SURGICAL MANAGEMENT OF INTRACTABLE SPASTICITY

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ABSTRACT

Background: Spasticity is motor disorder characterized by a velocity dependent incease in tonic stretch reflexes (muscle tone) with exaggerated tendon jerks, resulting from hyperexcitability of the stretch reflex, as one component of the upper motor neuron syndrome. **Objectives:** Comparison between spinally based surgical procedure and peripherally based surgical procedures in management of hypertonia in the lower limbs of pediatrics. **Patients and methods:** Over 3-year period selected, fifty children with intactable, lower limb spasticity were prospectively treated by selective neurotomy (group A, 35 patients) and dorsal rhizotomy (group B, 15 patients) with 6-month follow up. This study aimed at evaluation of the results of the surgical procedures utilized. **Results:** The operative duration was longer with dorsal rhizotomy mean of 292.2 minutes versus 76.8 minutes with neurotomy (p = 0.001). The hospital stay was longer with dorsal rhizotomy with mean of 6.2 days versus 1.7 days with neurotomy (p = 0.001). Of the total rhizotomies, 24/45 muscles exhibited significant improvement with $G_5 + G_4$ power versus 6/45 muscles preoperative (p = 0.001). Marked improvement of the muscle tone following neurotomies as 52/75 muscles had normal tone and 23/72 muscles had mild spasticity following neurotomies (p = 0.001). Marked improvement of the muscle tone following dorsal rhizotomies (p = 0.001). Selective peripheral neurotomy produced excellent improvement of the preoperative restricted joint movement (p = 0.001). The mean ankle dorsiflexion after neurotomies of ankle plantar flexors was 18.77° representing 94% of normal range movement versus 7.2° preoperatively representing 36% of normal movement with improvement rate of 161.1%. Dorsal rhizotomies had excellent improvement of the preoperatively restricted joint movement (p = 0.001). 18/35 patients were ambulatory following neurotomies of the spastic lower limb muscles versus 7/35 patients preoperatively. Only a patient still could not walk after neurotomy versus 10/35 patients preoperatively (p = 0.001). 11/15 patients were ambulatory following dorsa rhizotomies versus 2/15 patients preoperatively (p = 0.001) of whom 3/11 patients had normal walk G_5 (p = 0.001). 29/35 patients had no or occasionally mild lower limb pain following neurotomies versus 4/35 patients preoperatively (p = 0.001). A patient still had frequent severe pain following neurotomies versus 26/35 patients had G_3, G_4 pain which was of high significance. 13/15 patients had no or occasionally mild pain in lower limbs following dorsal rhizotomy versus 2/15 patients preoperatively (p = 0.001). The H/M ratio following neurotomies showed marked reduction of the ratio, the mean was 0.14 versus 0.63 preoperatively. The H/M ratio following dorsal rhizotomies showed marked reduction of the ratio, the mean was 0.11 versus 0.58 preoperatively. **Conclusion:** Both neurotomies and dorsal rhizotomies were safe surgical procedures and were provided with good improvement in respect of: muscle power, severity of spasticity, patient's ambulation, gait, range of joint movement, associated pain, functional disability and nerve excitability with no significnat diffference between both procedures.

Keywords: intractable, spasticity

INTRODUCTION

Spasticity is motor disorder characterized by a velocity dependent incease in tonic stretch reflexes (muscle tone) with exaggerated tendon jerks, resulting from hyperexcitability of the stretch reflex, as one component of the upper motor neuron syndrome.

This definition emphasizes the fact that spasticity is only one of the many different features of the Upper Motor Neuron (UMN) syndrome. The UMN syndrome can occur following any lesion affecting some or all of the descending motor pathways[(1)].

Pathogenesis of spasticity is multifactorial, now it is generally accepted that there is no single mechanism responsible for the development of spasticity[(2)].

A key point in the assessment of spasticity is to standardize the environment i.e. to perform the patient's assessment at the same time of day and in the same manner, at each visit. Exacerbating factors, such as urinary tract and other infections, pressure sores, ingrown toenails, and constipation, should be accounted for and removed to the extent possible before performing the assessment. Observing the person with spasticity perform activities such as walking, drinking from an open cup, and moving from one position to another often yields valuable information. In this manner, the assessment should eamine the extent to which spasticity is limiting function:

- The amount of spasticity in each limb.
- The impact of changing spasticity on function.
- The degree of weakness.
- The impact of weakness on function[(3)].

