The Importance of Dressing Conformability to Antimicrobial Action of Silver-Containing Wound Dressings: *In Vitro* Studies

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Introduction

Chronic wounds are polymicrobial, with bacterial colonisation originating from external sources such as surrounding skin, the gut and the mouth. As a consequence, bacterial burden exists predominantly in superficial wound tissue where biofilm inevitably develops, providing the colonising bacteria with an environment that may give them a competitive advantage over the host.

In order to minimise the opportunity for infection in chronic wounds, it is important that the superficial bioburden is controlled and maintained in a state that is not problematic to the host. In this respect, wound management practices such as cleansing, sharp debridement and the use of antimicrobial dressings are important. In order to maximise antimicrobial potency in superficial wound tissue, selection of a dressing that conforms well to a wound's unique topography is likely to be important in order to maximise exposure between bacteria and the antimicrobial agent.

In these *in vitro* studies, models were utilised that enabled both visualisation of the conformability of silver-containing dressings with a simulated wound tissue, and visualisation of the antimicrobial activity of these dressings in a shallow wound microbial model.

Materials and Methods

The silver-containing wound dressings used are listed in Table 1.

Dressing	Dressing Type
Hydrofiber® dressing	Silver-containing Hydrofiber® dressing (SCHD, AQUACEL® Ag) containing ionic silver, was covered with adhesive Hydrocolloid cover dressing (DuoDERM® EXTRA THIN)
Foam A dressing	Adhesive foam dressing containing silver sulfadiazine
Foam B dressing	Non-adhesive foam dressing containing silver sulfadiazine
Foam C dressing	Silicone adhesive dressing foam containing silver sulphate

Table 1: List of silver-containing dressings used:

Tissue Conformability Model

- Porcine muscle tissue was used to simulate an irregular wound surface.
- A Crono pump (PCA Model - 20 ml) was used to deliver Alcian blue-dyed physiological saline.
- An Olympus SZ61 Light microscope, with QImaging camera and Image Pro Plus 5.0 image analysis software (MediaCybernetics, UK) was used to capture the images.
- SCHD, Foam A and Foam C were tested in this model.

Shallow Wound Microbial Model

Challenge organisms: *Pseudomonas aeruginosa* (NCIMB 8626) and *Staphylococcus aureus* (NCIMB 9518).

- A suspension of *S. aureus* (approximately 4x10^{3}cfu/ml) was inoculated into the centre of the indentation within the agar plate.
- Each silver-containing dressing (SCHD applied with an adhesive Hydrofiber cover dressing (Versiva® XC®) and foams A, B and C, (n=3)) was gently applied such that it covered the agar indentation.
- Positive controls (n=1 for each challenge organism) were also utilised to confirm the extent of bacterial growth in the absence of silver-containing dressings.
- All agar plates were then incubated at 35°C (±3°C) for 48 hours prior to removal of dressings.
- Photographs of the agar plates were also taken following dressing removal.
- This procedure was repeated using P. aeruginosa as the challenge organism.

Results and Discussion

Tissue Conformability Model

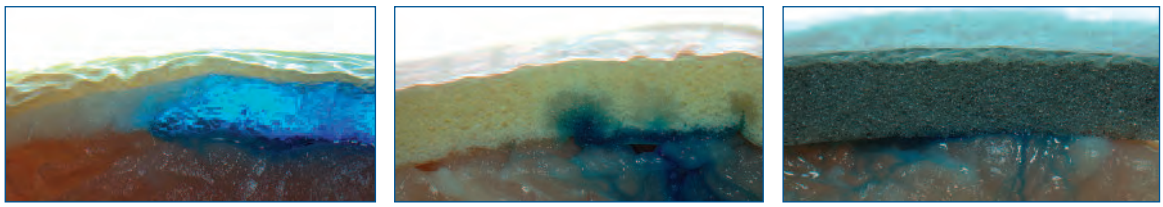


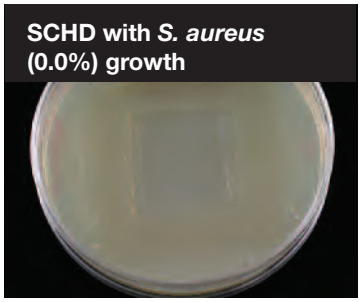
Figure 1: As dyed saline was made available at the dressing/tissue interface it was observed that the SCHD rapidly gelled and conformed to the tissue surface (left). In comparison both Foam A and Foam C dressings were observed not to conform as closely to the tissue surface (middle and right respectively), and there was evidence of fluid accumulation within the "open" non-contact spaces.

Shallow Wound Microbial Model

Table 2 shows the percentage growth of *S. aureus* and *P. aeruginosa* in the indented agar surface beneath the silver-containing dressings over a 48 hour contact period. Additionally, lateral spreading of both *P. aeruginosa* and *S. aureus* on the prominent agar beyond the edges of the indented agar surface was observed in association with Foam dressings A and C but this was not observed with SCHD or Foam B dressing.

