

Surgical Treatment of Spasticity by Selective Posterior Rhizotomy: 30 Years Experience

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Abstract

Background: Spasticity is a common neurologic disorder with adverse effects on the patient's function. Conservative management is unsuccessful in a significant proportion of patients and neurosurgical intervention should be considered. The mainstay of surgical treatment of spasticity is selective posterior rhizotomy, i.e., section of sensory nerve roots of the cauda equina.

Objective: To report our experience with selective posterior rhizotomy in the treatment of spasticity.

Methods: We retrospectively reviewed our experience in 154 patients who underwent SPR during 30 years. The indication for surgery was spasticity that significantly hindered the patient's function or care and was resistant to conservative treatment. All patients were evaluated for spasticity in the lower and upper limbs, the presence or absence of painful spasms, and sphincter disturbances. The decision as to which roots to be sectioned, and to what extent, was based mainly on clinical muscle testing.

Results: Reduction of spasticity in the lower limbs was obtained in every case, with improvement in movements in 86% of cases. Painful spasms were alleviated in 80% of cases. Amelioration of neurogenic bladder was observed in 42%. A minority of the patients also showed improvement in speech and cognitive performance. There was no perioperative mortality or major complications.

Conclusion: SPR is a safe and effective method for the treatment of spasticity with long-lasting beneficial effects. We suggest that this method be considered more frequently for patients with spasticity that interferes with their quality of life.

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Spasticity is defined as "a motor disorder characterized by velocity-dependent increase in muscle tone with exaggerated tendon jerks, as one component of the upper motor neuron syndrome" [1]. It may affect children and adults suffering from various neurologic diseases such as cerebral palsy, cerebrovascular accident, multiple sclerosis, cerebral or spinal trauma, spinal cord tumors, or degenerative diseases of the central nervous system.

In some patients spasticity compensates partially for the coexistent muscle weakness (useful spasticity), but in most patients it is associated with decreased range of motion and increased energy requirement for active movement (harmful spasticity). When involving the whole body, spasticity may interfere with commu-

nication, feeding, sphincters, hygiene, skin care, positioning, and even respiration.

Although spasticity is a common and serious clinical problem encountered by physicians from several different specialties, it remains largely under-treated. The management of spastic patients is multifactorial, and includes physical therapy, occupational therapy, pharmacologic treatment, mechanical devices for mobilization, orthotic devices for spinal or limb deformities, and nursing care for severely affected patients. Orthopedic surgery is frequently indicated to repair fixed muscle contractures and skeletal deformities.

Surgical treatment of spasticity was initiated in 1908, when Foerster [2] performed "posterior rhizotomy," i.e., resection of posterior sensory roots of the cauda equina. This was based on Sherrington's experiments [3], which demonstrated that section of the dorsal roots abolished decerebrate rigidity in animals. However, Foerster's operation caused significant sensory disturbances and did not gain favor. Other surgical methods were introduced, such as ventral rhizotomy, longitudinal myelotomy and distal cordectomy [4], but all were abandoned due to severe side effects. Resurgence of dorsal rhizotomy started with Gros, who modified Foerster's technique by sparing one-fifth of the dorsal roots in order to reduce the sensory effects. Gros coined the term "selective posterior rhizotomy" and his first 25 cases were reported in 1965 in Ouaknine's thesis [5,6]. Ouaknine later developed a microsurgical technique for SPR, in which resection involved one-half to two-thirds of each group of rootlets in the posterior roots from L1 to S1 – "selective posterior rootlets resection" [7]. Preoperative detailed muscle testing was undertaken to differentiate between useful spasticity in the abdominal, quadriceps and gluteus medius muscles, which is related to postural tone (to be preserved), and the harmful spasticity of the hip flexors, adductors, hamstrings and triceps surae (to be abolished).

Materials and Methods

This retrospective study included 154 consecutive patients operated on by one surgeon (Ouaknine) since 1969. The patients, 86 males and 68 females, 72 children and 82 adults, were aged 5–67 years (mean 27) at the time of surgery. The underlying diseases are shown in Table 1.

