The effect of anti-bacterial nanofibrous scaffolds on osteogenic differentiation of human mesenchymal stem cells

Thamonwan Diteepeng[1] Mahsa Mohiti-Asli[2] and Adisri Charoenpanich[1]

[1] Department of biology, Faculty of science, Silpakorn University, Nakornpathom, Thailand
[2] Department of biomedical engineering, North Carolina state university, North Carolina, USA
Email addres: di.thamonwan@gmail.com

Abstract

Silver is a well known antimicrobial material for a wide range of microorganisms. In this study, silver-releasing poly(lactic acid) (PLA) nanofibrous scaffolds were synthesized and evaluated for it biocompatibility with human adipose-derived mesenchymal stem cells (hAMSC). Co-culture of hAMSC with Methicillin-Resistant *S. aureus* (MRSA) on silver-releasing scaffold was performed to mimic the situation of *in vivo* bone infection. The results showed that silver-releasing nanofibrous scaffolds were suitable for proliferation and osteogenic differentiation of hAMSC. However, the silver-coated scaffolds did not diminish the growth of MRSA. Further study to improve the anti-microbial properties of the scaffold will progress the scaffold development for bone engineering.

Introduction

Various types of silver have been used as antimicrobial material such as silver nanoparticles, silver ion and silver nitrate.[1,2] However, overuse of silver can cause adverse effect on human cells.

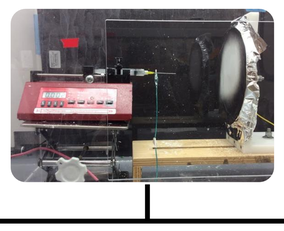
Control-released nanofibrous scaffold, a new approach to release an appropriate concentration of silver, have been developed to exhibit the excellent antimicrobial properties without mammalian cell cytotoxicity.[3]

In this study, silver-releasing nanofibers were synthesized by electrospinning of poly(latic acid), following with Silvadur ET™ coating. Biocompatibility and antimicrobial effect of the scaffold was then evaluated with hAMSC co-culture with MRSA on the scaffold.

Objective

To investigate the effect of silver-releasing nanofibrous scaffold using Silvadur ET™, a silver release coating, on the proliferation and osteogenic differentiation of hAMSC, and on growth inhibition of MRSA.

Methods



Fabrication of PLA nanofibrous scaffold by electrospinning method

Pure PLA nanofibers

Coating with 62.5 µg/ml of Silvadur ET™ (commercially available solution with silver ion and polymeric binder)

Silver-releasing PLA nanofibers

Negative control (No cells) | Nanofibers + hAMSC | Nanofibers + MRSA | Nanofibers + hAMSC + MRSA (co-culture system)

Day 7 and day 14

Evaluation of cells proliferation and osteogenic differentiation
- DNA assay
- Alizarin red staining
- Calcium quantification assay

Methicillin-resistant *S. aureus* (MRSA) (50 CFU/ml)

Human adipose-derived mesenchymal stem cells (hAMSC) (120k cells/nanofibers)

Results

1. Characterization of silver-releasing PLA nanofibers

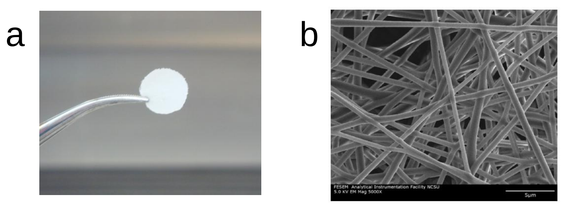


Fig. 1. Silver-releasing nanofibers with the naked eyes (a) and under SEM. (b)

- Synthesized silver-releasing PLA nanofibers appeared as a smooth fabric sheet (Fig.1a).
- SEM analysis of the nanofibers showed that the silver particle was not presence on the fiber surface (Fig.1b).

X-ray photoelectron spectroscopy (XPS)

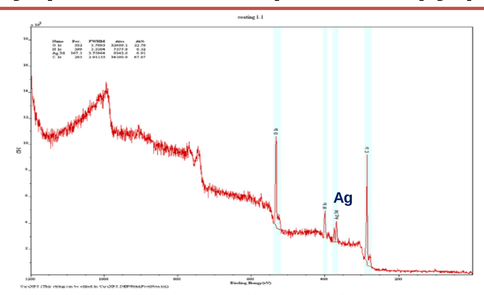
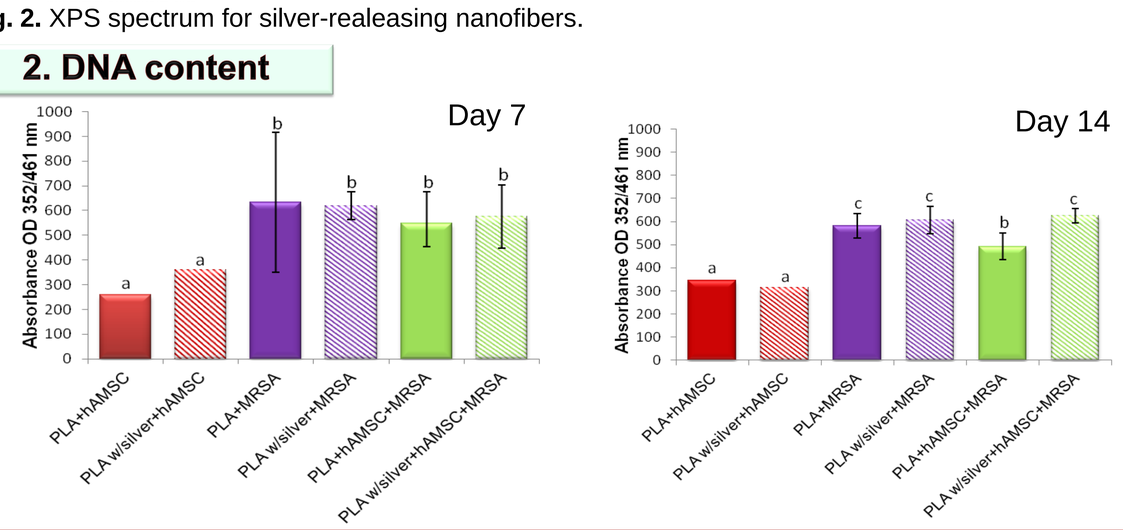


