

An Outcome Comparison of Electrode Configurations and Intraoperative Testing Techniques for Thoracic Spinal Cord Stimulators for Chronic Neuropathic Pain

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INTRODUCTION

Thoracic spinal cord stimulation (tSCS) is a therapeutic option for the treatment of neuropathic pain, such as that generated from post-laminectomy syndrome, reflex sympathetic dystrophy, or neuritis. Two variables that have scarcely been examined in relation to effective stimulation are the electrode type used and the method of intraoperative confirmation of paresthesia employed. We compared the effective paresthesia distribution of 3 distinct configurations of thoracic spinal cord stimulator electrodes and the 2 different neurophysiological techniques of intraoperative paresthesia confirmation.

METHODS

A retrospective comparative cohort study was performed on 26 patients examining electrode type and a separate group of 11 patients examining the method of intraoperative confirmation of paresthesia. The group of 26 patients consisted of 11 patients implanted with a 5-column electrode (Penta™, St. Jude Medical)[Figure 1], 8 implanted with a 3-column electrode (Specify™5-6-5,

Medtronic)[Figure 1], and 7 implanted with a 2-column electrode (Artisan™2x8, Boston Scientific)[Figure 1]. In the group of 11 patients being studied for intraoperative paresthesia confirmation testing, six patients underwent SCS placement using EMG for confirmation and five patients used Collision testing. For each patient, preoperative and postoperative Visual Analog Scale(VAS) scores, Oswestry Disability Indices (ODI) and pain maps were collected. In addition, overall satisfaction and stimulation maps were recorded to quantify each patient's degree of pain relief.

Defining Regions of the Low Back

Despite our frequent use of the term, the region of the low back remains poorly defined and subject to differing interpretations. In order to assess the effect of stimulation on the low back, we felt it was important to clearly define regions that were not only easily understood, but also reproducible. These features were essential to reducing variability not only in patient reporting, but also in recording on the part of the interviewer. The resulting segmentation of the low back consisted of 9 regions defined by 4 surface landmarks [Figure 2]. The lateral aspect of the 12th rib, the top of the iliac crest, the level of the PSIS, and the gluteal folds each served as cranio-caudal delimiters of these regions; while the mid-axial line and vertical lines through the PSIS served to demarcate the borders to the regions horizontally.

Defining Regions of the Lower Extremities

The lower extremities were segmented in a more traditional manner. As a slight modification the body areas described by Barolat¹, each limb was divided into upper leg, lower leg, dorsum of the foot, and sole of the foot; defined by the gluteal fold, knee, and ankle, respectively. These regions were further divided into inner and outer portions for a total of 8 regions [Figure 2].

