Lesions in the central nervous system can produce abnormal upper-limb function patterns secondary to spasticity, with variable degrees of flaccid paralysis and paresis, general neurological disorders, and disturbances in hand sensibility. Several surgical alternatives for treatment of spasticity have been proposed: soft-tissue release, tendon lengthening, bone surgery, neurectomy, and posterior rhizotomy. Posterior rhizotomy for relief of spasticity was first reported in 1908 by Foerster, although he credited Monro with performing similar work as early as 1904. For some reason, Foerster’s method remained unpopular until 1967, when Gros, et al., published their results on partial posterior rhizotomy. There has been a major resurgence of interest in this procedure during the past 10 years. However, this mode of treatment has been used almost exclusively in the lower limbs.

Foerster stated that the effect of posterior rhizotomy on spasticity was likely to be better in the lower than in the upper limb. He also proposed treating upper-limb spasticity with dorsal rhizotomy of C4–T2, preserving C-6, or alternatively with partial dorsal rhizotomy of all the aforementioned roots. We demonstrated in rats that the proprioceptive neurons are located at the same level of the motor neuron pool. Based on this anatomical knowledge, in the present study, when the patient’s shoulder and elbow were observed to be spastic on clinical examination, the C-5 and C-6 dorsal roots were completely divided. When the wrist and fingers were spastic, C-7 and C-8 dorsal rhizotomies were performed.

To our knowledge, no clinical series of brachial plexus dorsal rhizotomy for the treatment of upper-limb spasticity has been published. In this report, 15 selected spastic upper limbs were treated surgically and studied prospectively. The effects of dorsal rhizotomy on upper-limb spasticity and functional improvement were evaluated. Also, the effects on limb coordination and hand sensibility were assessed.

Clinical Material and Methods

Patient Population

Thirteen patients with 15 spastic upper limbs were selected to undergo brachial plexus dorsal root section. Eleven of these patients had normal intelligence. The other two had some reduction in intelligence but, for the most part, were able to understand and obey orders, and they were therefore included in this study. Five patients suffered from CP, six had head trauma, and two had suffered a stroke. Four children with an average age of 6 years and

Key Words • brachial plexus • spasticity • rhizotomy • dorsal root section

Abbreviations used in this paper: CP = cerebral palsy; SD = standard deviation.
nine adults with an average age of 29.9 years underwent operation (Table 1). Spasticity was assessed based on the Ashworth scale.\textsuperscript{2} When the shoulder was involved, adduction contracture was observed in all but one patient, who presented with an abduction posture. This particular patient with spastic dystonia presented with sustained involuntary shoulder abduction and elbow flexion movements. In the patients with adduction posture, five had no voluntary abduction, whereas the remainder had an average voluntary abduction of 60˚ (SD ± 12˚). The elbow was flexed with no voluntary extension in all affected patients, except in three who had an average arc of motion of 100˚ (SD ± 11˚). The wrist was flexed in all patients whose hand was affected, but no active extension was observed. Six patients were capable of active finger extension when the wrist was flexed. Voluntary finger flexion was observed in 10 cases. No patient was able to release an object easily after grasping it. Eight patients presented with muscle and articular contractures. The shoulder was contracted in three cases, the elbow in five, the wrist in seven, and the digits in three. Contractures were easily observed after induction of general anesthesia and limb mobilization, just before surgery.

Hand sensibility was assessed by examination of each digit by light touch alone, light touch plus questioning the patient as to which digit was touched, painful stimulation, and two-point discrimination. Painful stimuli and light touch were detected by all patients except one, and these were detected on the radial side of the hand only. Four patients were not able to discriminate which digit was touched. Four patients were able to discriminate touch at two points less than 10 mm apart in all digits. These patients had normal sensibility that was comparable to the unaffected contralateral hand; they also had normal cognition, which allowed adequate evaluation. Pain during limb motion was observed in eight patients, clonus elicited by passive or active elbow extension was observed in two, spastic dystonia in one, and hand athetosis in five. All patients with hand athetosis were capable of voluntary digital extension. However, they were unable to keep their digits extended for more than 3 seconds.

