Antianionic™ Wound Care: Electrostatic Binding of Anionic Pathogens and Biofilms by Cationic Dressings in Chronic Wound Management

This technology offers a new way to provide safe, sustainable wound care.

BY DARLENE E. MCCORD, PHD., WILLIAM HESIDENCE, DPM, AND ROBERT FRYKBERG, DPM, MPH

Structured Abstract

Objective: To evaluate the scientific and clinical rationale for using cationic wound care materials to electrostatically bind and neutralize anionic pathogens, biofilm matrices, and inflammatory mediators in chronic wound environments.

Approach: This review synthesizes bioelectric, microbiological, and clinical evidence supporting the application of positively charged materials—including mineral clays, cationic octenidine-based hydrogels, and polysaccharides—as biologically compatible alternatives to conventional antimicrobials.

Results: Cationic dressings bind anionic bacterial cell wall components, extracellular DNA, and biofilm matrix polysaccharides, disrupting microbial architecture and sequestering inflammatory mediators. Clinical studies have demonstrated the efficacy of cationic hydrogels and mineral-based dressings in resolving complex wounds with minimal cytotoxicity and no observed resistance. A multicenter study using a cationic mineral blend (Fentonite®) showed wound closure in 82% of chronic wound cases within 90 days.

Innovation: The antianionic™ approach provides a non-toxic, resistance-evading mechanism for infection control by leveraging electrostatic interactions instead of chemical biocides. This novel strategy supports antimicrobial stewardship and enhances wound healing without impairing host tissue.

Conclusion: Electrostatic binding by cationic dressings represents a safe, biologically smart alternative to conventional antimicrobials. Antianionic wound care may become a cornerstone of next-generation chronic wound and biofilm management strategies.[5,7,15-17,20] Chronic inflammation is pivotal in non-healing wounds.[5]

KEYWORDS

chronic wounds
biofilm
cationic dressings
antianionic™
electrostatic binding
Fentonite®
antimicrobial stewardship
non-toxic wound care

Persistent infections, often driven by biofilm-producing bacteria, contribute to delayed healing and increased morbidity.

Introduction

Chronic wounds pose a significant challenge to global health systems, with more than 6.5 million individuals affected in the United States alone and an estimated annual treatment cost exceeding $25 billion. Persistent infections, often driven by biofilm-producing bacteria, contribute to delayed healing and increased morbidity. Biofilms protect bacterial communities within a matrix of extracellular polymeric substances (EPS), rendering them resistant to antibiotics and host immune defenses.

Conventional wound antimicrobials such as BZK, iodine, and polyhexamethylene biguanide (PHMB) function via oxidative or membrane-disruptive mechanisms. However, these agents may impair keratinocyte and fibroblast viability, ultimately delaying tissue regeneration. An alternative therapeutic paradigm has emerged: electrostatic elimination of pathogens and biofilm components using cationic materials.

Continued on page 107

New Concepts and Studies

"Clinical Innovations" is PM's ongoing series of articles dedicated to introducing new concepts, technologies and studies to the podiatric community. Readers should be aware that Podiatry Management does not specifically endorse any of the technologies, concepts, or products being discussed.

This strategy, termed antianionic™ wound care, capitalizes on the negative charge of bacterial surfaces, inflammatory exudate components, and biofilm matrices to achieve targeted neutralization through cationic binding. Unlike conventional antimicrobials, cationic agents act extracellularly, avoiding toxicity and the development of resistance.[2-4,7,13,14] Oxygen availability is a critical determinant of wound repair[1].

The Charge Landscape of the Wound Environment

Anionic Targets in Infected Wounds: The wound bed of infected or inflamed tissue contains multiple negatively charged components: bacterial outer membranes (lipopolysaccharides and teichoic acids), biofilm EPS (composed of DNA and sulfated polysaccharides), and inflammatory mediators like histones, heparan sulfate, and proteases.

