Novel polyethyleneimine-functionalised antimicrobial polymers as titanium surface coatings to prevent Orthopaedic infections

Zhen Chang Liang[1], Yi Yan Yang[2], Chuan Yang[2]
[1]National University Health System, Singapore, Singapore. [2]Institute of Bioengineering and Bioimaging, A*STAR, Singapore, Singapore
Name of Presenting Author: Zhen Chang Liang
Institution: National University Health System

Introduction / Objection

This study utilises novel synthetic polymers with inherent antimicrobial properties to functionalise the titanium substrate to prevent implant-related infections. Novel polyethyleneimine-based polymers with tuneable amphiphilicity and cationicity were developed as implant coatings to prevent bacterial and protein adhesion whilst maintaining osteoblastic viability. The amphiphilicity of these polymers were modulated via the incorporation of phenylurea and PEG groups, and their effects on microbial killing, protein adhesion and cellular biocompatibility were investigated. Mechanistic evaluation of microbial killing were studied using dedicated imaging studies.

Materials & Method

The various polymers were coated onto pristine titanium surfaces via a 3-step process. Firstly, hydroxyl passivation in NaOH, followed by silanization and immersion in polymer-solvent solution for 24 hours. Successful coating of the polymers was confirmed with X-ray photoelectron spectroscopy. Polymer-coated Ti surfaces were cultured in *Staphylococcus aureus* and *Pseudonomas aeruginosa* for 14 days. Bacterial viability was evaluated using the Baclight assay and XTT reduction assay. Mechanistic evaluation of microbial killing was determined using confocal microscopy. MTT assay was used to determine cellular viability. Cellular morphology of seeded osteoblasts were visualised using confocal laser scanning microscopy.

Results / Discussion

All polymer-coated surfaces demonstrated antimicrobial activity compared to controls. Hydrophobic modification of bPEI, as well as a higher molecular weight bPEI improved anti-microbial efficacy. Bacteria viability for our best-performing polymer was 5.8±1.2% (*S. aureus*) and 2.8±1.7% (*P. aeruginosa*) respectively at 2 weeks.

Confocal microscopy confirmed the physical disruption of polymer-treated bacterial membranes as the mechanism for microbial killing. All polymer-coated surfaces were bio-compatible towards MC3T3 osteoblasts with good cellular viability.

Conclusion

bPEI-functionalised polymers show good antimicrobial activity against both *S. aureus* and *P. aeruginosa*, whilst retaining cellular biocompatibility. They work via the novel mechanism of physical bacterial membrane disruption. These novel bPEI-functionalised polymer coatings represents a promising approach towards the reduction of Orthopaedic infections.