THE USE OF WOUND CLEANSING SOLUTIONS IN CHRONIC WOUNDS

Key words

- Octenidine
- Wound irrigation solution
- Biofilms
- Surface tension

This review collates a selection of *in vitro* and *in vivo* evidence relating to the antimicrobial activity of three topical agents. The low surface tension of a wound irrigation solution through the addition of surfactant-like agents can increase the fluid-'seeking' behavior and hence increase cellular contact time. Wound cleansing solutions should be capable of lowering the wound bioburden of both planktonic and biofilm phenotypes.

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Biofilms are primarily surface-associated microbial communities that are responsible for many of the microbiologically related challenges that are encountered in nature, industry and medicine (Costerton, 1995). These sessile entities are profoundly different to their planktonic (free-floating) counterparts, are extremely difficult to treat and underpin many refractory infections (Lewis, 2001).

The management of medically associated biofilms is becoming increasingly important as knowledge in respect of their influence on health increases (Del Pozo, 2007). Broadly speaking, the management of biofilms in chronic wounds is based principally on two tenets: the reduction of existing biofilms and the prevention of biofilm formation.

In general, resolution of a biofilm is not achieved with a single one-off treatment, but through application of targeted repetitive treatments. Where wound healing has been delayed as a result of suspected biofilm presence the concept of biofilm based wound care (BBWC) has been proposed (Wolcott and Rhoads, 2008; Wolcott et al, 2010). BBWC consist of three components — frequent debridement, application of topical agents, including antiseptics and systemic antibiotics based on molecular pathogen diagnostics (Wolcott et al, 2010).

OCTENILIN® WOUND IRRIGATION SOLUTION

Octenilin wound irrigation solution (schülke) is a colourless, alcohol-free solution, intended for cleansing and moisturising chronic wounds. This water-based irrigant contains octenidine dihydrochloride, a safe and effective antimicrobial agent that prevents bacterial growth (Vanscheidt et al, 2011). In addition, octenilin contains ethylhexylglycerin, a surfactant-like molecule that reduces the surface tension of aqueous solutions (Leschke, 2006) and thereby enhances its wetting behaviour (Schülke and Mayr, Data on file 1).

The surface tension of octenilin wound irrigation solution and two other solutions intended for wound cleansing was determined in the laboratory using the pendant drop method (Schülke and Mayr, Data on file 2). Differences in surface tension were assessed using a two-tailed students t-test — $P<0.05$ was considered significant.

Comparative wetting behaviour was verified by measuring the photographed contour of a suspended drop of the test solution. The contour was dependent on the surface tension of the test fluid. This examination showed a surface tension of 30.6 mN/m for octenilin wound irrigation solution, which was significantly less than that of the surface tension of Ringer solution (71.7 mN/m) and of Prontosan® (B Braun) (44.4 mN/m) ($P<0.001$) (*Figure 1*).

References

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Data on file 1. Determination of the wetting behaviour of Octenilin wound irrigation solution on human skin compared with competitor products. Schülke & Mayr GmbH, Robert-Koch Str, D-22840 Norderstedt, Germany.

Data on file 2. Determination of the surface tension of Octenilin wound irrigation solution compared with Prontosan W and Ringer solution. Schülke & Mayr GmbH, Robert-Koch Str, D-22840 Norderstedt, Germany.

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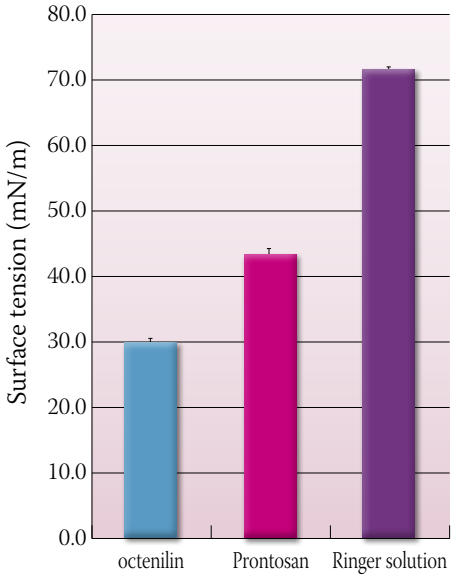

Figure 1: Comparison of the surface tension [mN/m] of octenilin, Pronotsan and Ringer solution. Bars indicate standard deviations.

The differences between the surface tension of the solutions were confirmed using a second method — the sessile drop method (Schülke & Mayr, Data on file 1). Here a suspended drop of the test solution was applied to the forearm of freshly washed and non-creamed skin. The contours of the test solutions were recorded via video camera and evaluated visually after a two-second contact time on the skin.

The 'spread' of a solution on a surface is influenced by the surface tension and thereby illustrates the wetting behaviour (*Figure 2*). A fluid low surface tension can favourably influence the 'seeking' behavior of the fluid and subsequent surface contact time (Greener, 2011) and is a valuable characteristic of a wound cleansing solution.

THE ANTIMICROBIAL AND ANTI-BIOFILM PROPERTIES OF WOUND IRRIGATION SOLUTIONS

The efficacy of octenilin was investigated in two *in vitro* experiments examining the prevention and eradication of *Staphylococcus aureus* bacterial biofilms (Westgate and Cutting, 2012).

In the biofilm prevention assay, the pins of a microtitre plate lid were coated with the wound irrigation solution and then immersed into a test inoculum of *S. aureus*. Incubation and shaking encouraged biofilm growth. Sampling occurred at 30 minutes (planktonic [non-biofilm] data), three, 24, 48 and 72 hours.

