

Field Sculpting to correct electric field distortion by percutaneous lead migration

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Introduction

Technical advancement in computational models can provide not only theoretical tools to improve understanding of the mechanism of electrical stimulation, but also evaluations of new stimulation technologies, such as current fractionalization to correct electric field distortion by lead migration. We report on our development and use of a new computer model to study (1) the effect of lead migration on activation of dorsal column (DC) and dorsal root (DR) neurons in spinal cord stimulation (SCS), and (2) correction by current fractionalization using independent multiple current sources.

Method

A volume conductor model of a low-thoracic spinal cord with three epidurally-positioned cylindrical percutaneous leads with medio-lateral, rostro-caudal and dorso-lateral migration were created using the finite element model tool ANSYS from which the electric field was calculated. The electric field results were then coupled with the NEURON simulator to determine the activated region of spinal cord DC and DR fibers. DC and DR fiber models were adopted from double-cable axon model (McIntyre et al., 2002) with various fiber sizes (5.7-15 μm diameter).

Results

Three leads placed in a symmetric, parallel mediolateral arrangement with medio-lateral tripolar configuration, has deeper penetration than a single lead or dual leads. However, the shape and depth of the activated region of spinal cord fibers is compromised by lead migration for any direction. The model predicts that properly adjusted current-fractionalization from independent multiple current sources can re-orient current flow to correct the electric field and potentially restore therapeutic benefits.

Conclusion

Our computational model was able (1) to predict the sensitivity of the region of activated spinal cord fibers due to variability in lead and spinal cord positions while using medio-lateral tripolar stimulation, and (2) to predict a candidate approach to compensate for variability in relative lead and spinal cord positions (namely, fractionalization of current using independent sources) that may yield improved therapy. Follow-up clinical investigation of the model-predicted solution is the appropriate next step.