Two patients presented with spastic tetraplegia and nine with hemiplegia. Among the latter patients, the left side was affected in four and the right side in five. Two patients were not able to walk and seven could walk with the help of crutches. Speech difficulties were observed in four patients.

In the postoperative period, the minimum follow-up time was 12 months, the mean follow-up period was 15.6 months, and the maximum period was 30 months. All patients were videotaped for comparison of spasticity before and after surgery.

Two major complications are likely to arise after dorsal rhizotomy: limb ataxia and limb anesthesia. We have performed brachial plexus dorsal rhizotomy in rats and have observed that, even when the C4–6 nerves were cut, the rats recovered normal behavioral elbow and shoulder function by 35 days postsurgery.\textsuperscript{4} This was confirmed in a patient with intractable upper-limb pain who was referred to us and who had undergone more than 20 surgical interventions for neurolysis, neurectomy, and tenolysis. Based on our experimental studies, we performed C4–7 dorsal rhizotomy for pain relief. Limb ataxia was observed only on the 1st and 2nd days postsurgery, and no complete hand anesthesia was found (unpublished observations).

With regard to hand anesthesia after rhizotomies, we knew from our use of the contralateral C-7 root in brachial plexus repair that its section did not lead to any permanent sensorial dermatome disturbance.\textsuperscript{5} However, we were still afraid of producing hand anesthesia if a second dorsal root was sectioned. Our first two clinical cases were patients with hand spasticity for which C-7 and C-8 dorsal root sections were indicated. In previous studies of avulsion injuries of the brachial plexus in animals, we demonstrated forepaw sensory recovery after median nerve repair, which was achieved by direct introduction of peripheral nerve grafts into the contralateral C-7 dorsal root ganglion.\textsuperscript{6} Based on these observations, these two patients underwent surgery in which C-7 and C-8 dorsal roots were sectioned. Two cables of 8-cm-long sural nerve grafts were harvested, introduced into the contralateral C-7 dorsal root ganglion, and connected to the rhizotomized C-7 root distal to its ganglion. Only moderate numbness of the hand was observed immediately postsurgery, and in the following weeks, sensory perception recovered to normal. Therefore, the dorsal root grafting procedure was abandoned (these two clinical cases were not included in this study). In the next patient, a third dorsal root section was performed and partial section of a fourth dorsal root was added. No complete hand anesthesia was observed. Finally, in an appropriate case, a complete four-level dorsal root section was performed.

\textbf{Surgical Technique}

After induction of general anesthesia, the patient was placed prone with the head in a Mayfield pin head-holder. A midline incision was made across the cervical region. The spinous process of C-7 was located and its appearance confirmed on fluoroscopic examination. A two- or three-level hemilaminectomy was performed in 11 patients. A three-level laminectomy was performed in one adult pa-

\begin{table}[h]
\centering
\caption{Clinical characteristics and treatment of 15 spastic upper limbs in 13 patients*}
\begin{tabular}{|c|c|c|c|c|}
\hline
Case No. & Age (yrs) & Cause of Spasticity & \begin{tabular}{c} Spasticity Grade† \\
Grade 1\end{tabular} & Rhizotomy \\
\hline
1 & 22, F & CP & E3, W4, H4 & C7–8 \\
2 & 50, M & stroke & S5, E4, W5, H5 & C-5, C7–8 \\
3 & 31, M & stroke & S4, E3, H4 & C5–8 \\
4 & 17, M & CP & S4, E5, H4 & C6–8 (partial) \\
5 & 23, M & CP & W4, H4 & C7–8 \\
6 & 8, M & HT & W4, H4 & C7–8, T-1 \\
7 & 6, M & HT & H3 & C7–8 \\
8 & 21, F & CP & H3 & C7–8 \\
9 & 27, M & HT & S5, E (AD), W5, H4 & C-5, C7–8 \\
10 & 34, M & HT & S5, E4, W5, H5 & C4–6 (partial), C7–8 \\
11 & 4, M & CP & S3, E5, W5, H3 & C6–8 \\
12 & 47, M & HT & S5, E5, W5, H5 & C5–8 \\
13 & 27, M & HT & S5, E5, W5, H5 & C5–8 \\
\hline
\end{tabular}
\end{table}

