# Neurosurgical Approaches

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**KEYWORDS**

• Neurosurgery • Spasticity • Dystonia • Rhizotomy • Deep brain stimulation

**KEY POINTS**

- Neurosurgeons play an important role in the treatment of muscle hyperactivity, and should be included in multidisciplinary efforts to treat these patients.
- Focal spasticity can be treated through identification and lesioning of a nerve target.
- Patients with generalized spasticity, especially ambulatory children with spastic diplegia, should be considered for selective dorsal rhizotomy.
- Dorsal root entry zone lesioning is an option for severe cases of spasticity in a nonfunctioning limb.
- Deep brain stimulation has demonstrated efficacy in the treatment of primary dystonias, especially those caused by DYT-1 gene mutation.

## INTRODUCTION

Neurosurgeons have historically played a significant role in the management of patients with upper motor neuron conditions that result in muscle hyperactivity, such as spasticity or dystonia. Nerve lesioning procedures for the treatment of spasticity were first proposed in the early twentieth century and have since undergone considerable surgical refinement and study.[1] The introduction of intrathecal infusion devices and the advent of deep brain stimulation have also expanded the neurosurgeon's role in this field. The aim of this article is to describe these techniques and the anatomy and pathophysiology involved, as well as delineate the indications for each procedure and associated data on efficacy and complications. Surgical techniques discussed in this article include the broad class of nerve lesioning procedures for spasticity (selective peripheral neurotomy, selective dorsal rhizotomy, and dorsal root entry zone lesioning) and deep brain stimulation for dystonia. Intrathecal baclofen delivery, an

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area where neurosurgeons are also involved, will only be examined in its relationship to selective dorsal rhizotomy. General knowledge regarding these surgical interventions is essential for those clinicians treating patients with conditions of muscle hyperactivity, as proper referral and patient selection can provide meaningful symptom relief and improve the quality of life for patients. For this reason, it is also important to include the field of neurosurgery within the comprehensive multidisciplinary team that is often required to adequately care for these complex patients.

## NERVE LESIONING

Since early work by Lorenz and Stoffel in the peripheral nervous system and Foerester in the central nervous system in the late nineteenth and early twentieth centuries, multiple sites and techniques for nerve lesioning have been proposed and include lesion to the peripheral nerve, spinal roots, dorsal root entry zone, and spinal cord.[2] The physiologic principles behind nerve lesioning depend upon which level of the nerve is being targeted, and each technique comes with its own set of indications, preoperative work-up, efficacy data, and set of complications. These factors will be discussed for each of the nerve lesioning procedures.

### *Selective Peripheral Neurotomy*

First introduced by Lorenz in 1887 for hip adduction spasticity[3] and Stoffel in 1912 for control of spastic foot,[4] selective peripheral neurotomy (SPN) involves the identification and surgical lesioning of pathologic peripheral nerves or nerve fascicles that contribute to spasticity. The disruption of the nerve supplying motor innervation to a spastic muscle or muscle group abolishes the motor reflex arc and limits the spastic potential of the muscle, theoretically resetting the balance between agonist and antagonist muscle groups.[2,5] Lesioning should be performed on at least 50% to 80% of the fibers innervating the muscle to expect a positive outcome.[2] Because the lesion disrupts only a population of efferent ($\alpha$-motor) and afferent (Ib proprioceptive spindle fibers) neurons, some of the remaining efferent inputs are capable of some muscle reinnervation. The afferent fibers are unable to reconnect in a cohesive manner, therefore allowing for the return of some motor function with continued loss of the afferent limb of the reflex arc that contributes to muscle hyperactivity.[6] The technique has been refined to include the use of identification of individual nerve fascicles within the nerve that contribute to the motor reflex arc by means of intraoperative electrophysiology. This process also allows for the identification and avoidance of sensory fibers, which if found and avoided, can help to prevent the development of painful postoperative allodynia or neuralgia.[5]

SPN is indicated for cases of focal or multifocal spasticity for which a clear muscular culprit can be identified preoperatively and for which repeated injection of botulinum toxin has become ineffective. Underlying causes of the focal spasticity can be numerous, but include cerebral palsy (CP), stroke, traumatic brain injury (TBI), or spinal cord injury (SCI). Examples of relevant nerve targets for SPN and the spastic conditions they are intended to ameliorate are summarized in **Table 1**.[2,6] Preoperative assessment of patients being considered for SPN is critical for proper target identification. In addition to a complete neurologic examination to determine the muscular groups(s) involved, peripheral nerve blocks using long-acting local anesthetics (eg, bupivacaine) or botulinum toxin should be performed.[5,7] Use of these agents allows for the simulation of the expected effects of SPN, and, following their administration, assessments of both symptom relief (ie, effect on spasticity) and adverse effects (ie, effect on ambulation or other