Development of Biodegradable Nanofiber Guide Tube for Nerve Regeneration

Doshisha University Biomaterial Laboratory
Akihiko Tarunaga, Yusuke Morita, Akeo Hagiwara, Eiji Nakamachi

Overview

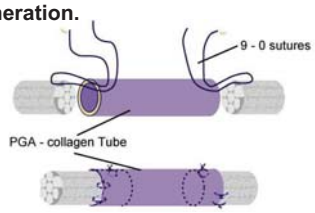
The purpose of this study is to develop biodegradable nanofiber guide tube that has high ability to resist radial deformation. Nanofiber tube of length 60 mm, inner diameter 5 mm was produced by electrospun. According to a scanning electron microscope observation, the thickness of nanofiber tube was about 50 μm, and fiber diameter of inner layer and outer layer about 667 nm and 861 nm respectively. The radial compressive test carried out to evaluate the tube compressive stiffness. The compressive stiffness of bilayer PLA nanofiber tube showed a value equivalent to that of a nerve. It was suggested that the tube could function as a guide tube without stenosis when it was implanted *in vivo*.

1. Introduction

When the gap between the nerve stump is wide, a guide tube is effective to get nerve regeneration.

The guide tube for nerve regeneration

Assumption : 100 mm gap



Requirement

- Surface structure for adhesion
- High radial stiffness
- Superior material permeability
- Biocompatibility and biodegradability

T. Nakamura, et al, Brain Research, Vol. 1027, (2004), pp.18-29.

Objective

Development of biodegradable nanofiber tube using polylactic acid with bilayer structure by electrospun

2. Materials and method

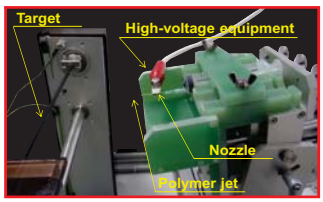
Materials

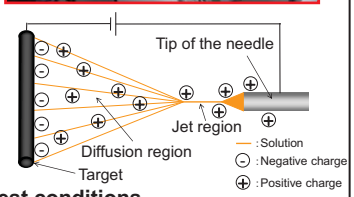
- Polylactic acid (PLA)
  - ・Biocompatibility
  - ・Biodegradability
- 1.3-dioxolane
  - ・Solvent
- 1.1.1.3.3.3-hexafluoroisopropanol (HFIP)
  - ・Surfactant

Solution conditions

Dioxolane/HFIP	70/30
Solution condition (w/v%)	12

Electrospun

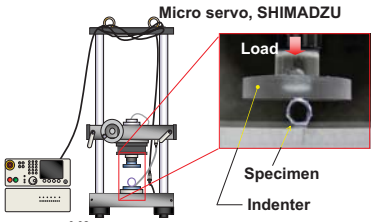


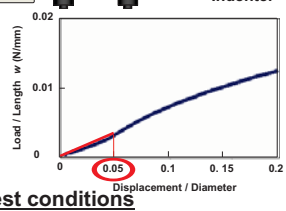


Test conditions

Tip-to-target distance (mm)	200
Applied voltage (kV)	20
Flow rate (mm/min)	0.5
Target speed (rpm)	300
Spinning time (h)	2
Temperature (℃)	23.5
Humidity (%)	15

Radial compressive test





Test conditions

Load rate (mm/s)	0.004
Applied strain (%)	10

$CS = w / \Delta y$

CS : Compressive stiffness (N/mm²)

W : Load / Length (N/mm)

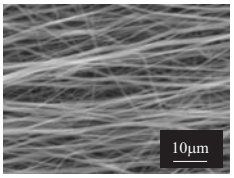
Δy : Displacement of the inner diameter (mm)

3. Results and Discussion

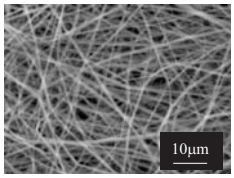
Observation of morphology by SEM

Appearance

Length : 60 mm
Inner diameter : 5 mm
Film thickness : 50 μm



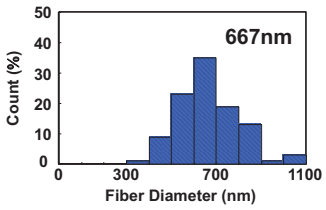
Inner layer (oriented longitudinally)

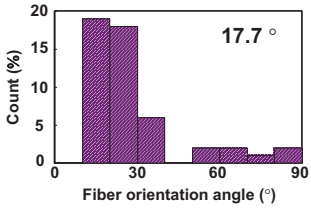


Outer layer (oriented randomly)

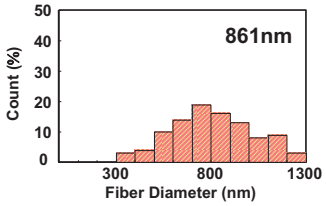
Evaluation of fiber diameter and fiber orientation angle

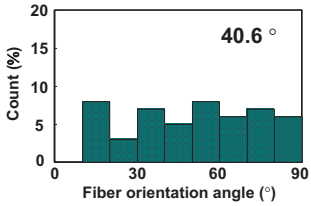
Inner layer



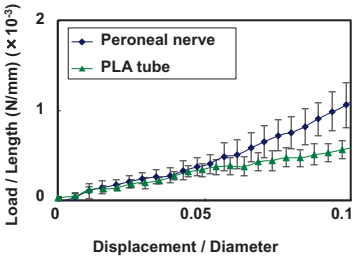


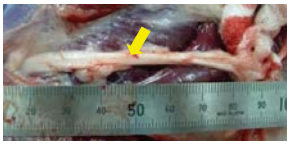
Outer layer





Evaluation of compressive stiffness

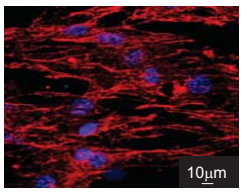




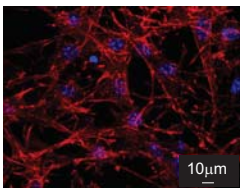
Peroneal nerve of beagle dog

PLA tube : 4.49 kPa
Peroneal nerve : 4.82 kPa

Evaluation of cell elongation



Inner layer



outer layer

Blue : cell nucleus
Red : cell cytoskeleton

4. Conclusion

The PLA guide tube with aligned nanofiber/ random microfiber bi-layer structure was developed in this study. The tube had suitable inner surface structure for cell elongation, and sufficient compressive stiffness against stenosis.

dmm0051@mail4.doshisha.ac.jp, Doshisha University, Japan