Biomechanical studies are typically reserved for use in research studies, they can provide objective measures of spasticity. Two types of studies are the Wartenburg pendulum test, in which an electrogoniometer is used to count the number and record the pattern of the swing when the knee is released from an extended position, and the torque motor test, which measures the amplitude and frequency oscillation during flexion and extension of the wrist[(4)].

Methods of spasticity management can be classified according to whether their effect is focal or general and whether the effects are permanent or temporary[5].

The goals of the surgical treatment of spasticity may include improving the passive functions like access of hygiene, improving the ability to tolerate braces, reducing pain, improving the active functions such as walking or reducing the risk of further deformity[6].

The aim of this work is to compare between spinally based surgical procedure and peripherally based surgical procedures in management of hypertonia in the lower limbs of pediatrics as regard indications, outcome (physical, electrophysiological and functional) and complications and to design an algorithm for management of hypertonia in countries with special economic settings.

PATIENTS AND METHODS

Fifty patients suffering from intractable, handicapping spasticity affecting lower limbs were subjected to different surgical modalities for management of spasticity between June 2009 and March 2012 in a prospective study which was done at the Department of Neurosurgery, Faculty of Medicine, Zagazig and Ain Shams Universities. All patients were presented to Neurosurgery Outpatient Clinic with intractable spasticity (showing progressively decreasing or even no response to medical and/or physiotherapy).

Patients were subdivided into two groups according to surgical modality done:

Group A consists of 35 patients which were subjected to peripheral procedures including selective peripheral neurotomies with/without orthopedic complementary surgery.

Group B consists of 15 patients which were subjected to central spinal procedures including selective dorsal rhizotomy and microsurgical dorsal root entry zone lesioning with/without orthopedic complementary surgery.

All patients were selected according to specific inclusion and exclusion criteria.

The inclusion criteria:

(1) Pediatric patients between 3 and 18 years.

(2) Lower limb spasticity.

(3) Patients with intractable spasticity (progressive or showing no response to medical and/or physiotherapy for one year).

(4) Electrophysiologically, the H/M ratio is more than 0.5.

(5) The patients did not undergo any previous surgery for tendon transfer or lengthening.

(6) The patietns do not have any MRI radiological abnormalities of the basal ganglia.

(7) Impaired mobility with spasticity.

(8) Good general health.

Exclusion criteria:

(1) Patients below 3 years or above 18 years.

(2) Patients with lower limb spasticity that did not receive conservative treatment for spasticity control.

(3) Electrophysiologically, H/M ratio is below 0.5.

(4) Patients undergone previous surgery for deformity correction such as tendon lengthening or tendon transfer.

(5) Patients with fixed joint contracture.

(6) Patients with MRI radiological abnormality of the basal ganglia.

(7) Patients that did not attend the follow up.

(8) Useful function with spasticity.

(9) Bad general health.

All patients in this study were subjected to complete evaluation utilizing the following sheet proposed specifically for this study:

I. ***Demographic data*** including name, age, sex and school attendance.

II. ***Clinical evaluation:***

- Neurological evaluation.
- General evaluation.

III. ***Investigations:***

A- Laboratory investigations: Complete blood picture, coagulation profile, liver and kidney functions, urine analysis and urine and culture sensitivities.

B- Radiological investigations:

- CT and MR to prove etiology of spasticity.
- **Plain** X-ray spine and joints to detect skeletal deformities.

IV. ***Electrodiagnostic studies:***

A- H reflex and H_{max}/M_{max} ratio.

B- Electromyographic studies.

C- Nerve block test/examination under anesthesia.

V. ***Treatment:***

A- Selective Peripheral Neurotomy (SPN).

B- Selective Dorsal Rhizotomy:

C- Orthopedic procedures.

VI. ***Physical rehabilitation.***

VII. ***Follow-up.***

Statistical analysis:

Statistical calculations were performed to determine the level of significance using chi-squared test and Fischer's exact test for frequencies less than 5. Significance was based on predetermined alpha level which is < 0.05.