In the biofilm removal assay, the test inoculum was transferred into a 96-well plate and bacteria were encouraged to grow, as a biofilm, on the microtitre pin lid.

The 24-hour biofilms were exposed to 11 serial dilutions of octenilin for five minutes, starting with the commercially available concentration. The pin lid was washed three times in sterile saline and then transferred to a recovery plate.

Attached bacteria, indicative of biofilm phenotype, were recovered using a sonic water bath. Recovery of viable bacteria from the microtitre plate test wells provided the minimum inhibitory concentration (MIC) of octenilin against planktonic phenotype bacteria. Whereas

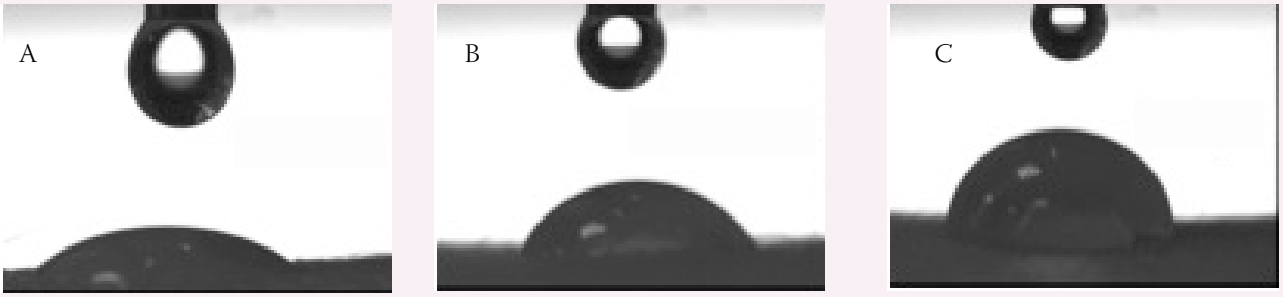

Figure 2: Comparison of the wetting behaviour (spreading of a sessile drop on human skin) of octenilin (A), Prontosan (B) and Ringer solution (C).

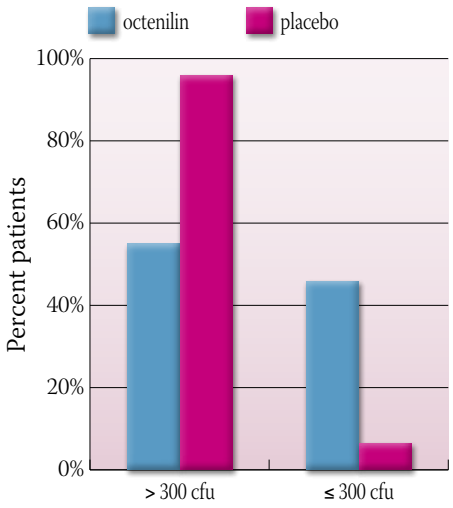

Figure 3: Percentage of patients and bacterial load in superficial wounds treated for three days with either octenilin wound gel or placebo (according to Eisenbeiss et al, 2012).

recovery of viable bacteria from the microtitre pin lids provided a minimum biofilm eradication concentration (MBEC) of the wound irrigation solution. All experiments were carried out in triplicate.

Octenilin prevented the formation of biofilm material at 30 minutes and at three hours. Although the biocidal activity of the agent decreased with time, the bacterial growth remained inhibited at 72 hours when compared to the positive control.

At the commercial concentration, octenilin inhibited the growth of planktonic and biofilm bacteria. Octenilin was active at a lower concentration against planktonic isolates when compared to biofilm phenotype bacteria.

These data suggest that cleansing a wound with octenilin has the capability to remove an established biofilm and remove planktonic bioburden, thus assisting in the prevention of biofilm formation.

CLINICAL EFFICACY OF OCTENILIN WOUND GEL

In a prospective, placebo-controlled, double-blind, randomised study the effect of octenilin wound gel on bacterial colonisation and epithelialisation was investigated in 61 patients with superficial skin graft donor site wounds (Eisenbeiss et al, 2012).

The site of split skin excision was treated with octenilin (n = 31) or placebo (n = 30) for three days. Octenilin gel efficacy was assessed by semi-quantitative analysis of superficial bacterial contamination of the wounds 24 hours after the end of the treatment period.

Wound surface bioburden levels were determined using contact cultures. Differences in the bacterial contamination were calculated using a Chi-square-test and differences in epithelialisation were calculated using a Student's T-test. In both tests, $P<0.05$ was considered significant.

Microbial colonisation was significantly lower in the treatment group compared to the placebo group ($p=0.014$). In the placebo group, a higher proportion of patients with bacterial counts >300 colony forming units (CFU) were observed than in the octenilin group (*Figure 3*), demonstrating that octenilin lowers bacterial contamination of the wound surface.

There was no statistical difference in time to epithelialisation between the treatment and placebo groups.

CONCLUSIONS

These data show that octenilin wound irrigation solution and octenilin wound gel are capable of managing wound bioburden of both planktonic and biofilm phenotypes.

Nevertheless, it should be borne in mind that the three components of biofilm-based wound care (debridement, topical agents and systemic antibiotics) are integral to achieving successful resolution in the management of chronic wounds and that reliance should not be placed solely on topically applied agents. WUK

DECLARATION OF INTEREST

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