* AD = arthrodesis; E = elbow; H = hand; HT = head trauma; S = shoulder; W = wrist.
† Numbers indicate spasticity grade according to the Ashworth scale.
tient for bilateral rhizotomy. An en bloc laminectomy and replacement was performed in a 4-year old boy with bilaterally involved upper limbs. After duraotomy, the dorsal roots were identified with the aid of a surgical microscope and were then coagulated and sectioned; major feeding arteries were always preserved. The dura mater was closed with a watertight seal. The muscle and fascial layers were reapproximated and the skin was closed.

When a hemilaminectomy was performed, no immobilization was used postoperatively. The patient who underwent a laminectomy wore a cervical collar for 2 weeks, and the patient who underwent replacement laminectomy was immobilized for 8 weeks postoperatively. The hospital stay lasted 2 to 3 days for the patients who underwent hemilaminectomy and 5 days for those who underwent laminectomy.

Results

Postoperative Findings

Spasticity. The degree of spasticity was reduced in the shoulder, elbow, and hand in all patients on Day 1 postsurgery. After surgery, patients were categorized as Ashworth Grade 1 or 2. These grades remained stable throughout the postoperative period.

The digital flexor reflex, which was elicited after cutaneous palmar stimulation and was partly responsible for the inability to release an object, disappeared in all patients. Recurrence of hand spasticity, but not elbow or shoulder spasticity, was noted at 3 months postsurgery in only one patient. Involuntary movements of the shoulder and elbow were greatly reduced in patients with spastic dystonia.

Functional Recovery. No patient lost presurgery movement ability and no patient presented with an ataxic limb.

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Motion was observed equally with the patient’s eyes open or closed. Active abduction was observed in the shoulder in all patients; an average gain of 118˚ (SD ± 27˚) was observed. In the elbow, full range of motion was observed in all patients except three. In these cases, a 101˚ (SD ± 11˚) arc of motion was recovered. In the hand, a gain of 20˚ (SD ± 7˚) of dorsal wrist extension was observed in five patients, and a gain of 45˚ (SD ± 11˚) of digital extension was observed in five. Four patients were capable of active digital extension with the wrist in the neutral position.

Recovery was very fast for the shoulder and elbow, beginning on Day 1 postsurgery and stabilizing by the 3rd month. For the hand, recovery was much more prolonged, with no stabilization observed before the 6th month postsurgery. Improvement in hand function was observed as late as 9 months postsurgery in one patient. Six patients regained the ability to perform normal daily activities with both hands. These patients were the ones who had exhibited good finger extension before surgery. Such improvements were also observed in patients who did not have normal hand sensibility before surgery.

Sensory Evaluation. Even after extended dorsal root section such as that from C-5 to C-8, total or partial hand anesthesia was not observed (Table 2). In the immediate postoperative period, disturbances in two-point discrimination were observed in all patients but not perception of pain and light touch. Two-point discrimination was recovered between 3 and 9 months postsurgery. In patients who underwent four-level dorsal root section in upper limbs, light touch and pain sensibility were preserved. However, in these particular patients, the recovery of two-point discrimination could not be assessed because they did not have this ability preoperatively. No patient suffered deafferentation pain. Joint-position sense was preserved in all patients. No patient reported sensory disturbance.