RESULTS

The age range was 3-18 years. The mean age was 7.65 years. 24/50 patients were in the age group of 3-6 years. 4/15 patients in group B were in the age group of > 15 – 18 years. There was no significant difference between group A and group B in respect of different age groups. 33/50 patients were males while 17/50 patients were females. Male to female ratio was 2.2:1 in group A and 1.5:1 in group B (table 1).

Variable improvement of the muscle power following neurotomies was encountered. Of the total neurotomies, 26/75 muscles exhibited significant improvement with G_5, G_4 power versus 4/75 muscles preoperatively. This finding has reached a high significant level with p value of 0.001. 49/75 muscles had G_3 power, walk with support of one person, following neurotomies versus 23/75 patients preoperatively, which has reached significant level with p value of 0.001.No muscle had G_2 power following neurotomies versus 37/75 patients which was of significant statistical level. No patients showed deterioration of the muscle power after neurotomies, as no patients had G_0 or G_1. Individually, each muscle group (hip adductors, hamstrings and ankle plantar flexors) showed variable improvement with no statistical difference following neurotomies with p value of 0.001 (table 2).

Of the total rhizotomies, 24/45 muscles exhibited significant improvement with G_5 + G_4 power versus 6/45 muscles preoperative which was of significant level with p value of 0.001. 18/45 muscles had G_3 power following rhizotomies versus 9/45 muscles. No muscle had G_2 power with rhizotomies versus 24/45 patients preoperatively. This finding had significant level with p value of 0.001. 3/45 muscles still had G_1 power after rhizotomies as preoperatively. No muscles were of G_0 following rhizotomies versus 3/45 muscles preoperatively.

Individually, each muscle group showed variable improvements following rhizotomies with no statistical difference (table 3).

Marked improvement of the muscle tone following neurotomies of the hip adductors, hamstrings and ankle plantar flexors involved in the spasticity as 52/75 muscles had normal tone and 23/72 muscles had mild spasticity following neurotomies. The tone improvement had reached a high significant level with p value of 0.001 (table 4).

Marked improvement of the muscle tone following dorsal rhizotomies of the involved spastic hip adductors: hamstrings and ankle plantar flexors. 36/45 muscles of each limb had normal tone and 9/45 muscles had mild spasticity following dorsal rhizotomies. The improvement of the muscle tone has reached a high significant level with p value of 0.001 (table 5).

Selective peripheral neurotomy produced excellent improvement of the preoperative restricted joint movement which was statistically highly significant with p value of 0..001 among all neurotomies operated upon. The mean ankle dorsiflexion after neurotomies of ankle plantar flexors was 18.77° representing 94% of normal range movement versus 7.2° preoperatively representing 36% of normal movement with improvement rate of 161.1%. The mean hip abduction angle after neurotomies of hip adductors was 37.2° representing 82.4% of normal hip abduction versus 20.56° preoperatively representing 45.8% of normal movement with improvement rate of 80.6%. The mean popliteal angle after neurotomies of the sciatic nerve was 137° representing 76.1% of normal joint movement versus 83.4° representing 46.3% of normal movement with improvement rate of 64.3%. The improvement rate of the preoperatively did joint movement was higher with neurotomies of the tibial branches followed by the obturator branches and with sciatic branches (table 6).

Dorsal rhizotomies had excellent improvement of the preoperatively restricted joint movement, the value was statistically highly significant with p value of 0.001 among all rhizotomies operated upon. The mean ankle dosiflexion after rhizotomies was 19.67° representing 99% of normal range of movement versus 8.66° preoperatively representing 43.5% of normal mount with improvement rate of 126.4%. The mean hip abduction angle after rhizotomies was 42.3% representing 94% of normal want versus 20.3° preoperatively, representing 45.1% of normal were improvement rate of 108.4%. The mean popliteal angle after rhizotomies was 140.3°, representing 77.9% of normal versus 87.3° representing 48.5% of normal with improvement rate of 60.7%. The improvement rates after rhizotomies was higher at measurement of ankle dosiflexion 126.4 followed by hip abduction of 108.4 and less with knee extension of 60.7% (table 7).

