Review Article

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Neurectomy for treatment of pediatric spasticity: a review of literature

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Introduction: Spasticity in the pediatric population presents significant management challenges. The aim of this study was to review the current literature on the use of selective neurectomy for treating pediatric spasticity. It is important to analyze children as a distinct group, as the selection criteria differ from those used in adults, and the procedure affects not only spasticity but also the overall development of the child.

Methods: After a PubMed database search and applying inclusion criteria, we identified 14 relevant studies for this review. The following parameters were analyzed: patient age, number of participants, follow-up duration, Modified Ashworth Scale (MAS) scores, goniometry/passive range of motion (PROM), and motor function.

Results: There was considerable variability in the first three parameters (age, sample size, and follow-up period). All included studies reported improvements in spasticity, range of motion, and motor function when these outcomes were assessed. However, the methods used to evaluate these outcomes varied, limiting direct comparisons across studies.

Conclusion: Although few studies on selective neurectomy for pediatric spasticity were found, all demonstrated significant improvements in parameters associated with enhanced quality of life. These findings highlight the need for further research focused specifically on this population.

Keywords: pediatrics, muscle spasticity, denervation

INTRODUCTION

Spasticity, defined as an increase in muscle tone characterized by a velocity-dependent enhancement of tonic stretch reflexes, is a common consequence of long-term neurological disorders. It is estimated to affect up to 42.6% of stroke survivors, 67% of individuals with spinal cord injuries, 78% of those with multiple sclerosis, 50% of patients with traumatic brain injury, and 80% of children with cerebral palsy. Spasticity typically involves antigravity muscle groups and can lead to complications such as permanent muscle contractures, painful spasms, clonus, and loss of voluntary movement in the affected limbs. (1,2,3)

The management of spasticity in the pediatric population is particularly challenging. Spasticity should not be treated simply because it is present, as in some cases it may serve a compensatory role by aiding in the maintenance of posture or movement in the context of muscle weakness. Intervention is only warranted when excessive muscle tone results in additional functional impairment, hinders mobility, or contributes to the development of musculoskeletal deformities. When spasticity becomes harmful and is unresponsive to physical therapy, medications, or botulinum toxin, functional neurosurgical options should be considered. (4,5)

Selective neurectomy is a surgical treatment option for spasticity that involves the partial excision of specific branches of peripheral motor nerves supplying the affected muscles. Initially developed for use in the lower limbs, the procedure has since been adapted for the upper limbs as well. Over the past two decades, advancements in microsurgical techniques and the use of intraoperative nerve stimulation have significantly enhanced the precision and effectiveness of this approach. More recently, the technique has evolved into hyperselective neurectomy, in which nerve branches are carefully dissected and partially resected at the junction where each motor ramus enters its target muscle. This allows for a more tailored reduction of spasticity while preserving as much voluntary motor function as possible. (2,5,6,7,8)

The present work aims to review the current literature regarding the application of selective peripheral neurectomy in the management of spasticity in the pediatric population.

MATERIALS AND METHODS

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A systematic review was conducted in accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. For this review, a comprehensive search was performed using the PubMed database to identify studies investigating neurectomy for the treatment of spasticity in the pediatric population. The following search terms were used: “neurectomy and spasticity and children” (459 results), “neurectomy and spasticity and pediatric” (155 results), “neurotomy and spasticity and children” (46 results), “neurectomy and spasticity and childhood” (25 results), “neurotomy and spasticity and pediatric” (7 results), “neurotomy and spasticity and childhood” (1 result). Titles and abstracts were initially screened for relevance. After removing duplicate entries, we excluded articles that were not in English, did not include pediatric participants, or were not available in full text, leaving 49 articles. Upon full-text review, additional exclusions were made for studies that did not specifically mention neurectomy or that lacked objective outcome measures. This resulted in a final selection of 14 studies (see Figure 1). From each included study, we extracted the following data: patient age, sample size, duration of follow-up, and outcome measures. The primary outcome parameters were changes in the Modified Ashworth Scale (MAS), goniometry/passive range of motion (PROM), and motor function. These data were summarized and presented in Table 1.

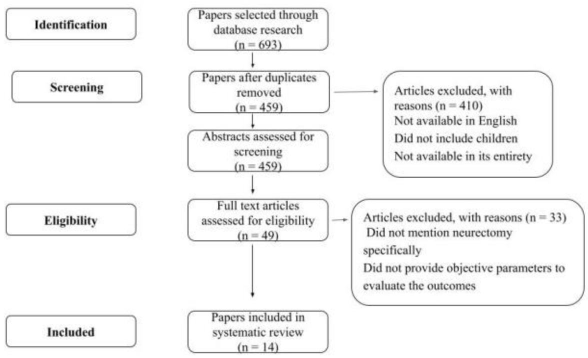

Figure 1 – Prisma flowchart

RESULTS AND DISCUSSION

In current literature, the terms hyperselective neurectomy, selective neurotomy, selective peripheral neurotomy, selective neurectomy, and selective motor fasciculotomy often refer to the same procedure. (23) The technique is employed for relieving focal or multifocal spasticity. It is done only on the peripheral nerve supplying spastic muscle without interference of residual motor or sensory function. Precise selection of surgical candidates is an essential strategy to achieve a favorable outcome. (20) Commonly it is recommended in spastic patients refractory to medical treatment and after botulinum toxin applications. Yong et al, however, in a systematic review of the role of selective peripheral neurectomy for the treatment of spasticity, did not find controlled or randomized clinical studies, nor consensus on the criteria used by the diverse authors. (1,21)