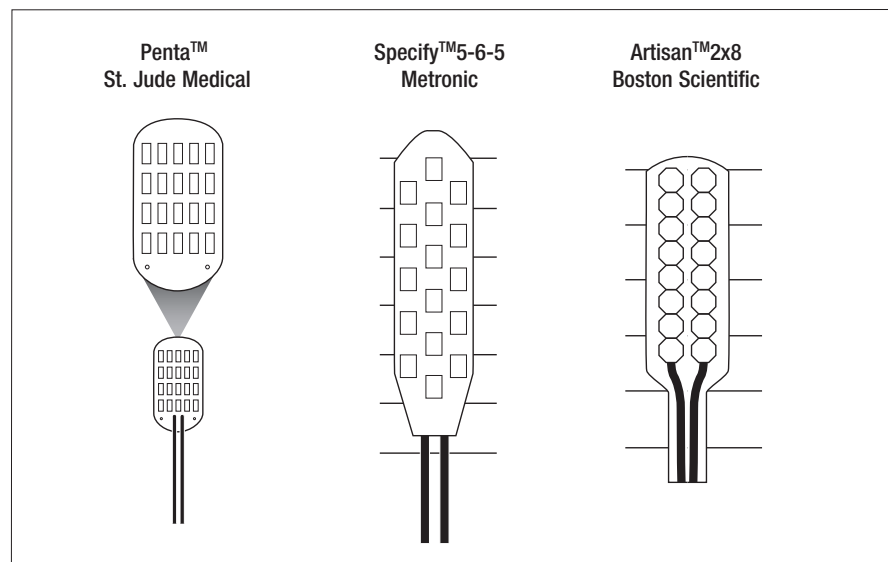


Figure 1

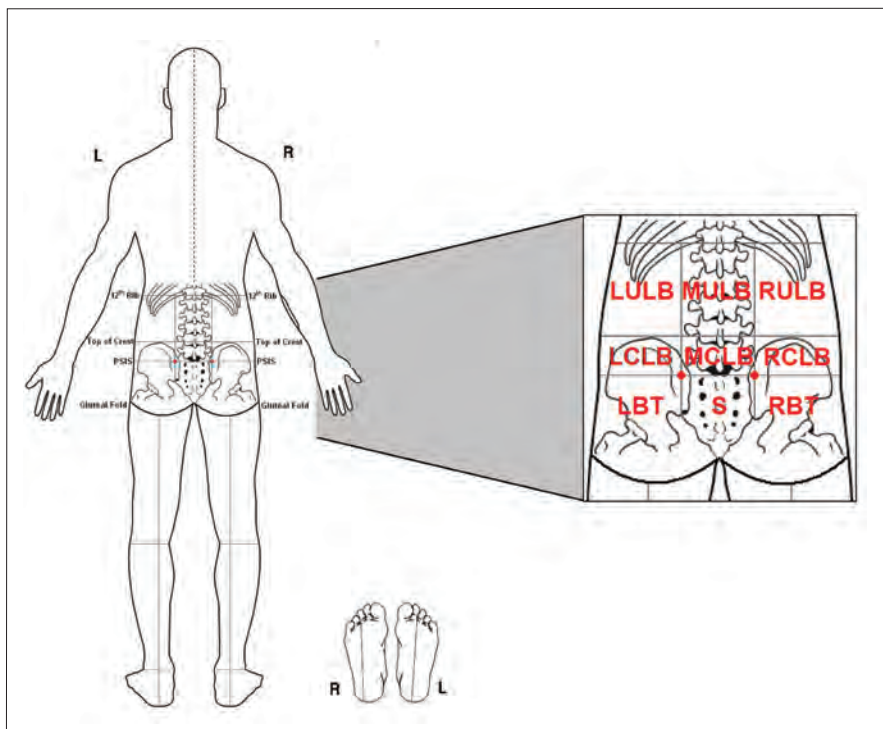


Figure 2

Collision Testing vs Motor-Evoked Potentials

One important aspect of treating neuropathic pain with tSCS is intra-operative confirmation of paresthesia. The gold standard of confirmation is to awaken patients intra-operatively; however, lack of reliability from effects of sedation, decreased patient safety, and surgeon preference triggered the search for methods of confirmation under general anesthesia. Furthermore, because large variations in paresthesia coverage occur with stimulator positioning changes in the scale of millimeters, developing confirmation techniques that are highly sensitive and specific is essential. Popular methods of intra-operative confirmation are motor-evoked potentials (MEPs) and inhibition of somatosensory evoked potentials (SSEPs). On the one hand, testing of MEPs involves applying stimulation to the spinal cord and measuring the resulting muscle activity distally. On the other hand, inhibition of SSEPs (otherwise known as “collision testing”) evaluates a sensory component by determining the extent of stimulator interference with conduction of SSEPs. The presence of interference is interpreted as positive confirmation of stimulation on a particular side or region of the body.

RESULTS

Electrode Comparison

See Table 1a-b and Figure 3a-c

Table 1a describes the average change in VAS and ODI of patients prior to operation versus post spinal cord stimulator implantation, across the 3 stimulator groups. A reduction in the number or percentage reflects an improvement in the patient’s pain or in their functional activity in life.

Table 1b describes the percentage coverage of each stimulator type. Percent coverage was calculated as follows:

Any regions of stimulation that did not correspond with a patient’s original pain were not counted in calculating the percentage and therefore each patient’s preoperative pain in every region of the low back and legs was compared to stimulation received in those areas.

Figure 3a-c describes all the patients in a group and the number of reports of pain in a specific region preoperatively and postoperatively. Lighter colors indicate a fewer number of patients reporting pain in that region and darker colors reflect more patients having pain in that specific region. All three groups demonstrate varying degrees of pain alleviation

Electrode Type	Mean VAS Reduction	Mean ODI Reduction
5-column	4.3 ± 2.4	28.7% ± 20.5
5-6-5	4 ± 1.8	22.01% ± 13.9
2 x 8	3.91 ± 1.9	15.6% ± 14.9

Electrode Type	Percentage Coverage of PreOperative Pain		
	Low Back	Buttock	Legs
5-column	44%	86.36%	90.77%
5-6-5	100%	84.21%	77.78%
2 x 8	68%	84.62%	73.68%

Intraop Testing Technique	Percentage Coverage of PreOperative Pain	Percentage of Remaining Pain as Compared to PreOp Pain
EMG	71.2% + 38.1	74.6% + 35.9
Collision Testing	59.8% + 24.6	42.0% + 16.6

