# MODELING OF AXONAL ELONGATION BY STEM CELLS USING FINITE ELEMENT METHOD

**Milica Obradovic[1], Nenad Filipovic[1,2]**

[1] *Faculty of Engineering University of Kragujevac, Serbia;*

[2] *Bioengineering Research and Development Center Kragujevac, Serbia*

## Introduction

Many researches at field of axon repair and regeneration is based on stem cells, because of their capability of differentiation. Basic function of an axon is conducting electrical impulses away from the neuron's cell body, thanks to special molecular structures.

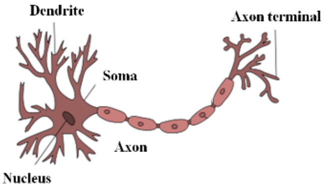


*Figure 1: Neural cell.*

Axons move through their environment via growth cone, which is placed on the top of the axon, and where the mass is added. Besides that, mechanical tension leaves impact on axonal elongation improvement. We created models of axons and calculated axonal elongation using finite element method.

## Methods

In the first example we applied force at the growth cone and mass adding too. Axon was considered as a material with viscoelastic properties (Matthew O'Toole et al, 2008). To accomplish nonlinear elongation through axon and to include viscoelastic material in our finite element model we changed Young's modulus along axon, according to equation (1):

$$E(x, L(t)) = \frac{F_0 \cosh(x \cdot \sqrt{\eta / G})}{\cosh(L(t) \cdot \sqrt{\eta / G})}, \ \mathrm{G=gA} \qquad (1)$$

$\eta$ – constant of friction between the axon and substrate

$g$ – axon's axial viscosity

In the second example we considered mass adding as a change of material concentration. The governing equation is (Douglas R. McLean et al 2004):

$$\frac{\partial c}{\partial t} + a\frac{\partial c}{\partial x} = D\frac{\partial^2 c}{\partial^2 x} - gc \qquad (2)$$

In equation (2) $D$ is diffusion of tubulin, $a$ is an active transport, $g$ is constant rate of tubulin degradation, and $c$ is concentration of tubulin along the length. Length of neurite is function of time (ODE).

## Results

When we modelled axon as a material with viscoelastic properties we obtained nonlinear elongation of axon along them. The diagram which represents velocity of axonal transport is shown in Figure 2.

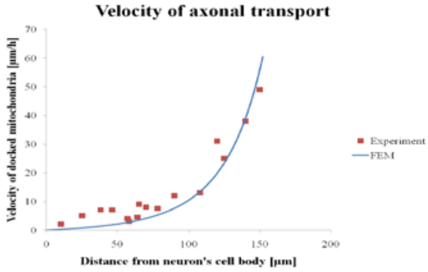


*Figure 2: Nonlinear axonal transport.*

If we consider that there is no mass adding to axon, then axon response to the mechanical exposion will be almost linear (Figure 3)

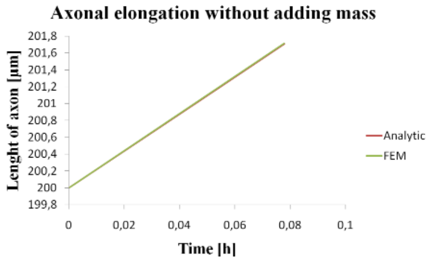


*Figure 3: Elongation without adding mass to axon.*

## Discussion

Using stem cells we can accomplished axon repair. Usually, they are placed in certain scaffold, where they are cultured, and then placed on the growth cone to provoke axonal repair. For now, considering axon as a viscoelastic material and calculation of axonal elongation using diffusion equation could be a good approach to appropriate model of axon. The goal is to create the model, that can give to us more information about process of axon healing and growing, that is in good match with future experimental approach in this area.

## References

Matthew O'Toole et al, Biophys J. 2008 April 1; 94(7): 2610-2620.

Douglas R. McLean et al, Neurocomputing 01/2004; 58-60; 511-516.