Nevertheless, this technique has shown satisfactory outcomes, with long-lasting benefits in reducing spasticity. In pediatric patients, this is particularly important, as early intervention—especially if performed before the pubertal growth spurt—may help prevent the progression of skeletal and musculotendinous deformities, thereby potentially reducing the need for future corrective surgeries. (1)

An additional difference observed in the pediatric population, as reported in one of the selected studies, is that children reported higher satisfaction with surgical outcomes compared to adults. However, achieving these results required intensive postoperative rehabilitation. (18)

In our review, the age range of participants across studies varied from 3 to 79 years. Although the primary focus of this paper was to evaluate the outcomes of neurectomy for spasticity in the pediatric population, many studies did not provide age-specific data that allowed for the isolation of pediatric outcomes. When such data were available, we included the summarized results for pediatric patients only in Table 1. The follow-up periods ranged from 4 months to 11 years, and the number of patients per study varied from 1 to 58.

Regarding spasticity outcomes, all studies reported improvement following neurectomy. However, some studies noted cases of recurrence. (17) In adults, the known one-year recurrence rate of spasticity following lower limb surgery was approximately 1%; however, recurrence tends to be more frequent in younger children. (4, 10)

The MAS was an objective parameter in almost all papers, but Feve et al, used Held score. (12) They demonstrated reduction of spasticity from 3,5 to 0, on average. (12) Msaddi and Buffenoir et al evaluated the patients improvements of spasticity through an indirect parameter, the correction of deformities. (13,16) Berard et al, on the other hand, divided their results in “excellent”, “good” or “poor”. (14) All these different and non-standardized forms of clinical evaluation make comparative analysis of results difficult.

When analyzing motor function, although some studies discussed the potential risk of motor function loss following neurectomy, only two of the included studies that involved pediatric patients assessed this parameter using objective measures. Feve et al. reported an average decrease of -2.27 in motor function, while Buffenoir et al. found that the function of the dorsiflexor muscles remained unchanged after neurotomy, both qualitatively and quantitatively. (12, 16)

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Table 1- Articles included in this review

Study	Age	Number of patients	Motor Function	MAS	Goniometry/ PROM	Time of follow up
Sindou M et al. 1998[10]	6-68	53	-	-2,31	77,35% improvement	15 months to 10 years
Abdennebi B, 1996[11]	5 - 65	58	-	Decreased in 72,4%	-	10 years
Feve A et al, 1997[12]	6-70	12	-2,27	-	7,5° change	1-12 months
Msaddi AK, 1997[13]	3-15	28	-	-	98,5% deformity correction	3-48 months
Berard C et al, 1998[14]	4.9-14.8	13	-	-	8,87° change	4 years
Decq P et al, 2000[15]	8-79	46	-	-2	100% Disappearance of equinus deformity	8-28 months
Buffenoir K et al, 2004[16]	12-74	55	Muscle function not modified	-	6,26° change	4-22 months
Collado H et al, 2006[17]	11	1	-	-1(after recurrence)	-	11 years
Kim JH et al, 2010[18]	5-15	32	-	-2.3	10,7° change	14-96 months
Sitthinamsuwan B et al, 2013[19]	4-15	8	-	-2,18	21,36 change in PROM	24-44 months
Sitthinamsuwan B et al, 2013[20]	4-78	33	-	-2,32	23,73° change in PROM	4-28 months
Leclercq C et al, 2021[2]	6.4-74.2	42	-	-1,1 average	-	12-85 months
Heredia-Gutierrez A et al, 2023[21]	3-17	9	-	-2,33	55,67° change in resting position	12 months
Feygin MS et al, 2024[22]	7-24	8	-	-1,25	-	1 year

Nearly all studies involving pediatric patients included goniometry as an outcome measure. Msaddi, Decq et al., and Sindou et al. specifically assessed deformity correction and improvement in joint angles as indicators of surgical success. (1, 10, 13) All three studies reported significant improvements in joint range of motion following neurectomy.

An important aspect of our review is that it includes studies of neurectomy procedures performed on both the upper and lower limbs. However, not all studies used the same outcome parameters, making direct comparisons difficult. Nonetheless, this variability highlights the versatility of selective neurectomy in the pediatric population, demonstrating favorable results in both upper and lower limb spasticity.

CONCLUSION

Our review identified a limited number of studies focusing on peripheral neurectomy in the treatment of spasticity in the pediatric population; however, all demonstrated significant improvements in clinical parameters associated with enhanced quality of life.

Neurectomy has proven to be an effective treatment for refractory spasticity in well selected conditions, with literature over the years supporting its benefits beyond the reduction of spasticity alone. In pediatric patients, this technique has also shown promising results and holds clinical value. However, careful patient selection is particularly important in this group, highlighting the need to study outcomes in children separately from adults.

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DISCLOSURES

Ethical approval

This study did not require ethical approval as it did not use human or animal subjects. This study did not require consent, as it did not involve human subjects.

Conflict of interest

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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Artificial intelligence

No artificial intelligence assistance were employed in the preparation of this manuscript.

CONTRIBUTIONS

-**Stephanie Oliveira Fernandes de Bulhões**: Data curation, Formal Analysis, Investigation, Software, Writing – original draft
-**Ricardo de Amoreira Gepp**: Conceptualization, Data curation, Formal Analysis, Methodology, Project administration, Supervision, Writing – review & editing
-**Márcio de Mendonça Cardoso**: Formal Analysis, Investigation, Supervision, Visualization, Writing – review & editing

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