Contractures. No patient needed surgical release of articular contractures; all were treatable by serial cast placement alone. However, recurrence of wrist and digital contractures was observed in two patients who were not able to perform active wrist and digital extension pre- and postoperatively. All patients who presented with articular contractures were the ones who experienced pain when the limb was mobilized. In these patients, pain exacerbated the spasticity. The first cast was applied during surgery, and limb mobilization was possible without pain postoperatively. Pain was perceived only when the joint was stretched to apply a second cast. One patient in whom a C5–8 dorsal rhizotomy was performed reported severe pain in the hand on Day 2 postoperatively. The cast was opened and the pain subsided immediately. This indicated that protective sensation was preserved, even in extended dorsal root sections.

Athetosis. After surgery, patients were able to keep their hands open longer (5–10 seconds). One patient, by touching his thumb with the contralateral unaffected hand, was able to inhibit digital athetosis and keep his hand open for as long as he wanted. In one patient, a dramatic improvement in athetosis was observed 9 months postoperatively. This was related to improvement in the hand’s intrinsic muscle function. In this particular patient, when digital extension was attempted before surgery, the metacarpopha-

### Table 2

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Hand Sensibility</th>
<th>Postop Evaluation (mos) Rhizotomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P, LT, 4 mm</td>
<td>P, LT, 4 mm 30 C7–8</td>
</tr>
<tr>
<td>2</td>
<td>P, LT(R)</td>
<td>P, LT(R) 24 C5, C7–8</td>
</tr>
<tr>
<td>3</td>
<td>P, LT</td>
<td>P, LT 12 C5–8</td>
</tr>
<tr>
<td>4</td>
<td>P, LT, 5 mm</td>
<td>P, LT, 9 mm 13 C5–8 (partial)</td>
</tr>
<tr>
<td>5</td>
<td>P, LT</td>
<td>P, LT 14 C7–8</td>
</tr>
<tr>
<td>6</td>
<td>P, LT</td>
<td>P, LT 12 C7–8, T-1</td>
</tr>
<tr>
<td>7</td>
<td>P, LT</td>
<td>P, LT 13 C7–8</td>
</tr>
<tr>
<td>8</td>
<td>P, LT, 7 mm</td>
<td>P, LT, 7 mm 12 C7–8</td>
</tr>
<tr>
<td>9</td>
<td>P, LT, 6 mm</td>
<td>P, LT, 6 mm 18 C5, C7–8</td>
</tr>
<tr>
<td>10</td>
<td>P(R), LT(R)</td>
<td>P(R), LT(R) 21 C4–6 (partial), C7–8</td>
</tr>
<tr>
<td>11</td>
<td>P, LT</td>
<td>P, LT 15 C6–8</td>
</tr>
<tr>
<td>12</td>
<td>P, LT</td>
<td>P, LT 15 C5–7</td>
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<tr>
<td>13</td>
<td>P, LT</td>
<td>P, LT 12 C5–8</td>
</tr>
<tr>
<td>14</td>
<td>P, LT</td>
<td>P, LT 12 C5–8</td>
</tr>
</tbody>
</table>

* LT = light touch; P = pain sensibility; R = radial side of hand.
† Numbers indicate the distance for two-point discrimination, which could not be assessed in Cases 2 and 11 because of cognitive or speech impairment.

Preservation of hand sensibility according to extent of rhizotomy in 13 patients with upper-limb spasticity*
Spasticity and brachial plexus dorsal rhizotomy

Fig. 1. Case 1. Photograph showing preoperative spasticity in the patient's hand.

Langeal joint hyperextended, resulting in claw hand. After surgery the patient was capable of complete digital extension without metacarpophalangeal hyperextension.

Clonus. This condition disappeared completely and permanently.

Secondary Gains. Improvement in speech was observed in two patients who required the assistance of family members to communicate during the initial evaluation; this assistance was not necessary postsurgery. Improvement in walking was observed in seven patients, who were able to walk without crutches after surgery (independent household ambulators). These data were not precisely evaluated before surgery because such gains were unexpected.

Surgery-Related Complications

No infection or cerebrospinal fluid fistulas were observed. After surgery, neck pain was constant but controlled in all patients. Children were free of pain by the end of the 1st week, whereas adults achieved this status only by the end of the 2nd week. Cervical x-ray films obtained 12 months postsurgery demonstrated no instability.

