Selective Dorsal Rhizotomy for Posttraumatic Spasticity: A Prospective Case Series

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Abstract

Background Spasticity following traumatic brain injury or spine injury is disabling and sometimes resistant to oral antispastic medications. It is painful and may lead to joint contractures. Selective dorsal rhizotomy, which is traditionally used in children with cerebral palsy, has limited evidence in posttraumatic spasticity.

Objective To evaluate the safety and efficacy of combined cervical and lumbar selective dorsal rhizotomy in patients with severe posttraumatic quadriparetic spasticity.

Methods This was a prospective case series that included six patients (mean age 25 ± 12.6 years; four males and two females) with drug-refractory quadriparetic spasticity following severe traumatic brain injury or cervical spine injury. The patients underwent cervical (C4–T1) and lumbar (L2–S2) dorsal rhizotomies under intraoperative neuromonitoring. Outcomes were assessed using the modified Ashworth scale (MAS), modified Rankin scale (mRS), reduction in antispastic drugs, functional gains, and complications, with follow-up to 12 months.

Results All patients showed significant reduction in spasticity (mean MAS 3.16 ± 0.75 preoperatively to 0.5 ± 0.54 postoperatively; $p = 0.03$). Functional disability improved (mean mRS 4.83 ± 0.37 to 2.67 ± 1.03; $p = 0.03$), with four patients achieving supported standing or ambulation. Drugs were reduced in all patients; one discontinued baclofen entirely. Two patients suffered pseudomeningoceles (resolved with conservative measures), one had transient weakness, and three patients had transient sensory symptoms.

Conclusion Cervical and lumbar selective dorsal rhizotomy is a safe and effective option for refractory posttraumatic spasticity. It provides durable reduction of tone, improvement in functions, and reduction in drugs.

Keywords
- quadriplegia
- rehabilitation
- rhizotomy
- spasticity
- spine injury
- traumatic brain injury

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Introduction

Spasticity is characterized by a velocity-dependent increase in muscle tone following upper motor neuron insult. Hypertonicity arises due to an imbalance between excitatory and inhibitory inputs to α motor neurons in the spinal cord, following trauma, stroke, or demyelinating disease.[1,2] Spasticity frequently leads to pain, contractures, impaired mobility, and significant disability. It can also lead to impaired daily activities and excessive caregiver responsibilities. While treatments such as physiotherapy and oral antispastic agents are helpful, not every patient experiences adequate relief.

Selective dorsal rhizotomy (SDR) is a surgical procedure wherein the sensory (dorsal) roots entering the spinal cord are selectively cut. Traditionally, SDR is primarily used for children with cerebral palsy and has not been widely utilized for spasticity secondary to traumatic brain injury (TBI), spinal trauma, or other acquired central nervous system insults.[3] Alternate treatment to SDR includes a baclofen pump; however, it carries limitations of lifelong device maintenance, pump refills, and surgical revision.[4,5] SDR is thus an intervention that is a single-time surgery and avoids the need for lifelong device management.

Performing both cervical and lumbar SDR is needed to target spasticity affecting all four limbs after a diffuse or high-level brain or spinal trauma. Cervical SDR addresses upper limb involvement, whereas lumbar SDR is needed for lower limbs. However, there remains a significant gap in evidence regarding optimal surgical technique, patient selection, and long-term outcomes for SDR in posttraumatic cases. This manuscript evaluates the application of cervical and lumbar SDR for patients with severe quadriparetic spasticity following posttraumatic brain and spine injury. It reports the surgical technique, patient selection, and outcomes.

Materials and Methods

A prospective, observational case series was conducted at the Department of Neurosurgery, NSCB Medical College, Jabalpur, India, enrolling patients from January 2022 to March 2024. The study received ethical approval from the institutional review board, and all participants (or their guardians) provided informed consent.

The inclusion criteria were (1) age group from 8 to 75 years, (2) history of moderate-to-severe head injury with subsequent development of quadriparetic spasticity, (3) modified Ashworth score ≥ 2 in at least three limbs, (4) failure of maximal tolerated doses of oral antispastic drugs (e.g., baclofen) over at least 6 months. The exclusion criteria were (1) medically unfit for surgery, (2) spasticity adequately controlled on oral agents, (3) severe fixed contractures or joint deformities precluding meaningful improvement with rhizotomies.

