Selective posterior rhizotomy: results of five pilot cases

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We report on two patients with spastic quadriplegia and three patients with spastic diplegia who underwent selective posterior rhizotomy. The mean period of follow-up was 15 months (range, 12-21 months). The patients were assessed preoperatively and at 2 weeks, 3 months, 6 months, and 1 year after surgery. Tests included those for muscle tone (using a modified Ashworth scale), range of passive movement, functional status, and gait pattern. Muscle tone was reduced substantially after the procedure, and the range of passive movement was increased. Both the dependent and independent ambulators showed an increment in their walking velocity and stride length. There were no postoperative complications apart from mild fever and the treatment was well tolerated by both patients and parents. There was no return of spasticity in any of the patients during follow-up. The reduced spasticity resulted in better motor performance, and patients felt more comfortable with their daily activities. We conclude that selective posterior rhizotomy should be considered for those patients who have cerebral palsy and are disabled by spasticity.

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Introduction

Selective posterior rhizotomy is a neurosurgical procedure that is performed in patients who have spastic cerebral palsy. In the early 1900s, Foerster demonstrated the effectiveness of performing total posterior rhizotomy from the L2 through S2 roots (but sparing the posterior roots of L4) to relieve lower-limb spasticity.[1] The unacceptable sensory loss, however, prompted the development of a number of more refined partial rhizotomy procedures. Gros et al[2] performed partial posterior rhizotomies by preserving one fifth of the posterior spinal rootlets. Fasano et al[3] introduced the method of selective posterior rhizotomy to identify only those rootlets that showed an abnormal response to electrical stimulation.[3] This method is based on the assumption that populations of rootlets that are maximally involved in the maintenance of spasticity can be identified by their response to intra-operative electrical stimulation. Peacock et al[4] modified this technique and applied it to the cauda equina region after having performed a multilevel laminectomy; the lower sacral roots could be identified and preserved, and hence sphincter function was preserved. The results of the procedure were reported to be good.[4-6]

The selective posterior rhizotomy clinic at the Tuen Mun Hospital was started in October 1996. This article reports on the first five cases of selective posterior rhizotomy for spastic cerebral palsy.

Methods

Patient selection

Patients were referred to the rhizotomy clinic by paediatricians and physiotherapists at the Tuen Mun Hospital from October 1996 through July 1998. The patients were assessed by a neurosurgeon and paediatric neurologist from the hospital, and physiotherapists from the hospital, child assessment clinic, and a number of different special schools. After the screening, five patients (three boys and two girls) were selected from 15 patients who had spastic cerebral palsy. Two of the children had spastic quadriplegia: one was aged 4 years and the other 7 years at the time of the rhizotomy. The severe spasticity caused them to experience much pain and discomfort. They also had difficulty swallowing and controllong body

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posture. The aim of the selective posterior rhizotomy was to improve patient comfort and to facilitate nursing care. Both patients showed radiological evidence of hip subluxation. The following criteria were used to select spastic quadriplegic patients for selective posterior rhizotomy: (1) significant lower limb spasticity that interfered with controlling body posture, passive movement, and care; (2) lack of the features characteristic of dystonia; (3) no severe truncal hypotonia; and (4) no fixed contracture at multiple joints.

Three children had spastic diplegia; two of the children were dependent on walkers and the third child was able to walk independently. Their ages were 6, 9, and 11 years. A subluxed left hip was observed in one of the children's X-ray; this patient had received a previous operation to release the adductor and hamstrings. The three patients were selected for selective posterior rhizotomy for the following reasons: (1) spasticity of the lower limbs interfered with their function; (2) there was good trunk control; and (3) the power of the lower limbs, especially the quadriceps and hip extender, was good and allowed sitting or standing without the help of the upper limbs.