Test Dressing Silver-Containing Dressings:	Challenge Organism	Bacterial Growth (within agar indentation) Replicates			Mean % Bacterial Growth indentation)
		1	2	3	
SCHD	*S. aureus*	0.0	0.0	1.2	0.4
	P. aeruginosa	2.7	3.6	20.8	9.0
Foam A	*S. aureus*	30.8	25.3	21.0	25.7
	P. aeruginosa	100.0	100.0	100.0	100.0
Foam B	*S. aureus*	17.3	18.4	14.6	16.7
	P. aeruginosa	96.1	97.9	99.4	97.8
Foam C	*S. aureus*	73.0	65.9	80.6	73.2
	P. aeruginosa	100.0	100.0	100.0	100.0
Positive Control (no dressing)	*S. aureus*	100.0	-	-	100.0
Positive Control (no dressing)	*P. aeruginosa*	100.0	-	-	100.0

Table 2: Percentage growth of *P. aeruginosa* and *S. aureus* in the indented agar area



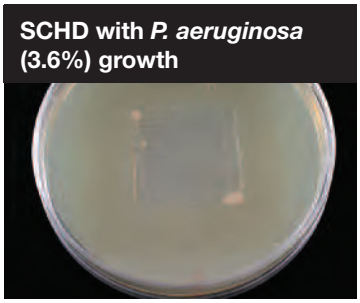
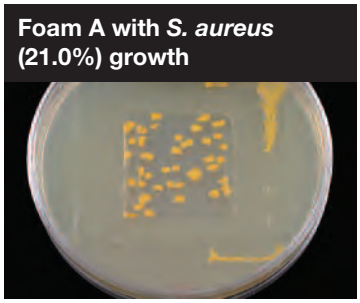


Figure 2: Examples of *S. aureus* and *P. aeruginosa* growth beneath SCHD in the indented agar. Figures in brackets indicate percentage bacterial growth relative to total indented agar surface area for an individual replicate (left – replicate 1; right – replicate 2).



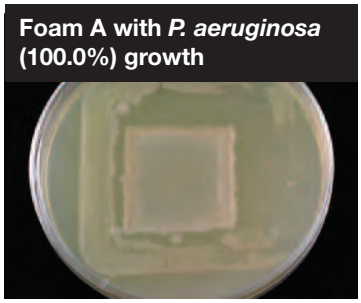
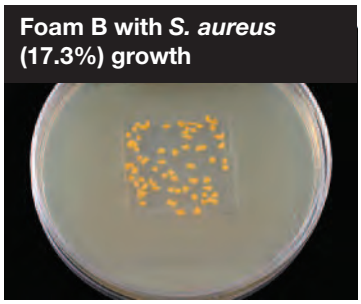


Figure 3: Examples of *S. aureus* and *P. aeruginosa* growth beneath Foam A dressing in the indented agar. Figures in brackets indicate percentage bacterial growth relative to total indented agar surface area for an individual replicate (left – replicate 3; right – replicate 3).



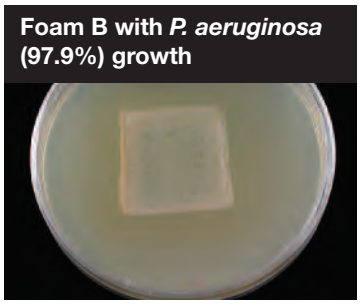
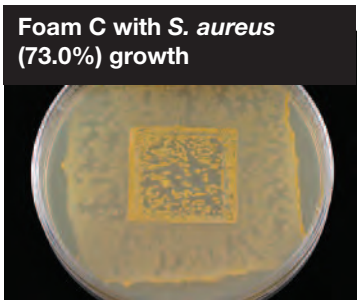


Figure 4: Examples of *S. aureus* and *P. aeruginosa* growth beneath Foam B dressing in the indented agar. Figures in brackets indicate percentage bacterial growth relative to total indented agar surface area for an individual replicate (left – replicate 1; right – replicate 2).



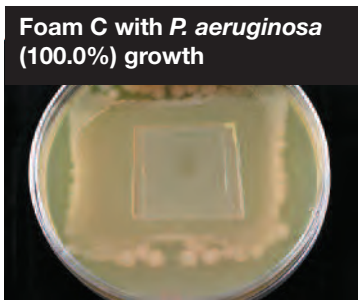


Figure 5: Examples of *S. aureus* and *P. aeruginosa* growth beneath Foam C in the indented agar. Figures in brackets indicate percentage bacterial growth relative to total indented agar surface area for an individual replicate (left – replicate 1; right – replicate 3).

Conclusion

- Using an *in vitro* tissue conformability model SCHD was observed to conform more closely to the tissue surface than the tested silver-containing foam dressings following hydration.
- There was no evidence of fluid accumulation at the tissue/dressing interface with SCHD, but this was observed with the tested silver-containing foam dressings.
- Using an *in vitro* shallow wound microbial model, it was observed that SCHD killed more bacteria (both *P. aeruginosa* and *S. aureus*) beneath the dressing than any of the tested silver-containing foam dressings.
- Additionally, SCHD was observed to not allow the spread of bacteria beyond the edge of the simulated wound.