a bed for the past 12 months or to tolerate any contact with clothing or bedsheets on her leg. She had consequently become housebound and her mood was very low. Her pain had become so unbearable that her GP referred her to hospital for symptom management. She presented with these wounds:

- A mixed-depth circumferential gaiter ulcer, covered with 70% slough, on the right leg (Fig 1)
- An ulcer, measuring 4x6cm, located over the Achilles tendon on the left leg
- Multiple small superficial breaks on the back of her left leg.

Both legs were leaking copious amounts of lymphovenous exudate.

A full vascular assessment revealed arteriosclerosis. Duplex scanning revealed incompetency in the great saphenous veins, although imaging was suboptimal due to the extent of her oedema and size of her limbs.

The patient was unable to tolerate an initial trial of short-stretch compression bandages. Nevertheless, a non-adherent wound contact layer, a superabsorbent dressing and a twolayer compression bandage system were left in place over the weekend, despite the patient reporting increased pain and asking for them to be removed. There were signs of systemic infection, while the exudate levels were increasing. However, these symptoms were missed partly because the bandages and wound dressings were not removed and a full assessment was not undertaken. The patient developed an infection in the ulcer on the right leg, with 70% of the ulcer covered with necrotic tissue and other parts showing signs of excoriation, while any granulation tissue was inflamed and friable.

Unfortunately, the intravenous antibiotics used to treat this infection resulted in a *Clostridium difficile* infection, which led to the patient being transferred to the isolation ward. This exacerbated her low mood and sense of social isolation. In addition, she was reluctant to try further antibiotics to treat what was now heavy colonisation of her wound and its malodour.

Forty percent of the necrosis on the ulcer on her right leg was sharp debrided under nitrous oxide and oxygen. During the first week, the dressings were changed every 48 hours due to the high exudate levels. Octenilin Wound Irrigation Solution was used to cleanse the wound and octenilin Wound Gel to gently debride the remaining necrosis and hydrate the surrounding tissue. It was covered with an absorbent non-adhesive dressing and pad, and secured with a retention bandage.

After one week, compression therapy was recommenced using three-layer long-stretch elastic bandages, which delivered reduced compression of up to 20mmHg at the ankle.

After 2 weeks, the pain levels had improved and the malodour reduced significantly. Dressing change frequency reduced to twice weekly (Fig 2).

By week 6, the bioburden had reduced sufficiently to eliminate the malodour at dressing changes. The ulcer was completely covered with



Fig 1. Wound on the right leg at presentation



Fig 2. Wound on the right leg following treatment for a systemic infection: use of octenilin helped debride the necrosis and reduce the pain levels



Fig 3. The same wound after 6 weeks

granulation tissue, while there was epithelial tissue at the wound margins and islands of epithelialisation in the centre. The wound had reduced by 30% in size and the ulcer was now superficial (Fig 3).

The patient's pain gradually reduced from a visual analogue score (VAS) of 10 to 3, and she commented that, following application of the octenidine solution, the 'gnawing sensation' was minimised and her neuropathic symptoms had eased. She was able to sleep in a bed and had her first unbroken night's sleep. Finally, her leg shape changed, with a 3–4cm reduction in the circumference of the ankle and 7cm reduction in the circumference below her knee.

Case 12: a neuroischaemic ulcer on the heel

This necrotic ulcer was managed with sharp debridement, octenilin Wound Irrigation Solution and Wound Gel, plus a non-adherent dressing. The significant oedema in the lower limb was controlled with reduced compression. The wound improved steadily over time, healing on week 16

Juliet Price, Senior Nurse Tissue Viability, and Zoe Boulton, Inpatient Podiatrist, both at Royal Devon and Exeter Foundation Trust

his case study concerns a 69-yearold man with a medical history of type 2 diabetes mellitus, a quadruple heart bypass, atrial fibrillation with congestive cardiac failure and peripheral vascular disease that had resulted in a longstanding lateral malleolus ulcer that required an angioplasty to improve the blood flow. Following a hip replacement, he had developed a painful neuroischaemic ulcer on the left heel when an oedematous limb was ineffectively offloaded. He smoked 30 cigarettes a day and showed little motivation to quit. His diabetes was not well managed at that time.