The indication for surgery was spasticity that interfered with daily living and was resistant to conservative treatment. The follow-up period ranged from 1 to 19 years (mean 11 years). All patients

SPR = selective posterior rhizotomy

* This article is dedicated to the memory of Prof. Ouaknine who passed away shortly after completion of this study.

Table 1. The effect of SPR on lower limb spasticity, according to the etiology

Etiology	No. of cases	Mean age at operation	Early results (< 1 yr)	Late results (> 1 yr)
Cerebral palsy	60	12	+++	+++
Multiple sclerosis	52	42	+++	++
Trauma	35	28		
Spine	30		+++	++
Head	5		++	+
Degenerative disease	7	51		
Spinocerebellar	4		++	++
Amyotrophic lateral sclerosis	3		++	+

The postoperative decrease in spasticity by grades of Ashworth scale:

+++ = a decrease of 3 grades or more,

++ = a decrease of 2 grades,

+ = a decrease of one grade.

were evaluated for the presence and severity of spasticity of lower limbs, movement, sitting, standing, walking, spasticity and performance of upper limbs, bladder function, speech, cognition, and the presence or absence of painful spasms in the lower extremities. The severity of spasticity was graded from 0 (normal tone) to 4 (extreme spasticity) according to the Modified Ashworth Scale [8].

The surgical technique has been described in detail elsewhere [7] and is summarized here briefly. After laminectomy of L1, alone or with L2 (the level of the conus medullares), the dura is opened and microsurgical partial resection of one-half to two-thirds of rootlets of the posterior roots (radiclectomies) from L1 to S1 is performed with preservation of the minute radicular arteries [Figures 1 and 2]. Unilateral partial resection of S2 can also be performed in cases of spastic bladder. The selective resection of the "spastic rootlets" depends on detailed preoperative muscle testing (although 36 patients underwent both pre- and intraoperative electrophysiologic stimulation).

An additional procedure for the treatment of painful flexor spasms was conducted in 27 patients: anterior rhizotomies (n=8), section at the dorsal root entry zone, i.e., DREZ-otomy (n=13), and release of tendons, i.e., tenotomy (n=6).

Results

The effect of SPR on spasticity of the lower limbs, according to the underlying pathology, is shown in Table 1. Reduction of spasticity in the effected muscles of the lower limbs was achieved in all patients. This was associated with disappearance of ankle clonus, and disappearance or reduction of deep tendon reflexes. An increase in the range of movement in the affected joints was achieved in 132 patients (86%). Reduction in spasticity persisted at the same degree in all 60 patients with cerebral palsy, while in all other groups there was a partial loss of improvement after an interval of 1–15 years. Of 62 patients who were able to walk before

surgery, 30 patients (45%) showed early gait improvement, and an additional 11 patients (22%) showed late improvement. Of patients who could not walk preoperatively, 20% developed the ability to walk using different aids during the follow-up. Painful spasms disappeared in 22 of 27 patients (80%), an effect that persisted in 16 of them (72%). Improvement of bladder function was obtained in 46 of 72 patients who had neurogenic bladder (64%). This improvement was lost in 16 patients (35%) during the long-term follow-up. Upper limb spasticity, which had been present in 93 patients before surgery, was reduced in 60 patients (65%), leading to improvement in functions such as feeding and writing in 52 patients (48%). During the follow-up these figures decreased to 57% and 40% respectively. Improvement in speech and cognition occurred in 21 of 48 affected patients (47%) and persisted in all of them [Table 2].

Complications

Transient hypoesthesia (9 days to 7 months) at the dermatomes innervated by the sectioned roots was observed in 12 cases and persistent hypoesthesia in 4 cases. Six patients had postoperative transient bladder incontinence (3 weeks to 11 months). There were five cases of wound infection that were managed conservatively. Adverse trophic changes in muscles of the lower limbs occurred in two patients. There was no perioperative mortality, exacerbation of muscle weakness, or anal sphincter disturbances.

Discussion

It is essential to determine the etiology of spasticity and its role in the patient's disability. Neurosurgical intervention is justified only when spasticity impedes the patient's function or care and only after failure of conservative management. In a patient who depends on spasticity for antigravity control during standing and walking (useful spasticity), alleviation of spasticity may aggravate weakness and inhibit ambulation.