Illustrative Cases

Case 1

History and Examination. This 22-year-old woman who suffered from CP sought help for a spastic left hemiplegia. On inspection we noted a 45° flexion deformity in her elbow. Her forearm was completely pronated and her wrist was completely flexed. She was able to extend and flex the elbow actively over a range of 60°. Shoulder abduction and external rotation was limited to 45°. Active supination and wrist extension were not observed, but active digital extension and flexion were noted. She was able to grasp but not release round objects 3, 6, or 9 cm in diameter. Voluntary and phasic contractions were observed after palpation of the triceps, biceps, wrist extensors and flexors, and digital extensors and flexors. This was later confirmed on electrophysiological evaluation. Spasticity in her elbow was rated Grade 3, and in her wrist and digital flexors it was rated Grade 4, according to the Ashworth scale (Fig. 1). An overactive stretch reflex with clonus was present in the digital and wrist flexors. Passive wrist extension was impossible and, when tried, was very painful (8 on a scale of 1–10). Slight digital athetosis was noted.

Hand sensibility was preserved, with two-point discrimination of 4 mm on her thumb, index, and little finger. Nociception was also preserved according to assessment with the pinprick test. When asked to compare her hand sensibility to the contralateral hand, the patient was aware of no deficit. In the preoperative assessment, the patient’s upper limb was useless. No visual, hearing, or speech deformities were identified. The patient was very intelligent and emotionally stable, and was engaged in university studies.

Operation. The patient was very motivated, and we decided to perform dorsal root sections of C-7 and C-8, which are responsible for the spastic muscles involved.

Postoperative Course. After surgery, spasticity was rated as Ashworth Grade 1 for the patient’s digits, shoulder, and elbow and Grade 2 for her wrist. The patient reported numbness in her ring and little finger, although she perceived light touch and pain in her whole hand. Two-point discrimination was observed on the radial side of her hand but not on the tip of her little finger. Nine months later, two-point discrimination perception of 4 mm was demonstrated in her whole hand.

No recurrence of spasticity was observed during the postoperative period, and clonus disappeared. Full arc of motion was observed in her shoulder and elbow, and 160° of pronosupination was recovered. Full digital extension and flexion were also observed. Active wrist extension to the neutral position was recovered; however, her wrist remained in the flexed posture, and by the 9th month postsurgery the flexor carpi ulnaris was transferred to the radial wrist extensors. Postoperatively, 20° of dorsal wrist extension was observed. Three years after dorsal rhizotomy, no recurrence of spasticity was demonstrated. For the most part, the patient was able to grasp and release an object 3, 6, or 9 cm in diameter. Hand motion was pain free and her hand was usable for daily tasks (Fig. 2).

Case 13

History and Examination. This 27-year-old man, who had suffered a head trauma at the age of 25 years, sought treatment. His entire left and right upper limbs were spastic. His shoulders were permanently adducted, both elbows were completely flexed, his wrists were in the neutral position, and his fingers were completely flexed (Fig. 3 upper). Spasticity was observed also in his lower limbs. His shoulders, elbows, and wrists were rated Grade 5, and his right and left hands were Grades 5 and 3, respectively, on the Ashworth scale. Active movement was observed.
only in the finger flexors and extensors. The digital arc of motion was 20° of flexion/extension for his right hand. Although voluntary contractions were perceived in the flexor and digital extensor muscles, there was no active digital motion on his left side because of contractures. When passive mobilization was attempted, severe pain was elicited. The patient was confined to bed. His hand sensibility was not normal, although he perceived pain and light touch throughout his whole hand. However, the patient was not able to discriminate two points. No visual or hearing problems were observed, but speech difficulties were identified, although he had normal cognition.