Fig. 2. XPS spectrum for silver-realeasing nanofibers.

The presence of silver over the entire surface of silver-releasing nanofibrous scaffold was shown in XPS analysis (Fig 2).

2. DNA content



- Silver-releasing nanofibrous scaffold supported the viability of hAMSC (red bar)
- The silver-releasing scaffold did not diminish the growth of MRSA (purple bar).

3. Calcium deposition

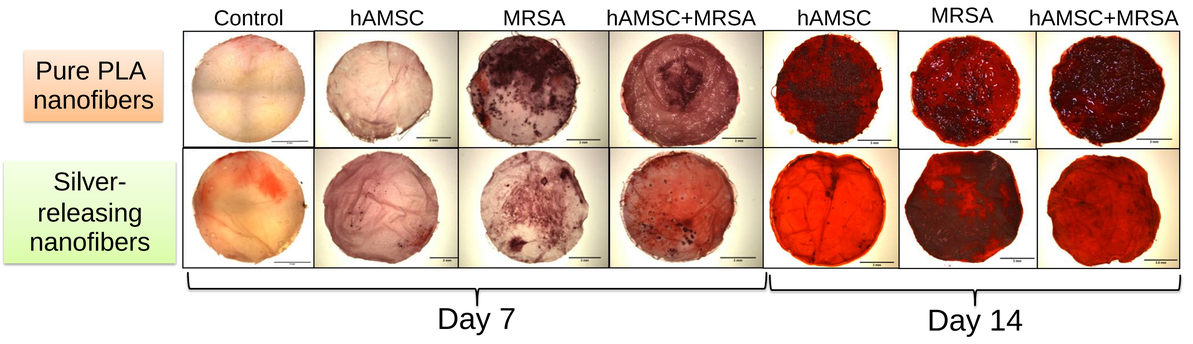


Fig. 3. Alizarin red staining for calcium deposition on the scaffold by hAMSC and MRSA

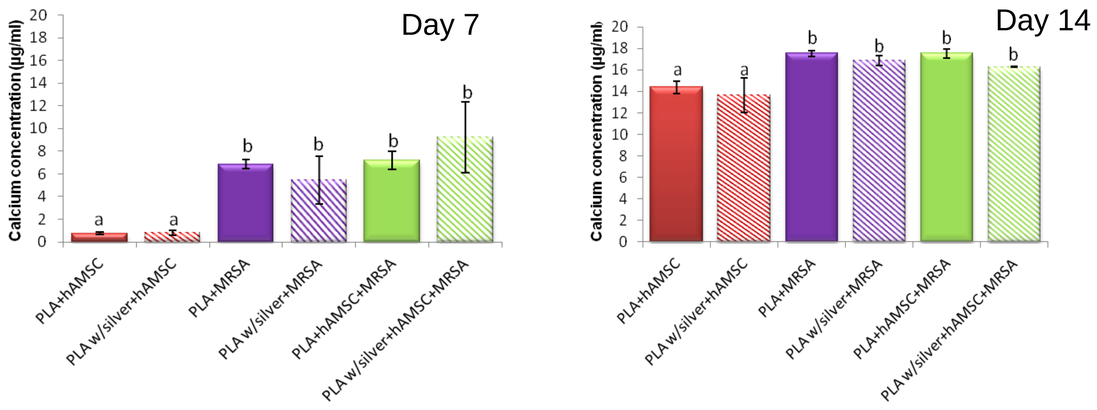


Fig. 4. Quantification of calcium deposition by hAMSC and MRSA

Silver-releasing nanofibrous scaffold did not affect the osteogenic differentiation of hAMSC. However, deposited calcium by MRSA interfered the results in the co-culture system.

Conclusions

Silver-releasing nanofibrous scaffold synthesized in this study was suitable for proliferation and osteogenic differentiation of hAMSC. However, the silver-coated scaffolds did not diminish the growth of MRSA. Therefore, antimicrobial efficacy of silver-releasing nanofibers should be developed to inhibit the growth of bacteria before any further study.

References

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