Today, the main methods in the management of generalized spasticity are intrathecal baclofen injection and SPR. Ventral rhizotomy, longitudinal myelotomy, and cordectomy are no longer performed for spasticity. Neurostimulation of the spinal cord might be effective only for mild spasticity [9]. Ablation of the dorsal roots

Table 2. Results of SPR during follow-up

	No. of patients	Immediate (<1 month)		Late (>1 year)	
		Improved	Worsened	Improved	Worsened
Lower limb spasticity	152	100%	0	100%	0
ROM in affected joints	152	86%	0	80%	0
Gait					
Preop walkers	62	67%	0	67%	0
Preop non-walkers	90	20%	0	20%*	0
Painful spasms	27	80%	0	72%	0
Bladder function					
Preop normal	80	–	8%	–	0
Neurogenic bladder	72	64%	0	42%	–
Upper limb spasticity	93	65%	0	57%	0
Speech and cognition	48	47%	0	47%	0

* These patients were able to walk after surgery and physical therapy.

ROM = range of movement.

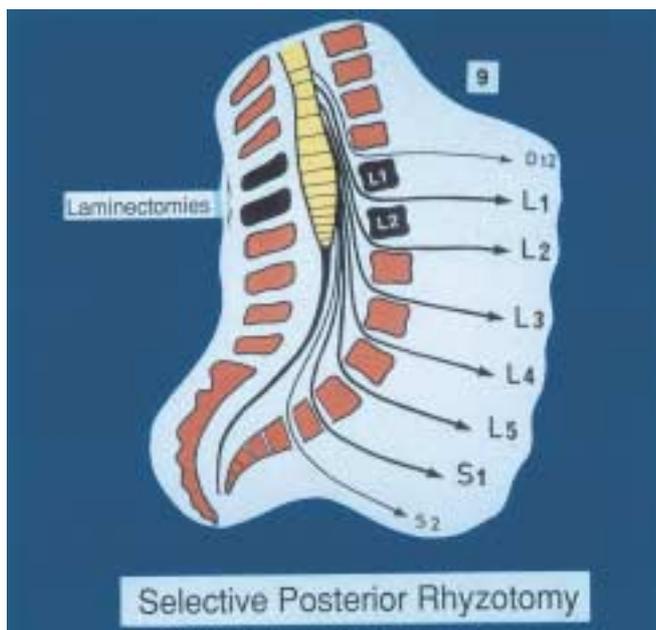


Figure 1. Diagram of the spine shows the site of the laminectomy used for SPR (L1 with or without L2), with relevance to the conus medullares and roots of the cauda equina.

at their entry zone in the spinal cord, i.e., DREZ-otomy or DREZ lesioning, is used for spasticity associated with painful spasms [10]. Spasticity that involves single muscle groups is best treated by local injection of botulinum toxin (Botox) or by orthopedic procedures [11].

Baclofen, an agonist of the inhibitory neurotransmitter GABA (gamma aminobutyric acid), is available for oral or intrathecal use. It relieves spasticity through its action on GABA receptors in the spinal cord, while its action on GABA receptors in the brain may cause adverse effects such as dizziness, memory disturbances, confusion, seizures and respiratory depression. Intrathecal delivery of baclofen allows adequate relief of spasticity with a very low dose (about 1% of the oral dose). This minimizes the undesirable effects of the drug, since the cerebral concentration with intrathecal injection is only 25% of that in the spinal cord and the blood level is insignificant. For intrathecal delivery, a programmed pump is implanted under the abdominal skin and is connected to a catheter, which is tunneled subcutaneously to the back and inserted into the spinal intrathecal space. The main advantages of intrathecal injection are that the dose can be titrated according to the patient's needs, and the effect is reversible. Disadvantages include the need for implantation of a foreign body with the risk of infection, obstruction or dislodgement of the system, and the need to refill the pump. Side effects of the drug may still appear and rapid discontinuation may cause withdrawal effects. In addition, this method is significantly more expensive than SPR. Intrathecal baclofen is the treatment of choice for patients with spasticity and dystonia, and for spastic patients with severe muscle weakness who will not benefit from SPR [12–14].

Selective posterior rhizotomy may be the treatment of choice for patients with spastic diplegia or for ambulatory patients with spastic quadriplegia who have adequate motor strength [13,15].