Operation. The patient underwent an operation in which bilateral dorsal rhizotomy of the C5–8 nerve roots was performed. His shoulder was mobilized during surgery, and mobilization followed by cast placement was used for both elbows. In the postoperative period, spasticity in his shoulder, wrist, and elbow was categorized as Ashworth Grade 1. Three weeks postsurgery, the patient was reanesthetized, both elbows were mobilized, and a second cast was applied. Soft-tissue release was performed in his right lower limb, and 2 weeks later the casts were removed.

Postoperative Course. At 12 months postsurgery, sensibility was the same as it had been preoperatively. Active shoulder abduction was 160° on his right side and 130° on his left. The active arc of motion of both elbows was 140°. Active wrist extension was 40° on his right side and 20° on his left. Wrist flexion was 50° and 40° for his right and left sides, respectively (Fig. 3 lower). He was capable of full digital active motion on his right side and demonstrated complete finger motion for the first, second, and third digits on his left. Motion was not observed in his remaining digits because of soft-tissue contractures; soft-tissue release is currently indicated. Upper-limb motion was free of pain. No recurrence of spasticity was observed. The patient was able to use both hands for basic daily activities. Improvement in speech and reduction in lower-limb spasticity were also observed.

Discussion

Dorsal root section was very effective in the treatment of upper-limb spasticity. Recurrence was observed in only one patient, and this patient was the second to undergo surgery. He had sensibility only on the radial side of his hand (C-6 dermatome). He also demonstrated strong biceps spasticity. In this case, section of the C-6 dorsal root was indicated; however, this was not performed because we were afraid of completely losing the hand’s sensibility. The same condition was not observed in the remaining cases; that is, the same root was cut and no hand anesthesia was observed. The flexor reflex elicited by cutaneous stimulation of the hand was abolished permanently in all patients except for the patient who presented with some recurrence in spasticity. This represents a great improvement in hand function, allowing patients to release an object.

Functional improvement was demonstrated in all patients with spastic shoulders and elbows. Their recoveries were fast, beginning on the day after surgery and finishing by the 3rd month. Functional recovery of the hand was also demonstrated, but it was clearly related to the presence of voluntary contraction of finger extensors before surgery. Several patients are now candidates for tendon transfer. After surgery, six patients became able to use both hands in daily tasks.

No patient presented with an ataxic limb after surgery. The effects of dorsal root section on limb control has been extremely controversial. In fact, the delays in most sensory loops are long, making feedback control too slow for rapid movement. The notion of an internal model, a system that mimics the behavior of a natural process, has now emerged as an important theoretical concept in motor control. The cerebellum is the proposed site for this model.

Another interesting aspect of this study is preservation of hand sensibility, even after C5–8 dorsal root section. Sensitivity to light touch and pain were demonstrated on the 1st day postsurgery, although recovery of two-point discrimination took a few months. This indicates that light touch and pain sensation in the hand may be conducted along other afferent pathways, such as adjacent cervical and thoracic dorsal roots or the brachial plexus ventral root. It is well established that mammalian ventral spinal roots contain a large number of unmyelinated fibers that are sensory in function. Hovelacque long ago demonstrated communicating branches between adjacent dorsal roots. The recovery of two-point discrimination probably involves some kind of plasticity. Deafferentation after peripheral nerve section and dorsal root section have been shown experimentally to be different. Certainly, the sensorial deficit after a dorsal root section is much less pronounced. Transection of the nerves results in the degeneration of neuron processes distal to the cell bodies in the dorsal root ganglia. In dorsal rhizotomies, the proximal processes of neurons degenerate, resulting in vacated synaptic space, thereby creating more favorable conditions for the growth of the remaining axons in the spinal cord and cuneate nucleus. Laitinen, et al., have also observed in their clinical case that cutaneous and joint sensation remained unchanged after C6–8 posterior rhizotomy. Foerster stated that if only the fifth to eighth cervical and...
Spasticity and brachial plexus dorsal rhizotomy

