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Mini Review

Silver Nanoparticle Decorated Chitosan Scaffold for Wound Healing and Tissue Regeneration

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Introduction

In human body, skin is the largest and one of the most complex organs. It is one of the main components of our innate immune system. Being the outer most part of human body, skin is vulnerable to different harmful external factors, especially fire [1]. In case of burn injury there is severe skin damage causing alteration of dermal cells, biomolecule homeostasis and tissue architecture. Since, the dermis layer of skin is severely damaged, dermal reconstruction is the critical procedure in wound healing. Burnt wound is frequently associated with trauma [2]. Again, continuous production of fluid and persistence of pathogen makes the healing process worse. Thus, there are many clinical challenges associated with the treatment of burn injured patients suffering from acute or chronic wounds.

Conventional treatment of burn wounds includes surgical removal of damaged skin to avoid bacterial contamination and use of topical antibiotics. But for proper and quick healing of wound, repairment and regeneration of dermis layer must be ensured with regenerative medicines known as dermal substitutes, produced by tissue engineering. Ideally a dermal substitute should maintain a moist environment at the wound interface, allow gaseous exchange, act as a barrier against microorganisms, and remove excess exudates. The substitute should also be non-toxic, non-allergenic and non-adherent in the sense that the product can be easily removed without trauma. It should be made from a readily available biomaterial that requires minimal processing. It should possess antimicrobial properties and promotes wound healing. Chitosan is one of such bioactive polymers. Porous chitosan structure with well-designed scaffold can act as an ideal dermal substitute because of its support to cell migration and guidance to vascular infiltration [3]. Chitosan is also claimed to have antibacterial activity [4], an added benefit to its wound healing application [5]. Silver nanoparticle is a broad-spectrum antibacterial agent [6].

There are multiple bactericidal mechanisms associated with silver nanoparticle. As a result, bacterial resistance to elemental silver is extremely rare. Silver nanoparticle is reported to decrease wound-healing time by an average of 3.35 days and increased bacterial clearance from infected wounds, with no adverse effects [7]. Silver nanoparticle is also capable of reducing cytokine release, decreasing lymphocyte and mast cell infiltration [8]. This anti-inflammatory action of silver nanoparticles promotes wound healing [9]. But toxicity issues are always associated with the use of silver nanoparticle.

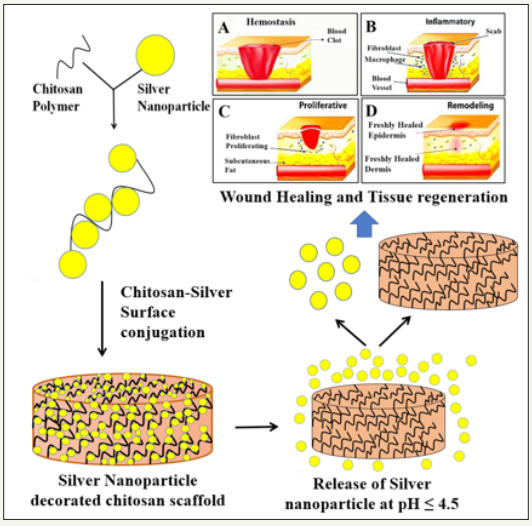

Figure 1: Strategy of Silver nanoparticle decorated chitosan scaffold for wound healing and tissue regeneration.

So, this is a great idea, in deed, to develop silver nanoparticle decorated chitosan scaffold that will have combined effect of silver nanoparticle and chitosan scaffold. The strategy is shown in (Figure 1). Commonly, silver nanoparticle is synthesized by reducing metal salt, like, silver nitrate with reducing agents like sodium borohydride, citrate, ascorbic acid or a combination of them. The nanoparticles are then incorporated in chitosan matrix. To avoid the use of harmful reducing agents, methods are developed where silver nanoparticles are generated, in situ, by the interaction between a silver salt and the chitosan surface. This reaction is favored in basic medium [10]. The synthesized nanoparticles remain conjugated on the surface of chitosan scaffold and thus get stabilized.

Since these functional nanocomposites have ultralow content of silver (<0.02%), the toxicity of silver nanoparticle is avoided. Bárcenas et al. [11] prepared silver nanoparticle embedded chitosan film as wound dressing material. It exhibited high antibacterial activity against *S. aureus* and *P. aeruginosa*. Actually, the hydrated film works like a micron-sized mesh with irregular pores, promoting bacterial penetration and direct contact with silver nanoparticle leading to inhibition of bacterial growth. The porous film act as a scaffold to promote tissue regeneration [11,12] and accelerated the healing process by increasing myofibroblasts, collagen remodeling, and blood vessel neoformation [11,13]. In general, the release of silver nanoparticles from chitosan surface is pH triggered. At pH ≤4.5, the nanoparticles are released. But the scaffold of chitosan is dissolved. So, hybrid scaffolds are prepared by combing chitosan with biocompatible materials like collagen. Han et al. [14] found that silver nanoparticle loaded collagen/chitosan scaffolds promote wound healing by regulating fibroblast migration and macrophage activation.

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