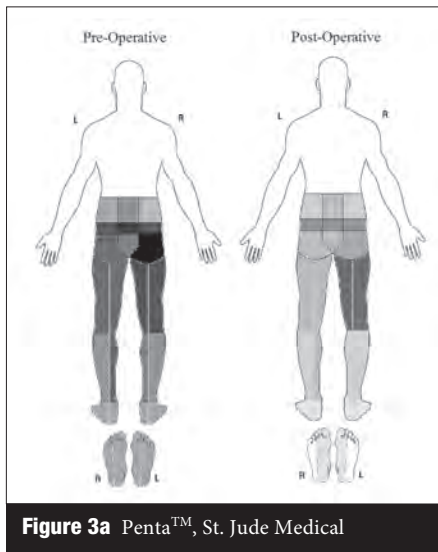


Figure 3a Penta™, St. Jude Medical

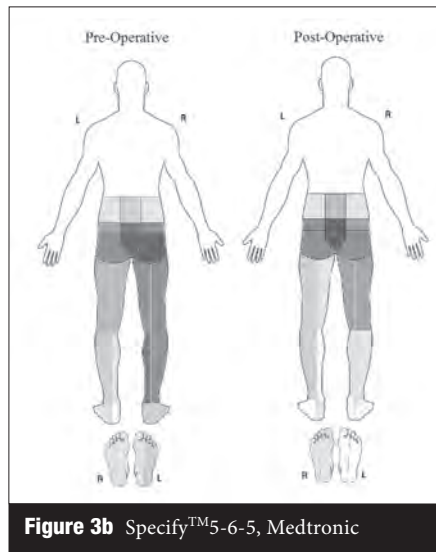


Figure 3b Specify™5-6-5, Medtronic

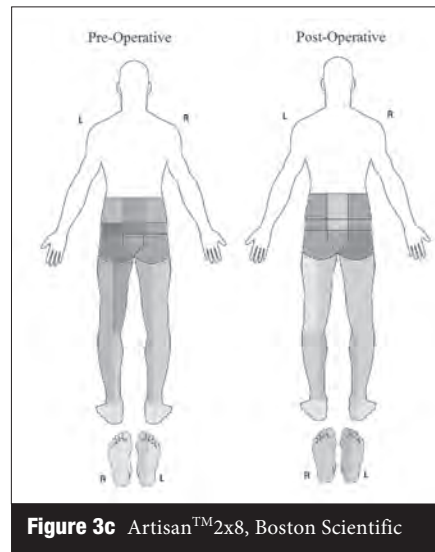


Figure 3c Artisan™2x8, Boston Scientific

from stimulation, as the postoperative maps are generally lighter in color than preoperative pain maps.

Intraoperative Testing Comparison.
See Table 2

Table 2 describes the average percent coverage for each patient and average percentage remaining pain for each patient in the EMG and collision testing groups. The average percent coverage was calculated in similar manner to Table 1b, except a percent coverage of preoperative pain was calculated for each patient and then averaged. This was done because of the smaller sample size. The remaining pain was calculated again, in a similar manner to Table 1b, except percent post-operative pain (compared to where patients had preoperative pain) was calculated for each patient and averaged.

CONCLUSIONS

Despite the common usage of tSCS, paddle electrode selection has remained more of an art than a science, and the comparison of different neurophysiological techniques for paresthesia confirmation has remained more theoretical than scientific. While different configurations have anecdotally been known to provide different areas of paresthesias, direct comparisons have not been performed to validate these findings. In this cohort of patients, the 5-column electrode produced the greatest improvements in VAS and ODI. Comparison postoperative coverage, demonstrated that the 3-column lead most effectively targeted the low back; all 3 electrodes similarly covered the buttock; and the 5-column lead most effectively targeted

the lower extremities. This study implies that electrode spacing and configuration may make a difference in the distribution of paresthesia.

In the second cohort of patients, our study suggests that collision testing may be as effective as EMG in confirming appropriate intra-operative placement of thoracic SCS under general anesthesia. In addition, collision testing may offer a benefit in reducing the amount of remnant preoperative pain. Although our studies are limited by small sample sizes and relatively short follow-up, we believe it serves as an important launching point for future investigations.

References

1. Barolat G, Massaro F, He J, Zeme S, Ketcik B: Mapping of sensory responses to epidural stimulation of the intraspinal neural structures in man. *Journal of neurosurgery* 78:233-9, 1993, 10.3171/jns.1993.78.2.0233



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