In 2014, the vascular surgeon had requested that he consider reduced compression to manage the chronic malleolus ulceration, but this had not been facilitated at his local GP practice. The necrotic tissue on his heel was debrided in a diabetic foot clinic, and standard treatment with a povidone-iodine dressing was initiated. However, the ulcer failed to progress.

The heel ulcer measured 6.2x5.2 cm and had a probeable depth of 0.7 cm (Fig 1), while the malleolous ulcer measured 1.5x1.4 cm. A treatment regimen was initiated comprising sharp debridement of (loose) eschar, plus irrigation with octenilin Wound Irrigation Solution, application of octenilin Wound Gel, followed by a non-adherent dressing.

Despite monophasic dampened pulses, the patient's highly calcified arteries were uncompressible to 220mmHG, so reduced compression (up to 22mmHG) was trailed, under strict monitoring in clinic, to manage his significant oedema and compensate for his reluctance to elevate his leg.

Although the wound was dry enough to leave the compression bandages in place

for longer than 72 hours, the suspected calcification of his arteries and neuropathy necessitated more regular changes to assess his feet. (While there is a paucity of evidence on the use of compression on diabetic foot ulcers, the authors have had excellent results when using it for this indication in a controlled manner.)

The malleolous ulcer healed uneventfully. The heel ulcer began to improve steadily over the next 6 weeks (Fig 2). The frequency with which the compression bandages were changed reduced until it was possible to leave them in place for a full week. At week 6, the wound was now shallow and its diameter had reduced to 3 cm, with a 0.4 cm central depth. There was a notable increase in temperature lateral to the ulcer, but no overt signs of cellulitis, although there was concern that calcaneal osteomyelitis could occur. A course of flucloxacillin 500mg was commenced three times a day due to concerns about renal impairment.

At week 7, the ulcer had decreased in size and the signs of infection had reduced. The dorsalis pedis and posterior tibial pulses were assessed as dampened monophasic. The patient was strongly advised to give up smoking. Offloading was attempted using a Scotchcast heel cup, which the patient admitted wearing only intermittently. Treatment with the octenilin soaks and wound gel continued. The malodour disappeared and the patient experienced minimal pain at dressing change.

At week 14, the patient was readmitted to the inpatient unit following a mechanical fall. The heel ulcer was 50% smaller and flush to the surface of the skin. The treatment regimen was changed to a povidone-iodine dressing and pad, although he continued to be given octenilin soaks until the ulcer healed, with only a small amount of eschar present, at week 16.



Fig 1. The heel ulcer at the start of treatment with octenilin



Fig 2. The ulcer at week 6



Fig 3. The healed ulcer at week 16

Case 13: chronic painful ulcer on the heel of a diabetic foot

This painful ulcer, which had signs of biofilm, was covered in necrotic tissue. Octenilin Wound Gel was used to soften the necrosis in preparation for sharp debridement. Three weeks later, the devitalised tissue had been completely removed, while there was a 50% reduction in wound size at week 5

Juliet Price, Senior Nurse Tissue Viability, and Zoe Boulton, Inpatient Podiatrist, both at Royal Devon and Exeter Foundation Trust



Fig 1. The heel ulcer on admission to hospital

n 84-year-old man developed a suspected deep tissue injury in his left heel as a result of direct pressure and increased tissue pressure from fluid. He had a significant medical history including atrial fibrillation, hypertension, biventricular failure, peripheral vascular disease and type 2 diabetes mellitus. The diabetes was controlled with diet and medication. Prior to his discharge and following strict offloading of the heels, the tissue appeared to be revascularising and the damage resolving.

