Motor Stimulation Testing in Lumbar Radiofrequency Neurotomy

Mathew Saffarian, DO1, Vivek Babaria, DO2, and Zachary L. McCormick, MD3, on behalf of the Spine Intervention Society's Patient Safety Committee

1 Michigan State University, Department of Physical Medicine and Rehabilitation, East Lansing, Michigan, USA
2 Orange County Spine and Sports, PC, Interventional Physiatry, Costa Mesa, California, USA
3 University of Utah, Division of Physical Medicine and Rehabilitation, Salt Lake City, Utah, USA

Myth: Motor stimulation testing prior to lumbar radiofrequency neurotomy guarantees prevention of inadvertent damage to the exiting spinal nerve or its ventral ramus.

Fact: Motor stimulation does not inherently protect against unwanted damage to the spinal nerve, exiting spinal nerve root or its ventral ramus due to a lack of sensitivity of this test for identification of electrode contact or close proximity to sensorimotor nerves. Even when motor stimulation is performed, verification of correct electrode placement with multiplanar imaging including a minimum of true anterior-posterior and lateral fluoroscopic views is a recommended safeguard.

Radiofrequency neurotomy (RFN) is an effective treatment for chronic lumbar zygapophysial joint pain when performed according to clinical practice guidelines [1,2,3]. When performed according to these standards, the rate of adverse events is very low [1,4-6]. If improper technique is used, the procedure is likely to be ineffective [7] and complications may occur [5,6,8]. In particular, if an electrode is advanced into the posterior aspect of the neuroforamen, damage to the exiting spinal nerve or its ventral ramus is possible [7,8].

Recent multispecialty working group recommendations promote the performance of motor stimulation testing to help ensure safety when performing lumbar RFN [9]. This guidance was based on a single case of dropped head syndrome following a cervical RFN [9,10]. Some clinicians may also use motor stimulation testing with the rationale that it aids in identifying proximity of the RFN electrode to the medial branch nerve, though the evidence for this practice is based on low quality evidence [11]. Alternatively, Spine Intervention Society guidelines recommend that with proper procedural anatomical location and accurate technique, motor stimulation testing of the medial branch nerve is not necessary for optimizing treatment outcomes or aiding in prevention of damage to the exiting spinal nerve or its ventral ramus [3]. Given this discrepancy, the following FactFinder describes the available published evidence relevant to motor stimulation testing as a risk mitigation strategy to prevent inadvertent damage to the spinal nerves during a lumbar RFN procedure. However, indirect information can be gleaned from studies performed on other nerves, which may be the best available evidence to determine whether motor stimulation, prior to thermocoagulation, can reliably prevent subsequent injury to the spinal nerve and/or its ventral ramus during lumbar RFN.

Electrical stimulation as a safeguard against neural injury has been studied extensively in relation to peripheral nerve blocks. In the 1950s, nerve stimulator use became popular to locate nerves [13] and to decrease the incidence of injury during peripheral nerve blocks [14]. Prior to the use of nerve stimulators, it was assumed that eliciting a paresthesia may predict proximity to a specific nerve. However, reports in the early 2000s questioned the correlation of needle-tip-to-nerve distance, paresthesia provocation, and the ability to produce a motor response [13,15].
The introduction of ultrasound allowed for objective measurement of needle proximity to a target nerve. Perlas et al. studied the use of motor stimulation during ultrasound-guided axillary nerve blocks [16]. These investigators found that application of 0.5 mA of current during epineural contact failed to produce a motor response in 25% of subjects. Bigeleisen et al. investigated the ability to evoke a motor response by stimulation of the supravclavicular nerve with needle tip contact of epineurium versus intraneural position. [17] Provocation of a motor response required greater than 1.0 mA of current in 18% (CI 95% 6%-30%) of subjects in the epineural contact group. Alternatively, intraneural stimulation was associated with a motor response upon application of 1.0 mA of current or less in all cases, though greater than 0.5 mA was required 10% of the time. Robards et al. investigated motor stimulation thresholds during ultrasound-guided intraneural sciatic nerve blocks and found that a current of 1.5 mA failed to elicit a motor response in 17% (95% CI 2-32%) of subjects [18]. This body of evidence indicates that a proportion of patients exhibit no motor response with both intraneurally and epineural needle tip position when a magnitude of current that maintains specificity is applied to peripheral nerves.

Animal studies provide additional evidence that motor stimulation lacks a reliable relationship with needle-tip-to-nerve proximity. Chan et al. placed 22-gauge needles into nerves of the brachial plexus of pigs via open surgery for direct visualization [19]. They found no relationship between the magnitude of electrical current applied during and a motor response, which occurred anywhere from 0.2mA to greater than 1.0 mA. Tsai et al. found that a motor response was absent upon sciatic nerve stimulation in pigs 30% (95% CI 56%-84%) of the time with a needle-tip-to-nerve distance of 1mm [20]. At a needle-tip-to-nerve distance of 2mm, these investigators reported failure to evoke a motor response upon all attempts, despite application of a current up to 1.7 mA. These findings reinforce that motor stimulation lacks sensitivity for needle tip proximity to a nerve that may result in thermal injury during lumbar RFN.

There are additional reasons that motor stimulation prior to lumbar RFN may not be a reliable indicator of needle proximity to the exiting spinal nerve or its ventral ramus. Sensorimotor fascicular organization in the nerve root is likely to vary across patients [17], which may influence the ability to evoke a motor response upon stimulation. Furthermore, patients with diabetes, and other medical co-morbidities that predispose to polyradiculoneuropathy, may require higher stimulation thresholds to elicit motor responses [17]. Genetics, age, psychology, medications, use of sedation, and underlying pathology may further complicate a patient’s response to motor stimulation [21]. Finally, use of conducting solutions, such as normal saline or lidocaine, decrease tissue impedance adjacent to the electrode. This will lead to an increase in lesion size during RFN [22]. Therefore, even if motor stimulation fails to provoke a motor response in the distribution of the exiting spinal nerve, once conducting fluid such as local anesthetic is applied prior to RFN, the tested area can expand and cause spinal nerve injury during RFN despite negative motor stimulation response. All of these factors may contribute to the insensitivity of motor testing to provide accurate information regarding electrode location, creating a false sense of security that an electrode is positioned at a safe distance from the exiting spinal nerve or its ventral ramus.

In summary, the available evidence indicates that motor simulation testing alone (at current magnitudes that maintain target specificity) lacks adequate sensitivity for both intraneural and close perineural RFN electrode position. If used, it should be combined with multiplanar fluoroscopic imaging to verify correct electrode position. However, more evidence is needed to show if this combination of precautionary measures works better than verifying electrode position by multiplanar fluoroscopic imaging alone.

Conclusions/Recommendations

- Motor stimulation testing without verifying electrode position by multiplanar fluoroscopic imaging prior to RFN does not inherently protect against unwanted damage to neural structures. Absence of a response to motor testing may give a false security that the RFN electrode is located in a safe position.
- Prevention of spinal nerve and/or ventral ramus injury during lumbar RFN is best ensured by multiplanar fluoroscopic imaging (true AP and lateral views at minimum) in order to verify that electrode position is dorsal to the associated lumbar intervertebral foramen.
- If despite these measures abnormal sensations are reported during thermocoagulation, the physician should halt the radiofrequency lesion, re-check multiplanar fluoroscopic views, and correct the electrode position, if appropriate. Ensuring that the patient is awake and able to report abnormal sensations is an important safety measure in preventing neural injury.
References