Preoperative Assessment

A detailed neurological and functional assessment was done based on modified Ashworth scoring for tone, Medical Research Council grading for power, sensory examination, degree of disability on modified Rankin scale (mRS), and magnetic resonance brain and spine imaging. All patients underwent extensive physiotherapy/rehabilitation before surgery to confirm the resistant cases.

Surgical Technique

Under general anesthesia with avoidance of muscle relaxants, the patients were positioned prone, as shown in ►**Fig. 1**. Needle electromyography was utilized for intraoperative neuromonitoring. The spinal level for SDR (lumbar, cervical, or both) were selected based on the distribution of spasticity and functional deficits.

A midline laminectomy was made over cervical C3–T1 levels and lumbar L2–S1 levels. Magnification and illumination were utilized using an operating microscope or an exoscope (Karl Storz, Tuttlingen, Germany). The dura was exposed and opened in the midline after conducting good hemostasis. The arachnoid over the dorsal roots was carefully cut to free the roots from the cord (►**Fig. 2**). In the cervical region, the dentate ligament separates dorsal and ventral roots. At the lumbar level, the dorsal and ventral rootlets travel and exit together from the neural foramen. These are separated near the neural foramen by a blunt hook and stimulated for confirmation. The stimulation is done at 1 mA current. At higher levels of current, both dorsal and ventral rootlets give muscle contractions, which may lead to confusion. The dorsal rootlets in both cervical and lumbar levels were selectively coagulated (►**Fig. 3**) and sectioned

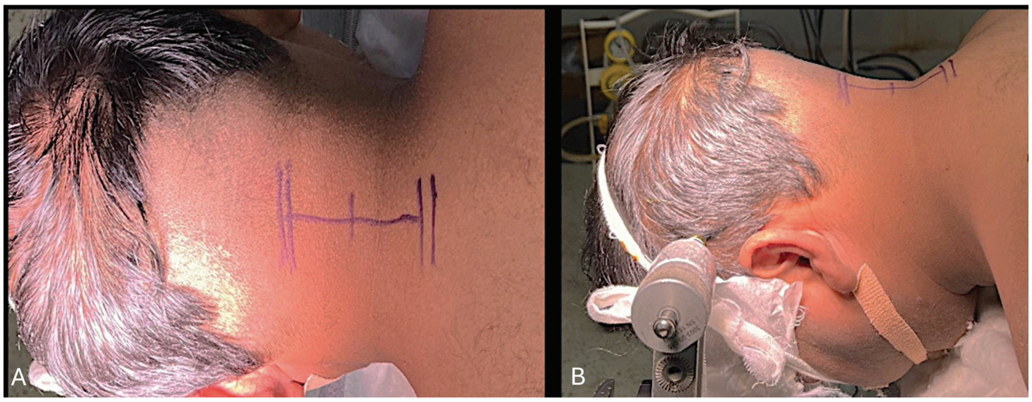

Fig. 1 A and B showing the positioning and incision of the patient.

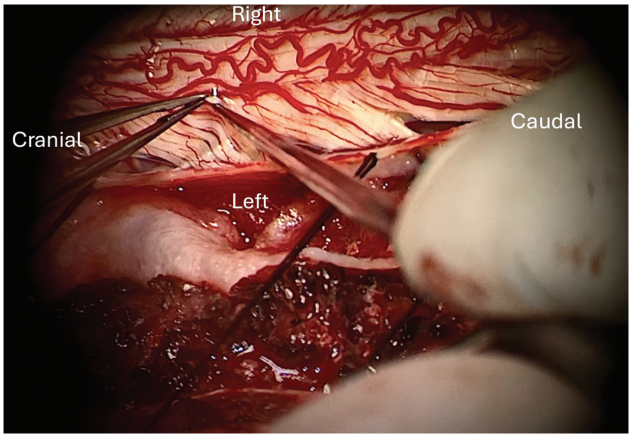

Fig. 2 The orientation of the patient with the surgeon standing on the left of the patient. One of the cervical dorsal rootlets has been lifted with a blunt hook after confirming with a neuromonitoring device.