Two weeks later, the patient was readmitted with severe pain secondary to his heel ulcer (Fig 1). Assessment identified a necrotic plaque



Fig 2. After 3 weeks of treatment, the necrotic tissue has been fully debrided and some epithelial tissue is present

covering 60% of the ulcer and a suspected biofilm across its entire surface. Signs of biofilm included persistent inflammation, higher than expected levels of exudate, lack of advancement of the wound edges and failure of the wound to progress towards healing. There was also notable malodour.

Octenilin Wound Gel was used to soften the eschar, and a non-adherent dressing pad and retention bandage were also applied. One week later the pain had reduced sufficiently (following analgesia) for sharp debridement to be performed.

By week 3, the necrotic tissue had been fully debrided and there was evidence of epthelialisation as well as contraction of the



Fig 3. The ulcer at week 5 when use of octenilin has been discontinued

wound margins. Use of the octenilin Wound Gel had prevented the secondary dressing from adhering to the wound as the exudate levels reduced. The patient was also able to elevate his leg, as advised, which improved his dependent oedema.

At week 5, the ulcer had reduced in size by 50%, although there was evidence of overgranulation in the central aspects of the wound. The treatment regimen was changed to a povidone-iodine dressing and a standard dressing pad. It was difficult to offload the heels effectively as the patient had vascular dementia secondary to advanced calcification of his arteries and he kept removing the heel protection as it contributed to his pain levels.

Case 14: Octenilin Wound Gel versus betadine/PHMB gel

Here, a clinician compares 4 weeks of treatment with Prontosan Wound Gel with a subsequent 4 weeks of octenilin Wound Gel on a complex diabetic foot ulcer prone to recurrent infection. The data show that, following the switch to octenilin, the previously static wound started to heal

Sharon Hunt, Advanced Nurse Practitioner, Independent Specialist in Tissue Viability, South Tees NHS Hospitals Foundation Trust

r A is a 33-year-old Asian man with type 2 diabetes mellitus who presented in 2013 with a large diabetic foot ulcer on his left inner ankle (malleolus region) as a result of ill-fitting footwear. During the previous 2 years, the patient had declined various offloading devices and strategies: Darco MedSurg Shoe, a plaster of Paris (POP) cast and elevation rest. His diabetes was well controlled by oral medication, with blood glucose ranges of 4.2–7.0 mmol and a static HBA1c of 5–6. His ankle brachial pressure index was normal, with no signs of arterial or venous insufficiency. He was a heavy smoker and, while his diet was high in cholesterol, his body mass index was within the normal range (24).

The patient, who worked as a taxi driver for up to 10 hours per day, had two children aged under 10 years and a large family network. He had no other medical conditions, allergies or ailments. His mobility was slightly impaired by an increasing right-sided weight-bearing gait caused by the diabetic foot ulcer. He self-managed his pain with over-the-counter paracetamol and ibuprofen as required. Previous treatments included a povidoneiodine dressing, a bordered foam dressing with a soft silicone contact layer, and honey.

The patient had also used Prontosan Solution (B Braun) and Prontosan Wound Gel (B Braun) for 3 months, with some benefits. However, while the wound had reduced in size, it had not healed and required frequent courses of oral antibiotics due to recurrent local *Staphylococcus aureus* infections. The dressings were changed every 72 hours, with the gel applied to the wound bed 10 minutes before each change.

It was decided to switch from Prontosan to

Table 1. Wound characteristics during treatment with the betaine/PHMB gel									
	Length	Width	Depth	Slough	Necrosis	Malodour	Exudate	Pain*	
Week 1	8.2 cm	5.4 cm	0.4 cm	60%	40%	Strong	High	8/10	
Week 2	8.2 cm	5.4 cm	0.4 cm	60%	40%	Strong	High	6/10	
Week 3	8.2 cm	5.4 cm	0.5 cm	60%	40%	Strong	High	9/10	
Week 4	8.0 cm	5.5 cm	0.5 cm	80%	40%	Strong	High	9/10	
Week 4.5	8.2 cm	5.4 cm	0.4 cm	60%	40%	Strong	High	8/10	

