Biofiber: an Advanced Dressing for Complex Wounds

E. M. Tottoli; E. Chiesa; I. Genta; B. Conti; G. Ceccherelli; R. Dorati

1Department of Drug Sciences, Viale Taramelli 12; University of Pavia, Pavia, Italy
2Department of Fondazione IRCCS PoliClinico San Matteo, Department of Surgery, University of Pavia, Pavia, Italy
3Department of Public Health, Experimental Medicine and Forensic, University of Pavia, Pavia, Italy
4CHT Center for Health Technologies, University of Pavia, Pavia, Italy

INTRODUCTION

Chronic wounds are the most traumatic and physically debilitating injuries that can lead to an aberrant healing response culminating with the formation of hypertrophic scars (HTSs). HTSs are common complications of severe wounds and other soft tissue injuries; they can result from aberrant processes like infection or inflammation of wounds; incidence is about 40 to 70% following surgery (30–52.5 min), up to 91% following burn injury (~ 10 min). The scarring wound healing response has a pathological spectrum, ranging from cosmetic annoyance to grave functional impairment. Unfortunately, once HTS has formed, treatments are only minimally effective; therefore, prophylaxis is a viable strategy against the scarring process. The aim of this research project is to develop an advanced medicated dressing combining a new polymeric patented fiber technology (PCT/IB2020/050267), with the ancillary action of an antifibrotic and antibiotic agents. Biofiber could represent an innovative non-invasive topical prophylactic treatment to prevent or treat HTSs modulating major factors involved in the scarring process.

METHODS

Biofiber prototypes were produced by electrospinning from a polymeric solution (PLA-PCL, 20% v/v) loaded with an antifibrotic (Drug A; 2% w/v), and an antibiotic (Drug B; 1% w/v). Biofiber mechanical properties evaluation. Biofiber prototypes were incubated at 34°C in Simulated Wound Fluid (SWF), at pH 7.4 in static condition and at different times (24-48 h) analyzed by a tensiometers and compared with the same sample in dry condition.

Figure 1 – A. Optical microscope (20X); B and C SEM images (1.07; 5.04 KX), of Biofiber advanced dressing obtained by electrospinning technology (16 min). D Biofiber mechanical properties evaluation. Biofiber prototypes were incubated at 34°C in Simulated Wound Fluid (SWF) at pH 7.4 in static condition and at different times (24-48 h) analyzed by a tensiometers and compared with the same sample in dry condition.

RESULTS

Results shown that the electrosprun fibers were homogeneous and well-interconnected, randomly oriented and diameter ranged from 2.16 to 4.00 µm (Figure 1 A-C); a complete release of active agents was reached at day 3 (Figure 2 A, B). Data shown that the percentage porosity (32.0 and 52.0%), pore size distribution (54.64 - 76.72 µm) and wettability (101.7-110.2°), were the fundamental features that support Biofiber to create a correct wound healing environment. The biocompatibility results indicated Biofiber safety after 72h of treatment, in all cell type analyzed, with 85-100% of viability (Figure 3). A consistent microbial effect was observed for S. aureus, in all experimental time set considered (5, 24 - 72h) and S. epidermidis at 24-72h; in both cases the microbial effect was ranged between 8.5 log (Figure 4 A, B). The prophylactic antifibrotic efficacy was highlighted for NHDF at 72h of treatment, with a significant decrement of α-SMA, TGF-β1 and COL1A1 gene expression (Figure 5A), data were confirmed by downregulation of α-SMA and COL1A1 protein levels (Figure 5B). For HSF, the inhibition of the hypertrophic process was evident only to the 24h. In conclusion, Biofiber has all the features required to fit into the category of advanced dressing. According to the T.I.M.E. concept, Biofiber is flexible, conformable and it is designed to guarantee a physiological healing, modulating the exudate, constraining infections, and preventing HTSs insurgence.

Figure 2 – Release profiles of Drug A 2% w/v (A) and Drug B 3% w/v (B) from Biofiber formulations (F16, F20 and F25), at different electrosprun times (16, 20, 25 min), incubated at 34°C in PBS at pH 7.4 in static conditions. The releases were measured by UV-VIS spectrophotometer at 282 nm (Drug A) and 360 nm (Drug B).

Figure 4 – Images of culture broth after treating with (A) placebo and (B) Biofiber (16 min). Biofiber microbial effect against Staphylococcus epidermidis, Staphylococcus aureus (106 CFU/ml). (C) The microbial effect of Biofiber at different experimental time setting, was expressed as logarithmic reduction of the pathogenic species and according to ASTM E2315-03 method the threshold value was set at 4log.