# Prototype gelling fiber dressings incorporating quaternary polyethyleneimine (QPEI) demonstrate superior antimicrobial activity compared to commercially available products containing silver

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## Aim

Evaluate the antimicrobial performance of prototype QPEI-based gelling fiber wound dressings compared to commercially available products containing silver

## Introduction

Chronic wounds affect 1-2% of the global population. The prevalence of chronic and complex wounds are a major clinical and economic burden, with high infection rates.

The use of silver in antimicrobial wound dressings has been associated with negative impacts on wound healing and the development of anti-microbial resistance. To counteract these issues, we prepared prototype gelling fiber wound dressings incorporating a quaternary polyethyleneimine (QPEI) polymer.

QPEIs are a family of broad-spectrum antimicrobial polymers that disrupt bacterial cell walls and membranes via electrostatic interactions, leading to cell lysis.

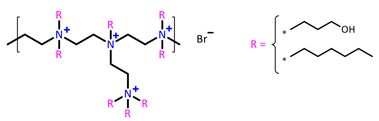


**Figure 1**. Quaternary ammonium polyethyleneimines (QPEIs) are alkyl-derivatives of a branched polyethyleneimine (a synthetic polymer). A representative QPEI structure is shown.

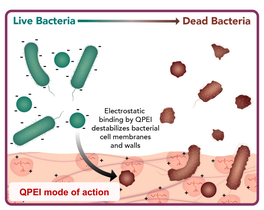


**Figure 2**. A pictorial depiction of the electrostatic interactions that take place between a positively charged QPEI and the negatively charged bacterial components, leading to anti-microbial activity.

### Evidence of antimicrobial activity by QPEI C24

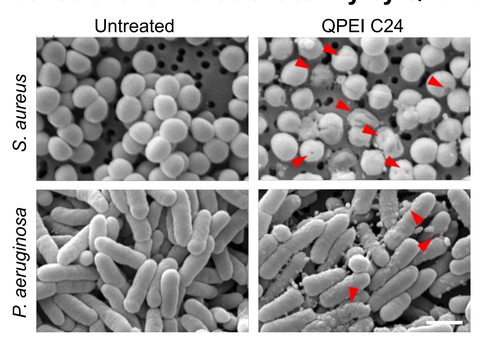


**Figure 3:** QPEI physically disrupts Gram-positive/-negative bacteria grown in biofilms. Bacterial cells were treated with QPEI C24 polymer at 37°C for 1 hour and visualized by scanning electron microscopy. Untreated cells served as controls. Upper panel: *S. aureus* cultures. Lower panel: *P. aeruginosa* cultures. Red arrows indicate cell wall damage caused by QPEI C24. Scale bar indicates 1 micron.

## Results

### *In vitro*

**Prototype QPEI gelling fiber dressings effectively control increasing *S. aureus* inoculum densities compared to Durafiber™ Ag and Exufiber™ Ag+**

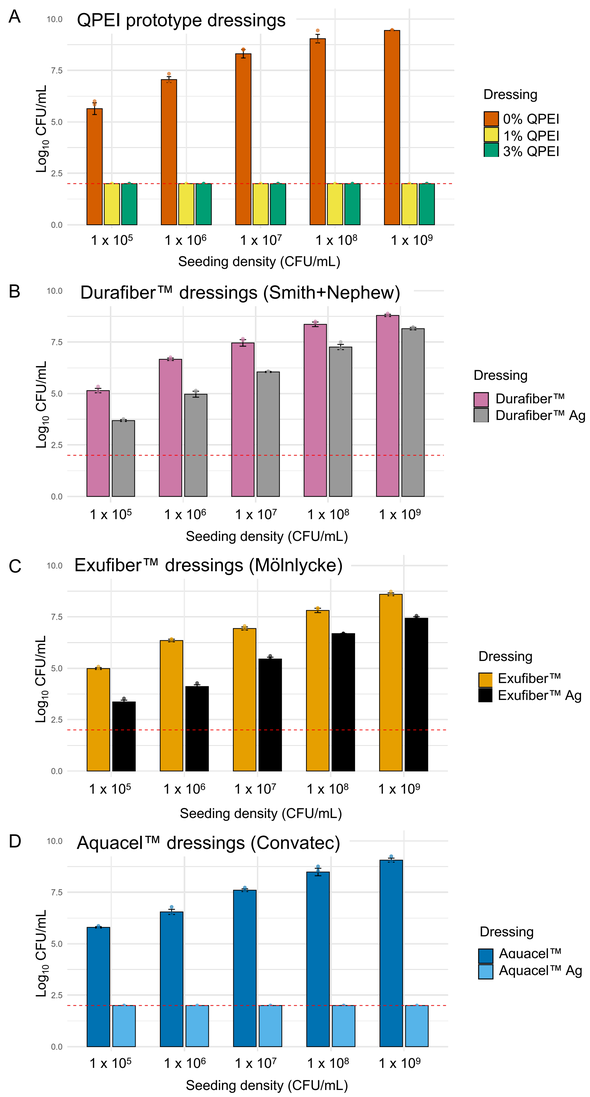


**Figure 4**. Efficacy of dressings on *S. aureus* MRSA (NRS384) survival under increasing inoculum densities. Bacterial suspensions ($10^5$–$10^9$ CFU/mL) were applied to A) QPEI dressings (1% and 3%) compared with 0% QPEI control, B) Durafiber™ Ag and its non-Ag control, C) Exufiber™ Ag and its non-Ag control, and D) Aquacel™ Ag and its non-Ag control and incubated for 24 h. The red dotted line indicates the assay detection limit (≤2 $\log_{10}$ CFU/mL).