Electrostatic Binding Mechanism: Cationic ions and materials bind to anionic targets via Coulombic interactions (calculation of the amount of force between two electrically charged particles at rest). Multivalent cations (e.g., Mg^{2+}, Zn^{2+}, Fe^{3+}) form ionic bridges across multiple binding sites. This binding destabilizes microbial membranes, collapses EPS architecture, and reduces inflammatory mediator activity without damaging host cells. Chronic inflammation plays a pivotal role in non-healing wounds.[5-9]

Cationic dressings represent a paradigm shift in infection control.

Cationic Materials in Wound Dressings

Mineral-Based Binders: Fentonite® is a naturally occurring, specific, rare-earth mineral rich in cations with high exchange capacity and redox activity. Studies have shown that Fentonite can bind LPS and DNA, disrupt established biofilms, and maintain tissue compatibility.

Cationic Hydrogels: Hydrogels containing octenidine, Zn^{2+}, Mg^{2+}, or Fe^{3+} serve dual purposes: binding bioburden and delivering bioactive signals for healing. Products like BioClense®, BioRelese®, and AgFresh® employ this technology to support safe and effective wound management.[9,10,13-17,20] Such hydrogels represent smart delivery systems for healing.[10,13]

Clinical Performance of Antioanionic™ Dressings

Multicenter Study with Fentonite-Based Dressings: A prospective study of 198 patients with complex wounds showed that Fentonite®-based dressings closed 82% of wounds within 90 days.

Laboratory Evidence for McCord Products: BioClense®, BioRelese®, and AgFresh® eliminate common wound pathogens within hours and disrupt biofilms without cytotoxicity.[13]

Advantages of Cationic Over Conventional Antimicrobial Strategies

Antianionic™ dressings offer non-toxic, resistance-free alternatives to BZK, iodine, and PHMB. Their advantages include safe biofilm disruption, improved healing outcomes, and alignment with antimicrobial stewardship guidelines.[4]

Implications for Antimicrobial Stewardship

CDC and WHO emphasize reducing reliance on traditional antimicrobials. Cationic dressings fulfill this mandate by preventing infections through physical sequestration of bioburden rather than biochemical toxicity. This lowers the risk of resistance and meets regulatory standards.[17-19]

Future Directions

Future research should focus on quantitative charge mapping of wounds, integrating cationic dressings with electrical stimulation, expanding use in pediatrics and burns, and developing protocols to implement antianionic™ dressings in clinical pathways.

Conclusion

Cationic dressings represent a paradigm shift in infection control. Antianionic™ technologies restore balance in the wound bed, accelerate healing, and support safer, more sustainable wound care by targeting anionic structures in pathogens and inflammatory molecules. **PM**

References

[1] Sen CK. Wound healing essentials: Let there be oxygen. Wound Repair Regen. 2009;17(1):1–18. DOI: https://doi.org/10.1111/j.1524-475X.2009.00466.x

[2] James GA, et al. Biofilms in chronic wounds. Wound Repair Regen. 2008;16(1):37–44. DOI: https://doi.org/10.1111/j.1524-475X.2007.00321.x

[3] Høiby N, et al. The clinical impact of bacterial biofilms. Int J Oral Sci. 2011;3(2):55–65. DOI: https://doi.org/10.4248/IJOS11026

[4] Hirsch T, et al. Antimicrobial agents and dressings: Cell toxicity and impact on wound healing. Burns. 2011;37(6):938–943. DOI: https://doi.org/10.1016/j.burns.2011.03.020

[5] Zhao R, et al. Inflammation in chronic wounds. Int J Mol Sci. 2016;17(12):2085. DOI: https://doi.org/10.3390/ijms17122085

[6] Nikaido H. Molecular basis of bacterial outer membrane permeability revisited. Microbiol Mol Biol Rev. 2003;67(4):593–656. DOI: https://doi.org/10.1128/MMBR.67.4.593-656.2003 Bacterial membrane permeability is a major factor in resistance (6).

[7] Flemming HC, Wingender J. The biofilm matrix. Nat Rev Microbiol. 2010;8(9):623–633. DOI: https://doi.org/10.1038/nrmicro2415

[8] Grinnell F. Fibronectin degradation in chronic wounds depends on protease activity and matrix organization. J Invest Dermatol. 1996;106(2):335–341. DOI: https://doi.org/10.1111/1523-1747.ep12341691 Protease-driven degradation of fibronectin delays repair (8).