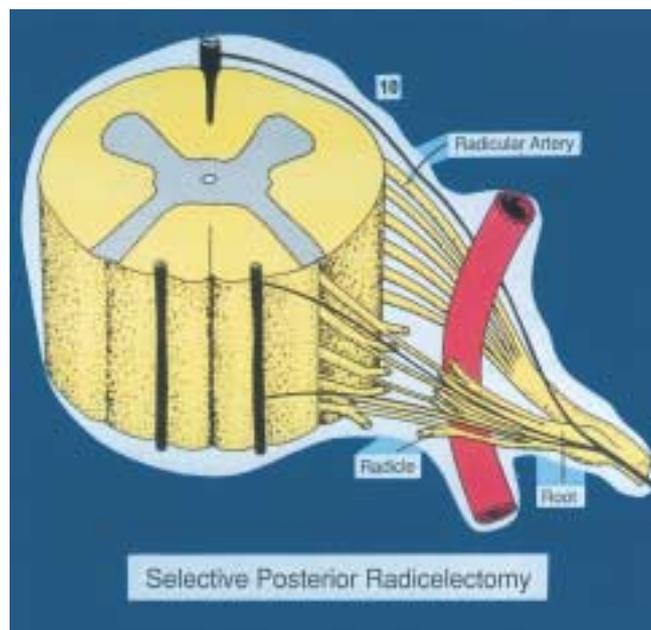


Figure 2. A diagram of a transverse section of the spinal cord to illustrate the SPR.

SPR is contraindicated in the presence of severe mental retardation, severe scoliosis, age under 2 years, and abnormal involuntary movements (dyskinesia, dystonia) that may worsen after rhizotomy.

An important issue in SPR is which nerve roots and what percentage of rootlets from these roots should be divided. Resecting more nerve rootlets provides better relaxation of muscle tone but might increase the complication rate. In order to avoid exaggerated resection, Fassano et al. [16] proposed the "functional posterior rhizotomy" based on intraoperative electromyographic mapping. Other authors have doubted the reliability of intraoperative EMG monitoring [17,18]. In our experience, detailed preoperative clinical muscle testing is as reliable as electrophysiologic mapping. Recently, Kim et al. [19] suggested including L1 and S2 roots in SPR, but to resect fewer than 50% of these roots in order to avoid complications.

Selective posterior rhizotomy reduces spasticity by decreasing the transfer of stimuli through the sensory roots to the spinal cord. Reduction of spasticity improves movements in the lower limbs with consequent improvement in sitting, standing and walking [7,20–23]. Beneficial effects on lower extremity function was achieved in the majority of our patients and persisted during long-term follow-up in most of them. Arens and co-workers [23] also confirmed that lower extremity spasticity remained reduced in 95% of their patients during 10 years follow-up. Of note, improvement in the patient's performance may persist despite the re-increase in spasticity, probably because the initial reduction in spasticity motivates more intensive conservative treatments.

Improvement in upper limb spasticity, speech and cognition – all functions served by circuits higher than the dorsal lumbosacral roots that are sectioned in SPR (suprasegmental effects) – were also achieved in a significant number of our patients. This interesting effect was first reported by Ouaknine in 1965, and later also by

others [15,23,24], but its physiologic mechanism remains uncertain. Explanations have included improvement in the patient's mood and comfort, greater intervention by the care-giving teams, and possible effects on pathways ascending from the lumbar area to the cervical region or the cerebral cortex [15,24].

The current series differs from most other published series on surgical treatment of spasticity in the long-term follow-up, in that a significant percentage of our patients were adults whereas most surgical series deal mainly with the pediatric population. Compared with adult patients, children have a greater chance to benefit from reduction of spasticity because of the plasticity of their still-developing nervous system. On the other hand, children are at higher risk to develop skeletal deformities if left untreated.

Conclusion

In our experience, selective posterior rhizotomy of one-half to two-thirds of the "spastic rootlets," alone or associated with other methods, is effective in the treatment of harmful spasticity. Useful spasticity that helps standing position and gait must be preserved. SPR is a benign operation with acceptable morbidity. Preoperative detailed clinical evaluation is as good as pre- and intraoperative electrophysiologic assessment.

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