18/35 patients were ambulatory following neurotomies of the spastic lower limbs and muscles versus 7/35 patients preoperatively. This finding has reached a high significant value with p value of 0.005, of whom two thirds had normal gait that had high significant value with p value of 0.001. Only a patient still could not walk after neurotomy versus 10/35 patients preoperatively, while which was of high significant value.

2/35 patients could walk with support of two persons versus 8/35 patients preoperatively which was of high significant value (table 8).

11/15 patients were ambulatory following dorsa rhizotomies versus 2/15 patients preoperatively which had a high significant value with p value of 0.001 of whom 3/11 patients had normal walk G_5. A patient still could not walk after dorsal rhizoitomy versus 2/15 patients preoperatively. A patient could walk with support of two persons after dorsal rhizotomy versus 8/15 patients preoperatively. This had a highest significant value with p value of 0.001 (table 9).

29/35 patients had no or occasionally mild lower limb pain following neurotomies of the spastic musacsle groups versus 4/35 patients preoperatively. This finding had a high significant value with p value of 0.001. A patient still had frequent severe pain following neurotomies versus 26/35 patients had G_3, G_4 pain which was of high significant (table 10).

13/15 patients had no or occasionally mild pain in lower limbs following dorsal rhizotomy versus 2/15 patients preoperatively while was a highly significant value with p value of 0.001. No patients following rhizotomies has frequent nor permanent severe pain versus 11/15 patients preoperatively, while had a high significant value with p value of 0.001 (table 11).

18 patients can serve themselves with or without support following neurotomy versus 7 patients can serve themselves with support preoperatively which had a high significant value with p value of 0.001 of which 12/18 patients had a normal function. Patients still could not serve themselves after neurotomy versus preoperatively. There was significant difference between the preoperative and postoperative results (table 12).

12 patients can serve themselves with or without support following dorsal rhizotomy versus 2 patients can serve themselves with support preoperatively which had a high significant value with p value of 0.001 in which 3/12 patients had a normal motor function. Patients still could not serve themselves after rhizotomy versus preoperatively. There was significant difference between pre- and post-operative results (table 13).

The H/M ratio following neurotomies showed marked reduction of the ratio, the mean was 0.14 versus 0.63 preoperatively with reduction rate of 76.9% on the right side. The reduction rate of H/M ratio following neurotomies was 79.9% on the left side. The decrease of the H/M ratio after neurotomi9es means reduction of hyperexcitability phenomenon of UMNL with decrease of muscle tone and spasticity. The decrease of the H/M ratio removing neurotomies had statistically high significant value with p value of 0.001 with no difference between the night and left sides (table 14).

The H/M ratio following dorsal rhizotomies showed marked reduction of the ratio, the mean was 0.11 versus 0.58 preoperatively with reduction rate of 81% on the right side. The reduction rate of H/M ratio following rhizotomies on the left side was 80.7%. The decrease of the H/M rate following rhizotomies had statistically significant value with $p < 0.001$ with no difference between the right and left sides (table 15).

The operative duration was longer with dorsal rhizotomy mean of 292.2 minutes versus 76.8 minutes with neurotomy. The difference has high significant level with p of 0.001 (table 16).

The hospital stay was longer with dorsal rhizotomy with mean of 6.2 days versus 1.7 days with neurotomy. The difference has high significant level with p value of 0.001 (table 17).

No serious neurological complications were noted with no deterioration of the neurological status among patients in both groups. All complications encountered are usual as in any surgical procedures and completely reversible (table 18).

Table (1): Age and sex distribution among 35 patients in group A and 15 patients in group B

Age group (years)	Total		Group A (n = 35)				Group B (n = 15)				p
			Male		Female		Male		Female		
	No	%	No	%	No	%	No	%	No	%	
< 3 years	0	0	0	0	0	0	0	0	0	0	-
3-6	24	48	14	58.3	3	27.3	5	55.5	2	33.3	0.3
> 6 – 9	13	26	7	29.2	4	36.4	1	11.1	1	16.7	0.56
> 9 – 12	7	14	2	8.3	4	36.4	1	11.1	0	0	0.1
> 12 – 15	2	4	1	4.2	0	0	0	0	1	16.7	0.34
> 15 – 18	4	8	0	0	0	0	2	22.2	2	33.3	0.013
Total	50	100	24	68.6	11	31.4	9	60	6	40	

p = Group A versus group B in respect of the age group *p value is non-significant (0.1)*