### *In vitro*

**Prototype QPEI dressings exhibit faster antimicrobial kinetics as compared to silver dressings Durafiber™ Ag and Exufiber™ Ag+**

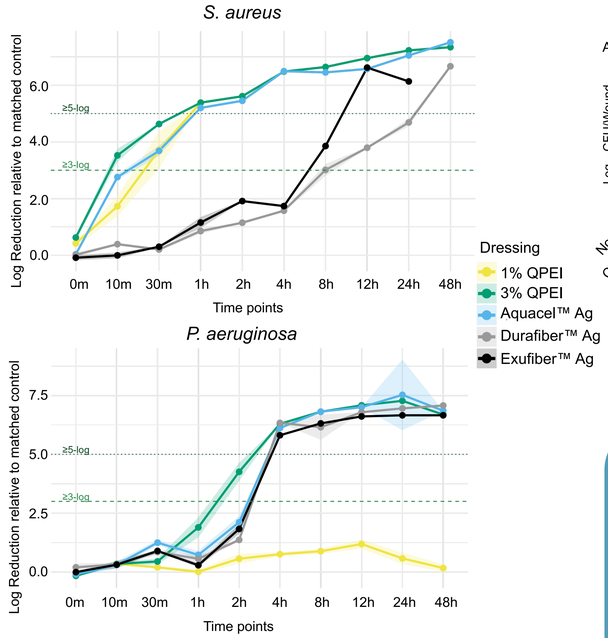


**Figure 5**. Time-kill kinetics shown as $\log_{10}$ CFU reduction relative to matched control dressings. Top graph: *S. aureus* (SANRS384) and bottom graph *P. aeruginosa* (PA27583). Error ribbons represent ±SD, n=3. Dark green dashed line represents 5 log threshold, while the light green dashed line represents a 3-log threshold.

**The antimicrobial effect of prototype QPEI-dressings is sustained and more potent for up to seven days as compared to other dressings**

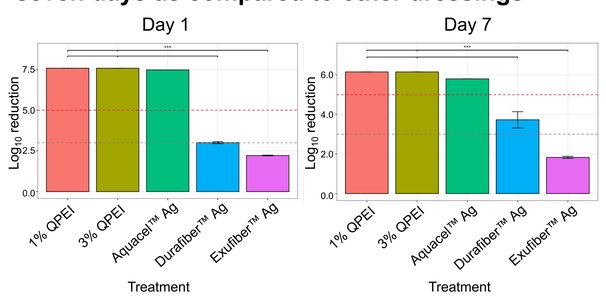


**Figure 6**. $\log_{10}$ reduction in *S. aureus* (MRSA NRS384) 4 h post-challenge on Day 1 (right) and Day 7 (left). Dressings were re-challenged with $1x10^6$ every 48 h to simulate persistent wound bioburden, and performance was benchmarked against commercial silver-based comparators. Dashed lines indicate 3-log (grey) and 5-log (red) thresholds. Data represent mean ± SD (n=3). *** is significant for both 1% and 3% QPEI dressings compared to Durafiber™ Ag and Exufiber™ Ag. Day 3 and Day 5 data not shown.

### *In vivo*

**Prototype QPEI dressings are significantly more effective at managing *S. aureus* wound infection *in vivo* relative to dressings containing silver.**

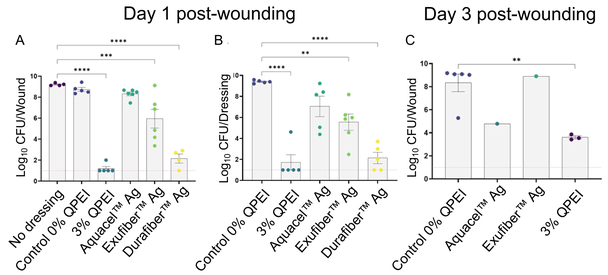


**Figure 7.** Bar plots show the bacterial load (mean ± SEM) of seeded *S. aureus* measured in A) wound samples and B) dressing samples at one day post wounding. Each data point represents a biological replicate (n = 4-6 mice per group). C) Bar plots show the bacterial load (mean ± SEM) of seeded *S. aureus* measured in wound samples at three days post wounding. Each data point represents a biological replicate (n=1-5 mice per group). The red dashed line indicates the limit of detection set at 1 $\log_{10}$ colony forming units (CFU).

## Conclusions and outlook

Prototype QPEI gelling fiber dressings demonstrate superior antimicrobial performance compared to commercially available dressings containing silver.

- Prototype QPEI-dressings were able to manage high bioburdens effectively
- Both rapid and sustained antimicrobial activity were observed for these prototype dressings *in vitro*
- *In vivo* planktonic studies demonstrate the efficacy of a prototype QPEI dressing in an infected full thickness wound model.

Clinical studies will be required to confirm these promising *in vitro* and *in vivo* results.

## Methods Summary

- Bacterial morphology post-QPEI treatment *in-vitro* was visualized by scanning electron microscopy (SEM).
- Prototype QPEI-dressings were assessed for antimicrobial efficacy against the key wound pathogens *Staphylococcus aureus* and *Pseudomonas aeruginosa in vitro* using modifications of the EN 17854 test method.
- *In vivo* efficacy (wound and dressing bioburden assessment) was evaluated in a full thickness murine wound infection model.

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