Treatment regimen: Prontosan Wound Gel; povidone-iodine dressing and a bordered foam with a soft silicone contact layer *VAS score ranging from 10 (maximum) to 0 (no pain)

Table 2. Wound characteristics during treatment with the octenilin Wound Gel									
	Length	Width	Depth	Slough	Necrosis	Malodour	Exudate	Pain	
Week 5	8.1 cm	5.2 cm	0.3 cm	30%	20%	Moderate	Moderate	6/10	
Week 6	7.8 cm	5.0 cm	0.2 cm	10%	5%	Low	Moderate	4/10	
Week 7	7.8 cm	4.8 cm	0.2 cm	0%	0%	None	Low	2/10	
Week 8	7.0 cm	4.8 cm	0.2 cm	0%	0%	None	Low	2/10	

Treatment regimen: octenilin Wound Gel, povidone-iodine dressing and a bordered foam with a soft silicone contact layer

CASE STUDIES

octenilin Wound Gel. The clinician overseeing the patient's care then set out to compare the wound characteristics documented in the 4 weeks before and after the switch to the octenilin Wound Gel.

Fig 1 shows the wound 4 weeks before the switch to octenilin Wound Gel (ie, week 1 in Table 1). There was high-density adherent slough on the wound bed, high volumes of viscous exudate, strong malodour and the peri-wound skin was erythematous and inflamed. Microbiology results, based on a wound swab, showed *Pseudomonas*, for which a 10-day course of oral flucloxacillin, 500mg four times per day, was prescribed. Codeine/ acetaminophen was prescribed for pain relief during that week. Table 1 lists the wound characteristics documented during the 4-week period before the switch to octenilin Wound Gel.

The octenilin Wound Gel, which was used on weeks 5–8, was applied in the same way as the betaine/PHMB gel had been: dressings were changed every 72 hours and the gel was left to soak into the wound for 10 minutes before dressing application. No oral antibiotics were required from week 5. Table 2 charts the wound progress over weeks 5–8. Fig 2 shows the wound on week 7: it was free of slough and necrosis, with a granular base and epithelial tissue extending in from the surrounding skin, low exudate levels and no malodour.

In the previous 2 years, despite treatment,



Fig 1. The heel ulcer on admission to hospital

this non-healing wound had persistently posed challenges to both the clinician and patient, with pain, exudate volumes and malodour all requiring frequent consultations for assessment and management planning. Oral antibiotics were frequently prescribed for recurrent localised infection, predominantly *Staphylococcus aureus* and, more recently, *Pseudomonas*.

I believe the switch to the octenilin Wound Gel as part of wound bed preparation turned a static wound into one with the potential to heal.



Fig 2. After 3 weeks of treatment with Octenilin Wound Gel, the necrotic tissue has been fully debrided and some epithelial tissue is present

This has been demonstrated by the reduction in exudate volumes and pain, elimination of malodour and reduction in wound size. The patient was pleased with the improved outcomes and reduced need for analgesia.

Having achieved success with this challenging wound, I am now more inclined to add octenilin Wound Gel to my wound-care toolbox as a regular cleanser for wound bed preparation.

Case 15: use as an instillation solution with NPWT

A patient with purpura fulminans, which resulted in amputation of three limbs, developed a *Pseudomonas* infection on the buttocks. Treatment comprised negative pressure wound therapy, with octenilin as the irrigation fluid. This eradicated the infection, resulting in granulation tissue formation

Steven Jeffery, Professor, Wound Study, Birmingham City University, and Consultant Plastic Surgeon



Fig 1. The wounds on the buttocks became heavily colonised with Pseudomonas



Fig 2. Application of octenilin Wound Irrigation Solution and NPWT



condition, which causes thrombosis of blood vessels, affected approximately 50% of the patient's total body surface area, resulting in amputation of both legs and his right arm.