first and second thoracic roots are divided, the whole arm does not become anesthetic. As quoted by Foerster in the same work, Clark, Taylor, and Hildebrand demonstrated that the division of four or even five adjacent thoracic roots produces no apparent disturbance of sensibility. Using retrograde labeling studies, we have demonstrated in rats that the lateral side of the forearm is innervated by four roots and the ventral side of the forepaw by at least five roots.7 Of interest is the preservation of hand sensibility in tetraplegic patients with upper cervical spinal cord lesions.14 In these patients, the level of motor palsy does not correlate with the level of sensory loss, which is in general preserved distally.10 We do not have a clear explanation as to why sensibility was preserved after dorsal root section, and therefore more experimental and clinical studies are needed. However, we would do well to remember the words of Sir Thomas Lewis who pioneered the study of pain: “If ever you observe a conflict between an observation that you have made and a theory you have learned, always trust your observation and be prepared to question the theory. A careful observation is always valid. Never deny an observation because it does not seem to fit a theory.” These words have recently been quoted in the medical literature by Paul Brand.8

Secondary gains in speech and lower-limb spasticity have been observed in our study. This is in agreement with other reports of speech improvement and reduction of upper-limb spasticity after dorsal rhizotomy of the lumbo-sacral plexus.11,12 Feinberg21 and Benedetti et al.3 have suggested that the cervical spinal cord is an area with a high density of proprioceptive impulses. The activity in this area, sustained by the afferents of the cervical dorsal roots, would increase the muscular tone of all four limbs. Speech improvement after dorsal rhizotomy has been related to the ephoristic state that occurs after surgery.11

For spasticity in the lower limb, many investigators have used electrical stimulation to selectively cut the presumably involved dorsal root. However, there has not been a consensus of criteria for the electrical parameters used, and the usefulness of this procedure has been questioned.5,10,12,25,30,32,33 Even when electrophysiologically affected rootlets are preserved, good results can be obtained.27 Recurrence of spasticity after dorsal rhizotomy off the lower limb has prompted some authors to curtail the treatment of upper-limb spasticity and leads to some functional improvement. We suggest dorsal rhizotomy from C-5 to C-7 in the spastic shoulder and elbow. If the hand is also involved, C-8 dorsal rhizotomy should be added. If only the hand and wrist are involved, C-7 and C-8 rhizotomies should be performed. Dorsal rhizotomies should be performed before any orthopedic procedure, because contractures can be relieved by cast placement, and spasticity and movement normally improve. The shoulder and elbow rarely need any other modality of treatment, whereas the hand and wrist may benefit from later tendon transfers and/or tendon lengthening.

Conclusions

Brachial plexus dorsal rhizotomy is very effective in the treatment of upper-limb spasticity and leads to some functional improvement. We suggest dorsal rhizotomy from C-5 to C-7 in the spastic shoulder and elbow. If the hand is also involved, C-8 dorsal rhizotomy should be added. If only the hand and wrist are involved, C-7 and C-8 rhizotomies should be performed. Dorsal rhizotomies should be performed before any orthopedic procedure, because contractures can be relieved by cast placement, and spasticity and movement normally improve. The shoulder and elbow rarely need any other modality of treatment, whereas the hand and wrist may benefit from later tendon transfers and/or tendon lengthening.

References

34. Tierney LM, McPhee SJ, Papadakis MA: Current Medical Diagnosis and Treatment. Stamford, CT: Appleton & Lange, 1995

Manuscript received April 1, 1999.
Accepted in final form January 28, 2000.
This paper was presented at the 10th Congress of the Brazilian Society of Reconstructive Microsurgery, November 26 to 28, 1998, Rio de Janeiro, Brazil; at a symposium on brachial plexus surgery, March 13 to 14, 1999, Barcelona, Spain; and at the 22nd Annual Meeting of the Group for Advancement of Microsurgery, April 30 to May 1, 1999, Paris, France.
Address reprint requests to: Jayme Augusto Bertelli, M.D., Ph.D., Praça Getulio Vargas, 322, Florianopolis, SC, Brazil, 88020030. email: bertelli@matrix.com.br.