# Revision of Vagal Nerve Stimulator Electrodes: Technical Approach

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**Abstract:**

**Purpose**

To demonstrate the feasibility of complete removal of the vagal nerve stimulator electrode using microsurgical technique.

**Methods**

Operative databases at the University of Utah (1995 through 2002), Westchester Medical Center (1995 through 2001), and University of Arizona Health Sciences Center (1995 through 1999) were retrospectively reviewed. Patients who had undergone removal or revision of a previously placed vagal nerve stimulator electrode were identified. Patients who had a vagal nerve stimulator device removed but had the lead trimmed and incompletely removed were excluded.

**Results**

Seven patients underwent complete removal of the lead. Microsurgical dissection allowed removal of the helical electrode from the vagus nerve without apparent physiological consequences. Four patients had a new electrode placed just proximal to the original lead site. The operative procedure required an additional 30 minutes to complete compared with initial device placement. The four patients who underwent replacement of the electrode demonstrated normal device function and lead resistance at the time of postoperative follow-up. Each experienced a return to prior stimulation response and seizure control.

**Conclusions**

This series suggests that the electrode can be removed from the vagus nerve and repositioned without significant consequence in most cases.


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**Introduction:**

Electrical stimulation of the vagus nerve was first investigated as a potential method for controlling seizures by Zabara in 1985. [1] The first vagal nerve stimulator was implanted in 1988. [2] Pilot studies and randomized controlled trials have subsequently shown that chronic vagal nerve stimulation can improve the control of intractable seizures. [2-8] As the number of patients with vagal nerve stimulators increase, the need to occasionally revise or remove these devices will also increase.

**Methods**:

Procedural data at the University of Utah (1995 through 2002), Westchester Medical Center (1995 through 2001), and University of Arizona Health Sciences Center (1995 through 1999) were retrospectively reviewed. Seven patients were identified who had undergone vagal nerve stimulator placement followed by either complete vagal nerve stimulator electrode removal or complete removal with immediate lead replacement. The Cyberonics® (Houston, TX) NeuroCybernetic Prosthesis (NCP®) system with pulse generator and open helical, biocompatible platinum ribbon bipolar electrode was utilized exclusively in all procedures. A standard surgical technique was employed as described below.

*Surgical Technique:* The patient is positioned supine with the head turned slightly to the right and the neck extended with a shoulder roll. Preoperative antibiotics are administered intravenously. The left anterior cervical and subclavicular region is prepped in standard fashion to include the previous operative scars. The scars are opened and the proximal lead is disconnected from the generator in the subcutaneous pouch. The generator is then interrogated.

The cervical incision is then opened and the lead is identified in the subplatysmal plane. The wire is carefully traced to the most proximal anchoring coil of the electrode. Sharp technique is used with the assistance of loupe magnification and microsurgical instruments. Although the lead wire is insulated, monopolar electrocautery should be avoided to prevent heat injury to the vagus nerve. Care is taken to avoid traction on the nerve. The helical electrodes are exposed and then cut along the long axis of the nerve. The electrode typically can be found embedded in a dense perineural scar (see fig. 1). The plastic portion of each coil is gently dissected away from the nerve. The platinum contact can then be easily lifted away from the surface of the nerve. Excess scar tissue along the nerve is then trimmed if necessary. The nerve is then placed back in its bed (see fig. 2). In patients requiring replacement of the electrode, the vagus nerve is further exposed in the cephalad direction and the new electrode is placed at a fresh location on the nerve. The lead is then tunneled subcutaneously to the subclavicular wound and connected to the generator in standard fashion. The electrode resistance is tested along with the functions of the generator. A relaxing loop is formed in the lead wire within the cervical wound and secured to the strap muscles with silastic tabs. The incisions are then closed in layers.

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**Results:**

Seven patients underwent vagal nerve stimulator lead removal; three devices were completely removed and four were revised. Two patients had a significant decrease in seizure frequency but were unsatisfied with the persistent seizures and requested that the stimulator be removed. Another patient developed laryngospasm during stimulation, which affected breathing, and desired removal. The electrode was completely removed from the vagus nerve in each of these patients.

Four patients required replacement of the helical lead. Two patients developed mechanical failure of the electrode. One of these patients exhibited an ictal automatism that caused her to twist the generator within the subcutaneous pouch causing fracture of the lead wire. Another 28-year-old male patient felt "electrical shocks" when turning his head to the extreme left, and the electrode was revised with resolution of his symptoms. One patient developed an infection of the lead wound. One final patient developed an infection at both implantation incision sites. The entire device was replaced after adequate antibiotic therapy.

The average time from implantation to removal or revision was one year. Revision surgery required approximately 30 minutes additional surgical time over that of a routine device placement. There were no surgical complications. The four patients who underwent replacement of the electrode demonstrated normal device function and lead resistance at the time of postoperative follow-up. Each experienced a return to prior stimulation response and seizure control.

**Discussion**:

The increased use of vagal nerve stimulation for control of intractable epilepsy will necessitate the occasional removal or replacement of the vagal nerve electrode. The theoretical basis for vagal nerve stimulation, clinical indications, technical aspects of surgery, and results have been reviewed in a report by Amar, et al. [5] Several principles of surgical technique for device placement were described. There are currently no studies that describe a technique for safe lead removal or replacement and no studies that document seizure response following revision. Our preliminary experience with these patients shows that removal of the leads is technically feasible without obvious adverse effects on the vagal nerve.

**Conclusion:**

Careful microsurgical technique permits the removal or replacement of vagal nerve stimulator electrodes with preservation of the vagus nerve.

**Figure 1 (see separate file)**


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**Figure 2 (see separate file)**


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