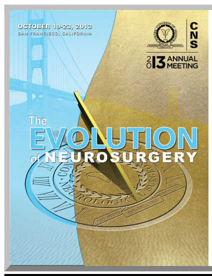

Steering the Stimulation Field beneath a New 32 Contact, 4 Column Paddle Lead Using 32 Dedicated Power Sources: A Computational Model

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Introduction

Boston Scientific has recently developed a 32 contact, 4 column paddle lead which, when powered by 32 dedicated power sources, may provide increased capability to shape the stimulation field and achieve paresthesia coverage. We use a computational model to study the ability of this lead to steer the field by anodic and cathodic steering. Anodic and cathodic steering is achieved by changing the current distribution between the lateral anodes and central cathodes, respectively.

Computational Modeling Framework

The modeling framework combines finite element models (ANSYS v 10.0) of the spinal cord [1] and stimulation leads with cable models of dorsal root and column fibers [2,3,4].

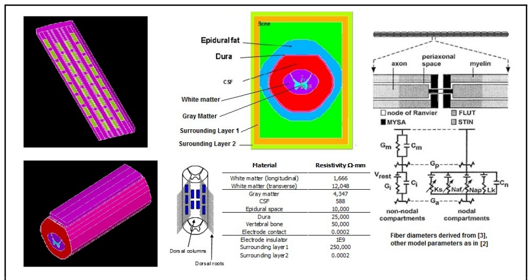

Figure 1. Computational Modeling

Threshold Ratio (TR)

Since excessive activation of dorsal root (DR) and activation of dorsal column (DC) fibers is thought to lead to discomfort and parasthesia, respectively, we computed, for contact configurations of interest, amplitude thresholds for DR and DC activation, and their ratio TR=DRth/DCth. TR>1 is preferred since it enables DC activation before DR activation.

Spatial Extent of activated DC fibers

We computed, at an amplitude of 1.4DCth, for each contact configuration of interest, the histogram of activated DC fibers, and estimated its median point and the 25th and 75th percentile points. In comparison with the amplitude, note that the perception and discomfort thresholds for SCS typically equal DCth[5] and 1.4DRth[6], respectively.

Results

Figure 2 shows the effect of effect of current steering in a four column transverse tripole configuration (TTS) for a lead placed on the spinal cord midline.

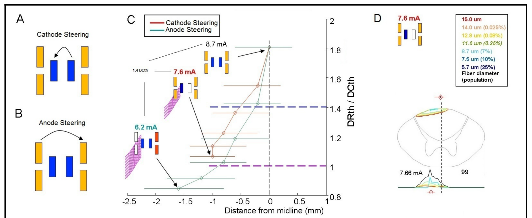

Figure 2. Ten % steps of Cathode Steering (A) and anode steering (B). TR and the spatial distribution of activated DC fibers at 1.4DCth (C), histograms of activated DC fibers for full cathode unbalancing at 1.4DCth (D). Steering moves the region of activated DC fibers laterally from the midline (C). When the cathodic current was shifted completely to one of the cathodes, fibers at the lateral edge of the DC were activated. Since TR remained >1, the discomfort threshold (1.4DRth) stayed above the amplitude (1.4DCth), suggesting that TTS and cathode steering may achieve full lateral coverage of the DC without discomfort.

Figure 3 shows the results for configurations combining a longitudinal tripole with a transverse bipole.

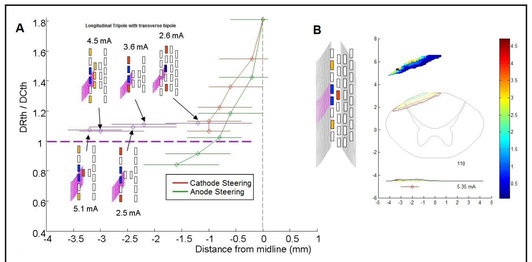

Figure 3. Longitudinal tripole with transverse bipole increases coverage relative to TTS based steering (A). The histogram of activated fibers (B) shows activation of fibers as far as 4.5 mm from the midline which corresponds to a transverse activation span of approximately 9 mm.

Since the lateral extent of the DC is approximately 5 mm, steerability of the activation by over 3 mm becomes particularly useful for leads migrated laterally from the midline. Figure 4 shows the results such a lead.

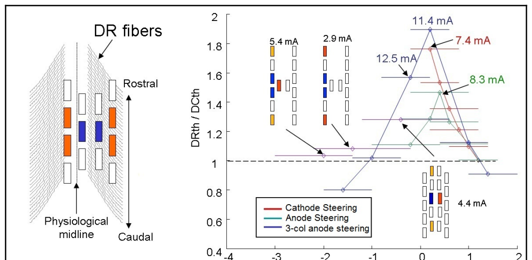

Figure 4. When the lead migrated 2 mm to the right of midline, TTS with steering shifted the activated area back to the midline. A longtiduinal tripole with transverse bipole activated more distant fibers, 5 mm away, at the opposite edge of the DC.

Conclusions

The model suggests that steering provided by Boston Scientifc's 32 contact surgical lead in combination with multi-column programming provides advanced programming flexibility to steer focused stimulation during SCS. This feature may provide benefits which may be adaptable to lead migration after lead implant and may reduce the need for revision surgery. Clinical validation of the results of this modeling study requires further work.

References

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Learning Objectives

By the conclusion of this session, participants should be able understand the relevance of dorsal column and dorsal root stimulation for SCS. They should also be able in a computational model 1) To appreciate the effect of lead migration on SCS efficacy and 2) To assess the value of independent current control to potentially modify stimulation effects in SCS.