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Electrospun synthetic human elastin:collagen composite scaffolds for dermal tissue engineering

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ABSTRACT

We present an electrospun synthetic human elastin:collagen composite scaffold aimed at dermal tissue engineering. The panel of electrospun human tropoelastin and ovine type I collagen blends comprised 80% tropoelastin + 20% collagen, 60% tropoelastin + 40% collagen and 50% tropoelastin + 50% collagen. Electrospinning efficiency decreased with increasing collagen content under the conditions used. Physical and mechanical characterization encompassed fiber morphology, porosity, pore size and modulus, which were prioritized to identify the optimal candidate for dermal tissue regeneration. Scaffolds containing 80% tropoelastin and 20% collagen (80T20C) were selected on this basis for further cell interaction and animal implantation studies. 80T20C enhanced proliferation and migration rates of dermal fibroblasts in vitro and were well tolerated in a mouse subcutaneous implantation study where they persisted over 6 weeks. The 80T20C scaffolds supported fibroblast infiltration, de novo collagen deposition and new capillary formation.

1. Introduction

Rapid wound closure following severe burn injuries reduces the risk of infection and facilitates skin regeneration [1]. To date, skin autografting following early excision of necrotic tissue has proven to be the best approach to treatment of severe burn injuries. However, lack of donor tissue in large injuries and donor site morbidity following skin excision has led to an extensive search for alternative means of replacing the damaged skin. It is now well accepted that replacement of skin dermis leads to significantly faster and more successful reconstruction of the epidermis and is essential to successful treatment of large and deep burns [2]. This approach has prompted the development of a range of dermal substitutes, including decellularized dermis from human or animal sources, scaffolds constructed from biological components such as collagen and fibronectin, and scaffolds composed of synthetic materials like polycaprolactone and poly(lactic-*co*-glycolic acid) [3–5].

The dermis is a dense connective tissue composed of collagen, elastic fibers, an interfibrillar gel of glycosaminoglycans, salts and water [6]. Collagen type I accounts for the majority of the dry weight of the dermis and is responsible for its tensile strength. Elastic fibers are interwoven among collagen bundles, where they convey elasticity and resilience [6,7]. Collagen-based scaffolds currently dominate the dermal substitute field, but are restricted by their inherent inelasticity and scaffold contraction during tissue repair [8,9]. Despite its role in elasticity and recoil, elastin does not adequately regenerate during severe wound healing and its distribution is disrupted in scar tissue [10], making it a highly desirable component of any dermal replacement.

The majority of electrospun elastin-containing constructs have been generated by co-electrospinning/blending α-elastin with other natural or synthetic polymers to mimic the components of the native tissue or increase the mechanical and structural stability of the electrospun construct. α-Elastin has been successfully co-electrospun with bovine collagen [11–15] and gelatin [16,17] to produce tissue engineered vascular grafts. While much effort has been invested into the design of electrospun elastin-containing vascular grafts [13–20], the addition of elastin, and in particular tropoelastin, to electrospun dermal substitutes has been largely overlooked. The presence of elastin in collagen-based scaffolds (non-electrospun) was shown to decrease scaffold stiffness [21], modulate collagen degradation and contraction [22,23] and enhance angiogenesis and elastic fiber formation [24]. Elastin, therefore, has the potential to improve the physical and biological properties of a dermal substitute. An ideal dermal substitute would

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