[9] Wang L, et al. Metal ions in wound healing—functions and applications. Coord Chem Rev. 2018;376:236–247. DOI: https://doi.org/10.1016/j.ccr.2018.08.006

[10] Zhao X, et al. Smart hydrogels for wound healing. Chem Soc Rev. 2021;50(20):8880–8903. DOI: https://doi.org/10.1039/D0CS01429K

[11] Jayakumar R, et al. Chitosan-based hydrogels for wound management. Int J Biol Macromol. 2011;48(1):13–18. DOI: https://doi.org/10.1016/j.ijbiomac.2010.10.003

[12] Tang J, et al. Clinical evaluation of chitosan-based hydrogel versus silver dressing in diabetic ulcers. J Tissue Viabil-

ity. 2020;29(4):239–245. DOI: https://doi.org/10.1016/j.jtv.2020.08.003 This aligns with clinical results comparing chitosan and silver-based dressings (18).

[13] Sen CK. Human wound and its burden: Updated 2025 compendium. Adv Wound Care. 2025. DOI: 10.1089/wound.2025.XXXX

[14] Nussbaum SR, et al. An economic evaluation of the impact, cost, and Medicare burden of chronic wound care. Value Health. 2018;21(1):27–32. DOI: 10.1016/j.jval.2017.07.007

[15] Haydel SE, et al. Broad-spectrum in vitro antibacterial activities of clay minerals. Antimicrob Agents Chemother. 2007;51(4):1157–1160. DOI: 10.1128/AAC.01129-06

[16] Williams LB, Haydel SE. Evaluation of the medicinal use of clay minerals as antibacterial agents. Int J Antimicrob Agents. 2010;37(3):213–217. DOI: 10.1016/j.ijantimicag.2010.10.012

[17] Morrison KD, et al. Unearthing the antibacterial mechanism of medicinal clay. Sci Rep. 2016;6:19043. DOI: 10.1038/srep19043

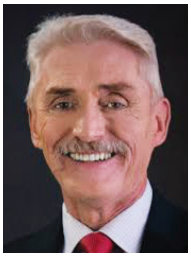
[18] Spellberg B, Bartlett JG, Gilbert DN. The future of antibiotics and resistance. N Engl J Med. 2013;368(4):299–302. DOI: 10.1056/NEJMp1215093

[19] Laxminarayan R, et al. Achieving global targets for antimicrobial resistance. Science. 2016;353(6302):874–875. DOI: 10.1126/science.aaf9286

[20] Cuadros J, et al. Clay minerals interaction with microorganisms: a review. Clay Miner. 2017;52(1):1–30. DOI: 10.1180/claymin.2017.052.1.01

Darlene E. McCord, Ph.D., is the CEO and Chief Science Officer of McCord Research, a global innovator in advanced wound care. She has been granted more than fifty patents over decades of licensing products. Her latest innovation, Fentonite, uses thermoresponsive, ion-balanced technology to facilitate wound healing.

William Hesidence has been in podiatry/ wound care practice for over 30 years. He is board-certified in wound care, surgery, medicine, and hyperbarics. He currently heads the Foot and Ankle Specialists' Limb Salvage Center in Gallup, New Mexico, on the Navajo Reservation. Originally from Pittsburgh, PA, Dr. Hesidence travelled the world in the military as a MEDEVAC pilot. After his combat tours, he attended medical school in Miami, Florida, and a residency in Miami Beach. He has advanced orthopedic surgical training from Italy.



Dr. Frykberg was the 2011 recipient of the prestigious Roger Pecoraro Award from the Foot Care Council of the American Diabetes Association. He received his Master of Public Health degree from the Harvard School of Public Health in 1994 with a concentration in quantitative methods. Dr. Frykberg's research and writing interests have included all facets of lower extremity disorders, but specifically focused on diabetic foot ulcers, infections, Charcot foot, Surgery, and Wound care. The author of over 100 peer reviewed publications and textbook chapters, he has also been the Editor of two textbooks: *The High Risk Foot in Diabetes Mellitus* (1991) and the *Diabetic Charcot Foot* (2010).