Operative technique and intra-operative monitoring

All patients received 2 months of intensive preoperative physiotherapy as part of their assessment. Before the operation, the muscle tone, range of joint movement, functional status, and gait pattern were measured. Each patient was placed in the prone position after having received general anaesthesia, during the induction of which a short-acting muscle relaxant was given. Paired needle electrodes were inserted into the hip adductors, vastus medialis, hamstrings, gastrocnemius, tibialis anterior, and the external anal sphincter. A Nihon-Kohden electroencephalograph (5410K Neurofax; Nihon-Kohden, Tokyo, Japan) was used to record the electromyelogram, while an evoked-potential electromyograph (Dantac Cantata; Medtronic, Copenhagen, Denmark) was used to stimulate the targeted nerves. A high-speed drill and craniotome (Midas Rex Medtronic, Fort Worth [Tex], United States) was used to perform the L2 to S1 laminotomies. The nerve roots of the cauda equina were made fully exposed and the S1 root was identified by its larger size and its response of plantarflexion on electrical stimulation.

Selective posterior rhizotomy required the identification and separation of the posterior from the anterior roots. The latter root usually lies more anterior and is always smaller. The threshold of this root to stimulation is very low—usually from 1% to 5% of that of the posterior root. The nerve root was subdivided into four to six rootlets, and each of them was stimulated in turn by using a modified bipolar-loop forceps. The procedure was repeated from the L2 to S2 roots on both sides. The following criteria were used to select an abnormal nerve rootlet[7]: (1) a low threshold towards single-pulse stimulation; (2) a sustained incremental response to tetanic stimulation which was typically a 50 Hz chain lasting for one second; and (3) the spread of the electromyographic response to the contralateral side. About one third to two thirds of nerve rootlets were regarded as abnormal according to these criteria. Abnormal rootlets were then severed. To avoid the unnecessary weakening of the antigravity muscles around the knee, however, the responses of the L3 and L4 rootlets were evaluated more conservatively.

After surgery, patients were nursed in the lateral or prone position for 2 days. Adequate analgesic therapy and chest physiotherapy were given. Patients were mobilised on the third postoperative day, and daily physiotherapy was given until patients were discharged home—usually on day 14. They continued to receive physiotherapy in their own institution on a daily basis. Home physiotherapy performed by the parents was strongly recommended. The muscle tone, range of joint movement, functional status, and gait pattern were measured at 2 weeks, 3 months, 6 months, and 1 year after the operation, during follow-up at the rhizotomy clinic of the Tuen Mun Hospital. The post-operative assessment was performed by a physiotherapist from the Child Assessment Centre at the Tuen Mun Hospital. Gait analysis was performed for the dependent and independent walkers.

Results

Five selective posterior rhizotomies were performed between December 1996 and July 1997, and the average duration of follow-up was 15 months (range, 12-21 months). The modified Ashworth scale (Box) was used to assess the muscle tone of the hip adductor, quadriceps, hamstrings, and plantar flexor at each patient follow-up visit. There were substantial reductions in muscle tone immediately after surgery, and the tone stabilised within 2 weeks of the operation. There was no further reduction in tone thereafter and no evidence of a return of spasticity in any of the patients. Sustained bilateral ankle clonus, which had been present in four of the five patients, disappeared after surgery. The following measurements were made by using a goniometer: the hip extensor range (the Thomas test); the popliteal angle while the hip was

Modified Ashworth scale

Score	Definition
-1	Hypotonic
0	Normal
1	Mild: slight increase in tone, minimal resistance to movement through less than half of the range
2	Moderate: more marked increase in tone through most of the range of motion but affected part is easily moved
3	Severe: considerable increase in tone, passive movement difficult
4	Extreme: affected part rigid in flexion or extension

at 90°; hip abduction; and ankle dorsiflexion while the knee was flexed. The range of motion improved immediately after surgery, and further improvement was observed after 1 to 2 weeks, by which time wound pain and nerve root irritation had subsided. Improvement continued until a plateau was reached within 3 to 6 months of surgery.

The range of motion of all joints except the hip abductor showed significant improvement after 1 year of the operation (Table 1; $P<0.05$). The tone of the hamstrings and the ankle plantar flexor also showed a significant reduction after 1 year (Table 2; $P<0.05$). Although the power of the lower limbs was weaker after surgery, normal strength returned after 2 to 3 months.