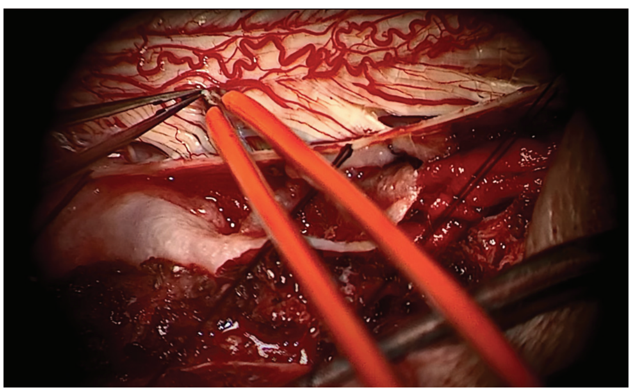

Fig. 3 The rootlet is being coagulated.

(►**Fig. 4**), ranging from 50 to 70% based on mapping. Around 2 mm of rootlet was excised to prevent the regrowth of the cut ends. The dura was closed primarily and wound was closed in layers over a suction drain.

Postoperative Care and Follow-up

All patients underwent physiotherapy after the surgery. The rehabilitation encompassed stretching, voluntary movement training, and gait (whenever possible). Outpatient follow-up occurred at regular intervals till 12 months with repeat assessments of spasticity, functional status, and adverse outcomes.

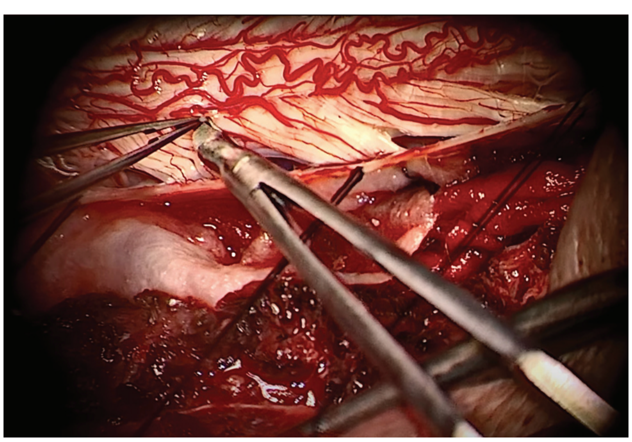

Fig. 4 The rootlet is being divided with a microscissor. About 2 mm of the rootlet is excised to prevent its regrowth.

Outcomes Measured

Patients were assessed on spasticity using modified Ashworth scale, modified Rankin score, power, sensations, drug reduction/elimination, and complications. The data were maintained on Microsoft excel sheet and analyzed. The statistical significance was calculated using the Wilcoxon signed rank test for the pre- and postoperative data, and a p-value of <0.05 was deemed significant.

Results

Demographics and Baseline Characteristics

Six patients fulfilled eligibility criteria and underwent SDR. The mean age at surgery was 25 ± 12.56 years (range: 10–44 years), with four males and two females. Five patients had a history of sustained severe TBI and one patient had cervical spine injury 6 to 24 months before the surgery. The spasticity was unrelenting to the medicines and physiotherapy. One patient was already tracheostomized at the time of surgery. All patients had modified Ashworth scores of 2 to 4 in all limbs, were nonambulatory, and having a mRS score of 4 to 5. The demographic details and outcomes are mentioned in ►**Table 1**.

Surgical Details

All patients underwent both cervical and lumbar SDR. In the cervical region, bilateral C4 to T1 levels were targeted and in lumbar levels bilateral L2 to S2 levels were targeted. Five patients underwent both procedures in one setting, and one patient underwent them in two settings. Intraoperative neuromonitoring was utilized in all cases, and sectioning ranged from 50 to 70% of rootlets at affected levels. No intraoperative complications occurred.

Clinical Outcomes

Spasticity Reduction

All patients improved on spasticity scales. There was an immediate and substantial reduction in spasticity from a mean of 3.16 ± 0.75 to 0.5 ± 0.54 postoperatively on the modified Ashworth scale. These results were sustained till the last follow-up of 12 months with only minor fluctuations. This was significant with a p-value of 0.03.

Power: There was transient reduction in motor power in one patient after cervical SDR. However, it got reversed spontaneously after 6 weeks.

Sensory examination: Three patients suffered numbness and tingling in limbs after the surgery; however, it was also transient and resolved in 3 to 4 months of follow-up.