Table (2): Correlation between postoperative and preoperative results in respect of the muscle power of the involved spastic muscle groups utilizing MRCS in group A (75 muscles in 35 patients)

Muscle group	Total		Group A (n = 35[a])																								p
			Preoperative												Postoperative												
			G_5		G_4		G_3		G_2		G_1		G_0		G_5		G_4		G_3		G_2		G_1		G_0		
	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	
Hip adductors	9	12	0	0	0	0	5	55.6	3	33.3	1	11.1	0	0	0	0	1	11.1	8	88.9	0	0	0	0	0	0	0.001[1]
Hamstrings	31	41.3	0	0	2	6.5	8	25.8	16	51.6	5	16.1	0	0	2	6.5	9	29	20	64.5	0	0	0	0	0	0	0.001[2]
Ankle planti flexors	35	46.7	0	0	2	5.7	10	28.6	18	51.4	5	14.3	0	0	2	5.7	12	34.3	21	60	0	0	0	0	0	0	0.001[3]
Total[b]	75	100	0	0	4	5.3	23	30.7	37	44.3	11	14.7	0	0	4	5.3	22	29.3	49	65.3	0	0	0	0	0	0	

[a]No. of patients [b]No. of spastic muscles
[1]Total G_5, G_4 postoperative versus preoperative
[2]Total G_3 postoperative versus preoperative
[3]Total G_2 postoperative versus preoperative
p value is highly significant (0.001)

Table (3): Correlation between preoperative and postoperative results in respect of the muscle power of the involved spastic muscle groups utilizing MRCS in group B (45 muscle groups in 15 patients)

Muscle group	Total		Group B (n = 15[a])																								p
			Preoperative												Postoperative												
			G_5		G_4		G_3		G_2		G_1		G_0		G_5		G_4		G_3		G_2		G_1		G_0		
	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	
Hip adductors	15	33.3	0	0	2	13.3	3	20	8	53.3	1	6.7	1	6.7	2	13.3	6	40	6	40	0	0	1	6.7	0	0	0.001[1]
Hamstrings	15	33.3	0	0	2	13.3	3	20	8	53.3	1	6.7	1	6.7	2	13.3	6	40	6	40	0	0	1	6.7	0	0	0.001[2]
Ankle plantar flexors	15	33.3	0	0	2	13.3	3	20	8	53.3	1	6.7	1	6.7	2	13.3	6	40	6	40	0	0	1	6.7	0	0	0.001[3]
Total[b]	45	100	0	0	6	13.3	9	20	24	53.2	3	6.7	3	6.7	6	13.3	18	40	18	40	0	0	3	6.7	0	0	

[a]No. of patients [b]No. of spastic muscles
[1]Total G_5, G_4 postoperative versus preoperative
[2]Total G_3 postoperative versus preoperative
[3]Total G_2 postoperative versus preoperative
p value is highly significant (0.001).

Table (4): Correlation between postoperative and preoperative results of the severity of spasticity utilizing modified Ashworth scale among 75 muscles in 35 patients in group A

Muscle group	Total		Group A (n = 35[a]) Preoperative												Postoperative												p
			Score 4		Score 3		Score 2		Score 1+		Score 1		Score 0		Score 4		Score 3		Score 2		Score 1+		Score 1		Score 0		
	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	
Hip adductors	9	12	0	0	2	22.2	5	55.6	2	22.2	0	0	0	0	0	0	0	0	0	0	0	0	5	55.6	4	44.4	0.001
Hamstrings	31	41.3	0	0	5	16.1	21	67.7	5	16.1	0	0	0	0	0	0	0	0	0	0	0	0	9	29	22	71	0.001
Ankle plantar flexors	35	46.7	0	0	6	17.1	24	86.6	5	14.3	0	0	0	0	0	0	0	0	0	0	0	0	9	25.7	26	74.3	0.001
Total[b]	75	100	0	0	13	17.3	50	66.6	12	16	0	0	0	0	0	0	0	0	0	0	0	0	23	30.7	52	69.3	0.001

[a]No. of patients
[b]No. of spastic muscles
p value is highly significant (0.001).