The wounds became heavily colonised with *Pseudomonas.* The residual buttock areas were particularly problematic to dress and were painful (Fig 1). Like many burns units, we treat pseudomonal infection with acetic acid soaks.¹ However, this requires daily application, which reduced the time available for physiotherapy and feeding, both of which are vital for patients who have spent prolonged periods in intensive care.

The wound was irrigated using the V.A.C.Ulta (KCI) negative pressure wound therapy (NPWT) device, with octenilin Wound Irrigation Solution as the instillation fluid. Every 3 hours, the sponge wound filler was filled with 50ml of the octenidine solution and held for 15 minutes (Fig 2). The dressing was changed every 3 days during a total of 9 days' treatment. The nurses found the dressings easy to apply, despite the proximity to the anus. As the treatment progressed, the wound looked much healthier, with a reduction in slough and an increase in healthy granulation tissue (Figs 3 and 4).

As the graft failure rate is higher for the buttocks than other body sites, surgeons are often reluctant to skin graft buttock wounds until the wound bed looks very healthy. The combination of the NPWT irrigation and the octenidine solution enabled excellent preparation of the wounds prior to skin grafting. The patient found the dressing comfortable. Furthermore, the reduction in dressing change frequency from every day to every 3 days allowed much more time for the patient to eat, socialise and attend physiotherapy, all of which were very important for his wellbeing.

1 Halstead, F.D., Rauf, M., Bamford, A. et al. Antimicrobial dressings: comparison of the ability of a panel of dressings to prevent biofilm formation by key burn wound pathogens. Burns 2015; 41: 8, 1683–94



Fig 3. There was little granulation tissue before treatment with octenilin Wound Irrigation Solution and NPWT



Fig 4. Following treatment, healthy granulation tissue appeared

Case 16: further success as an instillation solution with NPWT

An amputation stump developed a particularly painful abscess, which required incision and drainage. Combined use of NPWT and octenilin Wound Irrigation Solution as the instillation fluid proved successful, with a reduction in pain and sufficient healing for the wound to be closed in theatre

Steven Jeffery, Professor, Wound Study, Birmingham City University, and Consultant Plastic Surgeon

36-year-old man sustained a fractured tibia while parachuting abroad. The fracture was plated in the country in which the fall occurred, but it never healed and he subsequently developed osteomyelitis of the tibia and complex regional pain syndrome (CRPS). After much discussion, an elective above-knee amputation was performed. Approximately 6 weeks after the amputation, an abscess developed at the end of the stump, which was very painful and 'throbbing' (Fig 1). In

our experience, the surgical complication rate, particularly of postoperative infection, in patients with CRPS is higher than that of other patient groups.

The patient was admitted to hospital and underwent incision and drainage of the stump (Fig 2). The wound was irrigated in theatre using the V.A.C.Ulta negative pressure wound therapy (NPWT) device and octenilin Wound Irrigation Solution (Fig 3). Once every 3 hours, the sponge wound filler was filled with 45 ml of the octenidine solution and held for 15 minutes.

Postoperatively, the patient immediately reported a complete reduction in his pain. Three days later, the dressing was changed on the ward. On day 6, the wound was closed in theatre (Fig 4), after which a postoperative dressing was applied (Fig 5). One week later, the patient was reviewed (Fig 6) and the dressing was removed (Fig 7).

The wound healed completely 2 weeks after being irrigated (Fig 8). Use of the octenidine solution allowed for closure of a previously infected wound.



Fig 1. Painful abscess at the end of the stump



Fig 2. The stump required incision and drainage



Fig 3. Treatment with octenilin Wound Fig 4. Six days later, the wound was Irrigation Solution and NPWT



closed in theatre



dressing in place



Fig 5. The wound with postoperative Fig 6. The wound at assessment one Fig 7. The wound following removal Fig 8. After 2 weeks, the wound had week later of the postoperative dressing



completely healed

Case 17: intravenous drug user injection-site wound

This patient presented with a painful, malodorous, infected wound on his right leg, which was also his main heroin injection site. Following treatment with octenilin Wound Irrigation Solution and a superabsorbent dressing, within 3 weeks all of the symptoms of infection and non-healing had gone