Disability Improvement

Preoperatively, one patient scored mRS 4 and the remaining five had mRS 5, reflecting severe disability. Postoperatively, four patients improved to mRS 2, and two improved to mRS 4. The preoperative mean mRS was 4.83 (standard deviation

Table 1 Clinical and functional outcomes of patients undergoing cervical and lumbar selective dorsal rhizotomy for posttraumatic spasticity

S. no.	Age	Gender	Preop Ashworth score	Postop Ashworth score	Preop mRS	Postop mRS	Sensory symptoms	Functional gain	Drug reduction
1	10	F	3	0	4	2	No	Ambulation	Stopped
2	18	M	4	1	5	2	Yes (transient)	Standing	Reduced
3	20	F	3	0	5	2	Yes (transient)	Standing	Reduced
4	22	M	2	1	5	2	Yes (transient)	Ambulation	Reduced
5	36	M	4	1	5	4	No	None	Reduced
6	44	M	3	0	5	4	No	None	Reduced

Abbreviations: F, Female; M, Male; mRS, Modifed Rankin scale; postop, postoperative; preop, preoperative.

[SD]: 0.37), and postoperative mean mRS was 2.67 (SD: 1.03). This was significant with a p-value of 0.03.

Functional Gains

Four patients displayed improved voluntary movement and transitioned from bedridden to supported standing or ambulation. They achieved increased independence in self-care. Two patients, although improved in tone, did not regain meaningful voluntary movements due to concomitant severe weakness and cognitive disability. However, family-reported care became easier due to the absence of rigidity and improved hygiene.

Drug Use: The drugs were reduced in all patients. One patient became free from oral baclofen.

Complications: Two patients had pseudomeningocele in the cervical region requiring tapping and pressure bandage. There were no surgical site infections or new permanent neurological deficits. One patient experienced transient reduction in power, which resolved over 6 weeks with supportive care.

Discussion

Traditionally, SDR has been regarded as an intervention for children with spastic cerebral palsy, with only limited use in the context of acquired spasticity from trauma or other neurologic insults.[6] The present study highlights the safety and efficacy of SDR in the treatment of posttraumatic spasticity in patients with severe, drug-refractory quadriparesis. The observed immediate and sustained reduction in spasticity, as demonstrated by the decrease in mean modified Ashworth scores from 3.16 ± 0.75 to 0.5 ± 0.54, represents a clinically meaningful outcome. The study found both objective and subjective relief for patients and their caregivers.

The improvement in functional disability, as measured by the mRS, is important. Preoperatively, all patients in this cohort were moderate to severely disabled and confined to bed, with mRS scores of 4 or 5. Following SDR, patients achieved mRS scores of 2 or 4, translating to increased independence and improved participation in daily activities. Even among patients who did not regain ambulation, the alleviation of hypertonia permitted easier caregiving and enhanced hygiene. The improvements were persistent till the last follow-up of 1 year.

The surgical approach of simultaneous cervical and lumbar SDR was found to be feasible and safe. Intraoperative neuromonitoring is critical to allow targeted sectioning of abnormal rootlets. It is especially needed in the lumbar area. The complication profile was acceptable. While transient neurological deficits and pseudomeningocele occurred, no permanent neurological injuries or infections were recorded. The procedure was helpful in reducing the drugs, which is helpful for poor patients.

In this study, sensory disturbances were noted in 3 out of 6 patients, manifesting as transient numbness and tingling after the surgery. These symptoms resolved spontaneously within 3 to 4 months. This finding is consistent with the existing literature and is often attributed to intraoperative handling of dorsal rootlets rather than permanent injury. One should do adequate arachnoid dissection to avoid permanent severing of rootlets from the cord. Studies have shown that up to 8 to 14% of patients may experience sensory changes, and 3.8% patients may suffer persistent deficits due to a larger amount of dorsal tissue cut.[7,8] Persistent deficits are rare and typically not functionally significant, especially when care is taken intraoperatively to sacrifice only harmful tonic roots. Bladder and bowel dysfunction are avoided if less than 50% of the S2 roots are sacrificed.

The study has several limitations, including the small cohort size and a single-center design. Overall quality-of-life and participation domains should be investigated with broader, validated measures. The procedure may also help in improving the upper motor neuron type spastic bladder, which we need to study. For hemiparetic or monoparetic spasticity, it is better to do hyperselective peripheral neurotomies.[9–11] The study is also limited by a lack of a control arm. Future studies should aim to address these gaps.

Conclusion

The SDR is safe and effective for managing posttraumatic spasticity. It offers a meaningful and sustained reduction in spasticity as well as functional improvement for patients who have exhausted conservative measures.

Funding

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Conflict of Interest

None declared.

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