Table (5): Correlation between postoperative and preoperative results of the severity of the spasticity utilizing modified Ashworth scale among 45 muscles in 15 patients in group B

Muscle group	Total		Group B (n = 15[a]) Preoperative												Postoperative												p
			Score 4		Score 3		Score 2		Score 1+		Score 1		Score 0		Score 4		Score 3		Score 2		Score 1+		Score 1		Score 0		
	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	
Hip adductors	15	33.3	0	0	4	26.7	9	60	2	13.3	0	0	0	0	0	0	0	0	0	0	0	0	3	20	12	80	0.001
Hamstrings	15	33.3	0	0	5	33.3	8	53.3	2	13.3	0	0	0	0	0	0	0	0	0	0	0	0	3	20	12	80	0.001
Ankle plantar flexors	15	33.3	0	0	6	40	7	46.7	2	13.3	0	0	0	0	0	0	0	0	0	0	0	0	3	20	12	80	0.001
Total[b]	45	100	0	0	6	40	7	46.7	2	13.3	0	0	0	0	0	0	0	0	0	0	0	0	9	20	36	80	0.001

[a]No. of patients
[b]No. of spastic muscles
p value is highly significant (p = 0.001)

Table (6): Correlation between postoperative versus preoperative results in respect of range of joint movement among 35 patients in group A

Spastic muscle group	Joint movement	Group A						Improvement rate %	p
		Total		Preoperative		Postoperative			
		No	%	Mean	Range	Range	Mean		
Hip adductors	Hip abduction	9	25.7	20.56	15-25	35-40	37.22	80.6	0.001[a]
Hamstrings	Popliteal angle	31	88.6	83.38	60-100	120-150	137.09	64.3	0.001[b]
Ankle plantar flexors	Ankle dorsiflexion	35	100	7.2	0-10	15-20	18.77	61.1	0.001[c]

[a]Mean preoperative versus mean postoiperative in respect of hip abduction
[b]Mean preoperative versus mean postoperative in respect of popliteal angle
[c]Mean preoperative versus mean postoperative in respect of ankle dorsiflexion
p value is highly significant (0.001).

Table (7): Correlation between postoperative versus preoperative results in respect of the joint range of movement among 15 patients in group B

Spastic muscle group	Joint movement	Group B (n = 15)						Improvement rate %	p
		Total		Preoperative		Postoperative			
		No	%	Range	Mean	Range	Mean		
Hip adductors	Hip abduction	15	100	15-25	20.33	35-40	42.33	108.4	0.001[a]
Hamstrings	Popliteal angle	15	100	70-100	87.33	130-150	140.33	60.7	0.001[b]
Ankle plantar flexors	Ankle dorsiflexion	15	100	5-10	8.66	15-20	19.67	126.4	0.001[c]

[a]Mean preoperative versus mean postoiperative in respect of hip abduction
[b]Mean preoperative versus mean postoperative in respect of popliteal angle
[c]Mean preoperative versus mean postoperative in respect of ankle dorsiflexion
p value is highly significant (0.001).

Table (8): Correlation between postoperative versus preoperative results in respect of the gait grading scale system among 35 patients in group A

Gait grade	Group A (n = 35)				p
	Preoperative		Postoperative		
	No	%	No	%	
Grade 5	0	0	12	34.3	0.001
Grade 4	7	20	6	17.1	0.005
Grade 3	10	28.6	14	40	0.04
Grade 2	8	22.9	2	5.7	0.001
Grade 1	9	25.7	1	2.9	0.001
Grade 0	1	2.9	0	0	0.05

p value is highly significant (0.001)

Table (9): Correlation between postoperative versus preoperative results in respect of the gait grading scale system among 15 patients in group B (15 patients)

Gait grade	Group B (n = 15)				p
	Preoperative		Postoperative		
	No	%	No	%	
Grade 5	0	0	3	20	0.04
Grade 4	2	5.7	8	53.3	0.001
Grade 3	5	33.3	2	5.7	0.01
Grade 2	6	40	1	6.7	0.001
Grade 1	1	6.7	0	0	
Grade 0	1	6.7	1	6.7	

p value is significant (0.01)

