Electrospinning Nanostructured Scaffolds for Skin Applications Using Human Mesenchymal Stem Cells

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7-10% of all hospitalizations in the United States are caused by skin infection, of which roughly 50% of soft skin tissue infections are caused by bacteria and the remainder caused by a combination of fungal and viral infection.[1,2] These bacterial infections, especially methicillin-resistant *Staphylococcus aureus* (MRSA), have posed significant challenges to hospital staff, as evident by the increasing number of infections. The most common strategy for addressing these concerns is to use increasing doses of antibiotics which accelerates the prevalence of antibiotic resistant bacteria, such as MRSA. The best defense against bacterial resistance is still to maintain healthy, intact skin tissue. Healthy skin tissue wards off against not only bacterial infection but also against viral pathogens, UV radiation, and other environmental factors.

Healthy individuals can regenerate skin tissue if the damage is only limited to the epidermal layer. However, damage to the dermal, or anchorage, layer of the skin causes permanent damage in the absence of medical intervention. Specifically, without the dermal layer, keratinocytes, or skin cells, will migrate away from the wounded tissue and the skin tissue cannot regenerate. Current tissue engineering techniques for regenerating damaged skin facilitates only partial recovery. Thus, there exists a need for better tissue engineering approaches for skin regeneration.

An ideal tissue engineering scaffold would demonstrate the following qualities: biodegradability, anti-bacterial properties, increased vascularization, increased cellularization, strong mechanical properties, and anti-inflammatory properties. The scaffold would possess extra cellular matrix (ECM) like structures to promote the adhesion of endogenous cells and degrade and be cleared once an adequate amount of cells participate in forming a new epithelium.

The morphology of electrospun scaffolds closely mimics the physical structure of the ECM. Thus, by electrospinning poly(lactic-co-glycolic) acid (PLGA), it is possible to generate a biodegradable mimetic to the ECM structure of the skin. PLGA is an FDA approved chemical and has been widely investigated for skin applications.[3] Human mesenchymal stem cells (hMSCs) have shown many beneficial properties for wound healing.[4] However, there has been little research into the use of nanotechnology for improving the wound healing capabilities of hMSCs. By engineering electrospun scaffolds specific for hMSCs, we hope to improve existing skin grafts by utilizing the many wound healing benefits of hMSCs.

We will electrospin PLGA scaffolds modified by various nanoparticles, such as selenium nanoparticles and iron oxide nanoparticles, both of which display antibacterial properties, and secondary phase polymers, such as silk. These modifications will hopefully allow for better tuning of the hMSC response. Cellular responses, specifically hMSCs and keratinocytes, to the scaffolds will be the primary endpoint to this project. Proliferation of these cells and downstream activity will be quantified. In addition, the secondary endpoint of this project will be to test the antibacterial properties of these scaffolds.

References

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