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The Modulating Action of Silver Nanoparticles on Collagen Deposition in Producing Scarless Wound Healing

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Introduction

Burn wound healing is a complex process that is often addressed to problems of undesired cosmesis and mechanical property in the regenerated skin. Silver nanoparticles (AgNPs) are known to be bactericidal[1-2]. Its application to wound results in accelerated healing and excellent cosmesis with regeneration of hair follicles[2]. However, the skin functionality which is indicated by its tensile property is yet to be understood. The hypothesis of this study was that AgNPs could improve mechanical property of the repaired skin due to its ability to modulate collagen deposition, which is a source of strength and elasticity in skin[3]. Tensile test was performed to study the skin modulus, with collagen staining and SEM imaging to reveal the collagen expression and physical characteristics.

Materials and Methods

Skin defects were created on mice by excision of the full thickness dorsal skins. The wounds were topically applied with AgNPs or left untreated. The regenerated skins were harvested for evaluation. Three experimental groups were set up: control (n=7), AgNPs-treated group (n=5) and untreated (n=5). Macroscopic and microscopic appearance was compared. Tensile tests were performed to evaluate the skin modulus and results were statistically analyzed by Student's paired *t*-test (p=0.05). Masson Trichrome and immunohistochemical staining were employed to investigate collagen type I and III expression. SEM was used to study the architecture of the skins.

Results

Macroscopic and microscopic appearance of AgNPs treated skin resembled closely with normal skin with hair follicles regenerated but not in the untreated ones. The tensile modulus for normal, AgNPs and untreated group were 4.7±1.33 MPa, 4.9±1.73 MPa and 1.2±0.8 MPa respectively. No statistical significance was found between normal and AgNPs (p=0.85) whereas the untreated was found to be significantly different to both normal (p=0.0004) and AgNPs group (p=0.0026). Immunostaining showed higher collagen intensity in normal and AgNPs than untreated group. SEM illustrated well-oriented collagen fibrils in normal and AgNPs group while exhibited random chaotic alignment in untreated sample.

References List
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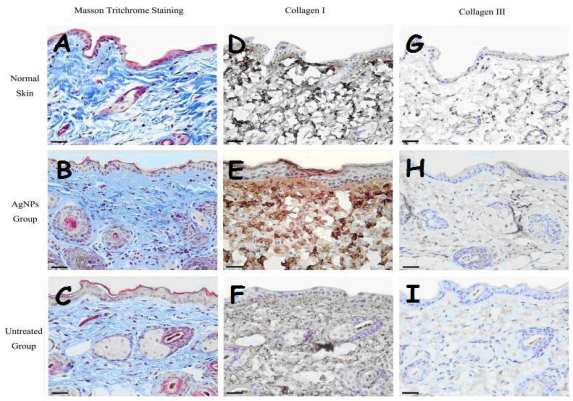

Fig.1 Collagen fibres were stained with Masson Trichrome (A-C). Expression of collagen type I (D-F) and III (G-I) were blotted with immunostaining. The normal and AgNPs group showed similar colour intensity and distribution of collagen, while untreated group exhibited considerably lighter colour and observance of cryptogenic structure. Scale bar: 20 μm.

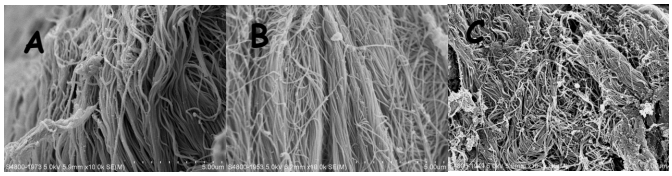

Fig.2 SEM (x10k) of collagen fibrils in normal(A), AgNPs (B) and untreated(C) samples. Fibril arrangement and morphology were essentially different. The fibrils in untreated sample had irregular outline with lateral fusion of collagen beads, whereas normal and AgNPs group had regular fibril outline.

Discussion and Conclusions

Wound healing with AgNPs demonstrated scarless healing with mechanical property resembling the normal skin. Skin modulus was found to correlate to the level of collagen expression, its physical characteristics as well as the organization. The overall improvement in appearance and mechanical property were attributed to the ability of AgNPs in modulating collagen deposition, resulted in excellent fibril morphology and alignment. However, only the surface collagen fibrils and matrix were characterized in this study. The continuing study would be to investigate the molecular pathway through which AgNPs regulate collagen deposition.

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