Table (10): Correlation between postoperative versus postoperative results in respect of severity of pain associated with lower limb spasticity among 35 patients in group A

Pain grade	Group A (n = 35)				p
	Preoperative		Postoperative		
	No	%	No	%	
Grade 0	2	5.71	20	57.14	0.001
Grade 1	2	5.71	9	25.71	0.01
Grade 2	5	14.29	5	14.29	0.05
Grade 3	20	57.14	1	2.86	0.001
Grade 4	6	17.14	0	0	0.001

p value is highly significant (0.001)

Table (11): Correlation between postoperative versus preoperative results in respect of pain severity associated with lower limb spasticity among 15 patients in group B

Pain grade	Group B (n = 15)				p
	Preoperative		Postoperative		
	No	%	No	%	
Grade 0	1	6.67	10	66.67	0.001
Grade 1	1	6.67	3	20	0.001
Grade 2	2	13.33	2	13.33	0.05
Grade 3	7	46.67	0	0	0.001
Grade 4	4	26.67	0	0	0.001

p value is highly significant (0.001)

Table (12): Correlation between postoperative versus preoperative results in respect of gross motor function index among 35 patients in group A

Gross Motor Function Scale (GMFS)	Group A (n = 35)				p
	Preoperative		Postoperative		
	No	%	No	%	
Grade 5	0	0	12	34.29	0.001
Grade 4	7	20	6	17.14	0.05
Grade 3	10	28.57	15	42.86	0.001
Grade 2	8	22.86	2	5.71	0.001
Grade 1	10	28.57	0	0	0.001

p value is highly significant (0.001)

Table (13): Correlation between preoperative and postoperative results in respect of gross motor function index among 15 patients in group B

Gross Motor Function Scale (GMFS)	Group B (n = 15)				p
	Preoperative		Postoperative		
	No	%	No	%	
Grade 5	0	0	3	20	0.05
Grade 4	2	13.33	9	60	0.001
Grade 3	5	33.33	2	13.33	0.05
Grade 2	7	46.67	1	6.67	0.001
Grade 1	1	6.67	0	0	0.05

p value is significant (0.05)

Table (14): Correlation between postoperative versus preoperative results in respect of the electrodiagnostic studies of H/M ratio among patients in group B

Data	H/M ratio in group B				p
	Preoperative		Postoperative		
	Right	Left	Right	Left	
Range	0.449-0.89	0.512-0.867	0.049-0.34	0.013-0.39	
Mean	0.63	0.66	0.14	0.13	< 0.001

p = Postoperative versus preoperative results in respect of the mean H/M ratio on both sides
p value is highly significant (0.001)

Table (15): Correlation between postoperative versus preoperative results in respect of the elecstrodiagnostic studies of H/M ratio among 35 patients in group A

Data	H/M ratio in group A				p
	Preoperative		Postoperative		
	Right	Left	Right	Left	
Range	0.448-0.832	0.111-0.871	0.019-0.197	0.001-0.231	< 0.001
Mean	0.58	0.577	0.112	0.111	

p = Postoperative versus preoperative in respect of the mean of the H/M ratio on both sides
p value is highly significant (0.001)

Table (16): Duration of the surgical procedures among 35 patients with selective peripheral neurotomy in group A and 15 patients with dorsal rhizotomy in group B

Operative duration (in minutes)	Group A (n = 35)	Group B (n = 15)	p
Range	30-180	210-360	
Mean	76.8	292.2	0.001

p value is highly significant (0.001)

Table (17): Duration of hospital stay after surgery among 35 patients in group A and 15 patients in group B

Hospital stay (days)	Group A (n = 35)	Group B (n = 15)	p
Range	1-3	5-7	
Mean	1.7	6.2	0.001

p value is highly significant (0.001)

Table (18): Correlation of the surgical results between neurotomies (35 patients) and dorsal rhizotomies (15 patients) in respect of the operative complications

Complications	Total		Group A (n = 35)		Group B (n = 15)		p
	No	%	No	%	No	%	
Number of patients	50	100	35	70	15	30	
Yes	10	20	4	8	6	12	< 0.04
No	40	80	31	62	9	18	
Mortality	0	0	0	0	0	0	-
Morbidity							
Neurological	0	0	0	0	0	0	-[b]
Surgical	8	16	3	6	5	10	0.2[c]
CSF leak	2	4	0	0	2	4	
Wound infection	6	12	3	6	3	6	
General	2	4	1	2	1	2	1[d]
Paralytic ileus	2	4	1	2	1	2	