Sharon Hunt, Advanced Nurse Practitioner, Independent Specialist in Tissue Viability, South Tees NHS Hospitals Foundation Trust

29-year-old man presented at a community-based GP surgery with an infected wound on his right mid-level tibial crest. He had a 2-year history of intravenous heroin drug abuse and used his right limb as his main site of injection. Prior to his attendance, the patient had been self-treating his wound with over-the-counter adhesive plasters and had not sought any health-care input. He had a low body mass index (BMI), was a heavy smoker, had a poor dietary intake and a high alcohol consumption.

At presentation, the infected wound was sloughy, malodorous and extremely painful (pain score of 8/10), with erythema extending to 9cm² from the wound margins. The high exudate volume had resulted in widespread maceration on the periwound skin and surrounding tissues. The wound was treated with octenilin Wound Irrigation Solution and a superabsorbent silicone foam dressing.

After 1 week of treatment, the pain score had reduced to 3/10, the malodour had disappeared, the exudate level had reduced to moderate and the amount of slough had halved (from 20% to 10%). While the wound was still infected, the spreading erythema now



Fig 1. The wound at presentation. It measured 3.5 x 2.5 x 0.2cm

only covered 6cm² of the surrounding skin.

After 2 weeks, the wound was no longer infected, with no malodour and only low levels of exudate. There was also a 50% reduction in the amount of spreading erythema and slough, while the periwound maceration



Fig 2. The same wound after 3 weeks of treatment. It now measured 1.9 x 1.1 x 0.1cm

had been eliminated. The pain score was unchanged.

After 3 weeks, these symptoms had been eliminated, with the exception of the exudate volume, which remained low for the following week.

Case 18: infected self-harm injury on the left ankle

This patient, who not only had unstable disease but also a long history of self-harm, presented with an infected malodorous wound filled with soft necrotic tissue and slough. Treatment including octenilin Wound Gel and antibiotics helped kick start the wound towards healing

Sharon Hunt, Advanced Nurse Practitioner, Independent Specialist in Tissue Viability, South Tees NHS Hospitals Foundation Trust

36-year-old man presented at a community-based GP surgery with an infected wound on his left medial malleolus region. He had a 4-year history of self-harm to his bilateral forearms and a 6-month period of sharp injury to his bilateral ankles with items such as penknives and biro pens. Prior to attendance, he had self-treated his wounds by washing them but had not used any dressing products. This patient has unstable type 2 diabetes mellitus, for which he was prescribed insulin. He had a poor dietary intake, was a non-smoker and was prescribed multiple medications for anxiety, depression and personality disorder.

At presentation, the wound bed, which was highly malodorous, comprised soft necrotic tissue (20%) and slough (80%) (Fig 1). Exudate levels were high, and there was minor maceration on the periwound skin. The wound was moderately painful (pain score 6/10). The wound was treated with octenilin Wound Gel, and a superabsorbent silicone foam dressing. Results of a wound swab taken after 3 days of treatment indicated there was a *Pseudomonas* infection. He was therefore prescribed a one-week course of oral flucloxacillin 500 mg four times a day.



Fig 1. The wound at presentation: it measured 5.2 x 4.5 x 0.3cm

After 1 week of treatment, there was an improvement in the pain scores (now 2/10) and a reduction in the amount of slough and necrotic tissue present, which reduced to 60% and 10% respectively, while the periwound maceration was eradicated. However, the wound was still malodourous and the exudate levels remained high. Both improved over



Fig 2. The same wound after 3 weeks of treatment: it now measured 4.5 x4.0 x 0.1 cm

the following 2 weeks, with the malodour disappearing completely at week 2 and the exudate progressing from moderate at week 2 to low at week 3 (Fig 2). Pain levels stayed low (2/10) throughout this period. Infection disappeared at week 3 and the wound became pain free at week 4, with low exudate levels.

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