Table 1. Range of motion at 1 year post-rhizotomy

Muscle group	Score		P value
	Pre-operative	Post-operative	
Left Thomas test	15	10	0.04
Right Thomas test	15	10	0.04
Left abductor	15	45	0.08
Right abductor	17	45	0.08
Left popliteal angle	30	60	0.04
Right popliteal angle	40	57	0.04
Left ankle dorsiflexion	10	30	0.04
Right ankle dorsiflexion	10	28	0.04

Table 2. Muscle tone at 1 year post-rhizotomy

Muscle group	Score		P value
	Pre-operative	Post-operative	
Left adductor	3	0	0.07
Right adductor	3	0	0.07
Left quadriceps	2	1	0.10
Right quadriceps	2	1	0.08
Left hamstring	3	0	0.04
Right hamstring	3	0	0.04
Left plantar flexor	3	1	0.04
Right plantar flexor	3	1	0.04

The level of patient locomotion was unchanged by the selective posterior rhizotomy. One of the dependent walkers could stand and walk independently for 30 seconds; these actions which had not been possible before the procedure. The exercise tolerance of all five patients improved: they could walk a longer distance and for a longer period of time. In addition, all patients could walk more quickly and the abnormal gait patterns such as scissoring, an absent heel strike, or the lack of the hip and knee extension were less obvious. Gait analysis was performed for the independent walker and showed a 62% increase in the walking velocity (from 0.730 m/s to 1.018 m/s) and an increase of 38% in stride length (from 0.900 m to 1.024 m) at 3 months after surgery.

The only postoperative complication was mild fever. Lower-limb sensation (pain and touch) was preserved and proprioceptive sensation tests of the three diplegic patients gave normal results. Lower-limb hyporeflexia was common after the selective posterior rhizotomy. Patients reported that they felt more comfortable after the operation and had better mood and concentration, and all parents reported that they were satisfied with the results.

Discussion

Two groups of patients with cerebral palsy would most likely benefit from selective posterior rhizotomy. The first group includes severely affected spastic quadriplegic patients for whom daily care and handling would be facilitated by a reduction in spasticity. These patients should not have any dystonic features, truncal hypotonia, or multiple joint contracture. The second group comprises primarily patients with spastic diplegia who have some ambulatory skills but are disabled by spasticity. These candidates should have good trunk control and the power of their antigravity muscles should be strong; their posture and movement patterns usually improve after rhizotomy. Improvements, however, do not come automatically. Rhizotomy merely helps to remove the disabling spasticity. Improvements in strength and in the ability to control and coordinate movement patterns require a longer period of learning, which involves motivation and intensive postoperative physiotherapy.

The lower limbs of the two quadriplegic patients in this study were in severe or extreme spasm before the rhizotomy. Their tone and range of motion improved immediately after surgery. As the period of follow-up was short, the long-term outcome is unknown. Some long-term follow-up studies have shown that tone reduction can be maintained and, in majority of patients, the motor function continues to improve.[8,9] The degree of spasm in the three spastic diplegic patients before the rhizotomy was less, and lower-limb function was improved after treatment. The independent walker of the group now walks at a higher velocity and with a longer stride length owing to the reduction in muscle tone of the hip, knee, and ankle, which allow better joint alignment and foot clearance.

Patients and their parents were interviewed in the rhizotomy clinic before the operation, and the possible perioperative complications and long-term adverse effects were explained. Perioperative complications of fever, bronchospasm, pneumonia, urinary tract infection, urine retention, ileus, sensory loss and postoperative pain have been reported[10]; cerebral spinal fluid leakage, although rare, is another concern. Spinal deformity (such as scoliosis, kyphosis, and lordosis) and hip dislocation are possible longer-term complications. Spondylosis has been detected in 9% of reported cases and is more common among the operated group than children with cerebral palsy.[11] Backache is also common after multiple-level laminectomy. The current trend, however, is to minimise this complication by replacing the laminae after laminotomy.

In conclusion, we have performed selective posterior rhizotomy in five selected patients, and the results of the surgery were good. Neurosurgeons should cooperate with paediatricians, orthopaedic surgeons, physiotherapists, occupational therapists, speech therapists, and developmental psychologists to form a team that can treat patients with cerebral palsy who have spasticity.

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