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Modeling morphological changes in spinal motoneurons following spinal cord injury to explore changes in electrical behavior

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Background

Following a contusion injury to the spinal cord (SCI), motoneurons below the level of injury undergo significant morphological and behavioral changes. Compared with uninjured controls, SCI motoneurons have a larger soma, fewer and thicker primary dendrites, and less dendritic branching [1]. Behaviorally, SCI motoneurons are more excitable and exhibit altered rhythmic firing and reflex properties [2]. While neuronal morphology and neuronal excitability are linked, to date it is not clear to what extent the morphological changes in motoneurons following SCI are responsible for the altered electrical behavior.

Methods

Using the program L-Neuron, two groups (control and SCI) of five morphologically realistic virtual motoneurons were created. L-Neuron "grows" compartmental neuronal models based on a stochastic selection of values from morphological parameter distributions from the literature [3]. The SCI motoneuron input parameters were identical to the control parameters except: mean soma diameter was increased by 18%, mean number of primary dendrites was decreased by 22% and mean primary dendrite diameter was increased by 20% as seen experimentally following SCI in [1]. Morphology of the neurons was then explored using L-Measure [3] and the models were converted into GENESIS format to explore their electrical behavior.

Results

The differences in the input morphological parameters resulted in differences in several "emergent" morphological parameters of the virtual motoneuron groups which were also seen experimentally, including: a decrease in maximum dendritic branch order and in the total number of dendritic bifurcations in the SCI motoneurons. Preliminary exploration of the different morphologies in GENESIS indicates that the differences in electrical behavior can be partially accounted for by the changes in morphology.

Conclusion

Changes in motoneuron morphology are likely to contribute to changes in motoneuron electrical behavior following SCI. Further exploration and quantification of the role of morphological change in altering electrical behavior will allow a better understanding of the interplay between form and function in motoneurons.

References

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