[a]Group A versus group B in respect of total number of patients with operative complications
[b]Group A versus group B in respect of number of patients with neurological complications of surgery
[c]Group A versus group B in respect of number of patients with surgical type of operative complications
[d]Group A versus group B in respect of number of patients with general type of operative complications
p value is non-significant (> 0.05)

DISCUSSION

Spasticity, as one component of the upper motor neuron syndrome which is characterized by a velocity-dependent increase in stretch reflex activity, is not that simple increase in stretch reflex activity that lead to progressive muscle shortening and functional impairment. Changes in intrinsic properties of the spastic muscle due to UMNL have an essential role in that process. **Lieber, Stienman and Barash**[7] have demonstrated two sourcses that affect the passive elasticity in the muscle,first is the variation in the giant intracellular cytoskeletal protein "titin"; second source is the extracellular matrix protein deposition and collagen.

The indication for functional neurosurgery not only depends on the topographic extent of the spasticity (local, regional or diffuse) but also the clinical stage and on the possible persistent functional motor activity. The strategy and objectives of treatment are not the same with bedridden, wheel-chair bound or walking patients, adults or pediatrics, and presence or absence of contractures[8].

Fifty patients were included in our study all with handicapping, intractable spasticity were divided into 2 groups according to the surgical modality they received.

Group A consists of 35 patients (24 males and 11 females) which were subjected to peripheral procedures including selective peripheral neurototomies with or without orthopedic complementary surgery.

Group B consists of 15 patients (9 males and 6 females) which were subjected to central spinal procedures including selective dorsal rhizotomy and microsurgical dorsal root entry zone lesioning with or without orthopedic complementary surgery.

Selective peripheral neurotomies were performed in 35 patients; 24 males and 11 females (2 of them had a complementary orthopedic surgery) (muscle lengthening surgery) due to the presence of fixed joint deformity associated with high spontaneous motor unit activity. Multilevel neurotomy was performed in 31 patients. The mean duration of illness before surgery was 3 years (range from 6 months to 7 years). In **Maarrawi, Mertens and Luaute**[9] series, 31 patietns undergoing selective neurotomies, the mean duration of illness was 6.8 years (range from 1-26 years), orthopedic surgery was done for 35.5% of patients, 19.3% had orthopedic surgery in the same session with neurotomy (we excluded patients with fixed joint contracture).

In our study, 68 procedures of selective tibial neurotomy was done for 35 patients (35 neurotomies) on right side with Talipes equines deformity and 33 in left lower limb. Bilateral tibial neurotomy was done in 33 patients (94.3%).

Tibial nerve is the most encountered among peripheral nerves in spasticity surgeries and topography of its fascicles is well known following the functional study of **Taira and Hori**[10], and was discussed intensively in most of published related articles.

In our study, dissection was directed towards motor branches after their emergence from the parent trunk to avoid sensory complications. Branches to medial head of gastrocnemius, not less than two branches in all cases, was found to emerge at higher level from the nerve trunk in popliteal fossa. Branches to lateral head, not less than one branch, was found thinner and emerged at lower level than that to medial head. The superior soleal branch was found to be situated posterolaterally in relation to nerve trunk after its emergence in the popliteal fossa, in 50% of cases we found that it may be more than one branch ensheathed together and could be dissected separately. In our patients, varus deformity was present, for which motor branch of tibialis posterior muscle was dissected.

In our study, a vertical incision was used in 30 cases (85.7%) and Bayonet incision was used in 5 cases (14.3%). Transverse incision was never used. In multicenter study of **Buffenoir, Roujeau and Lapierre**[11], the vertical incision is used in 20% of cases and Bayonet incision in 25.5% and transverse incision in 54.5%.

Disappearance of clonus and muscular flickers upon stimulation were the limit to stop sectioning, accordingly we found that sectioning did not exceed 50% of fascicles in each branch in all cases. In **Roujeau, Lefaucheur and Slavov**[12], resection was also based on intra-operative resolution of clonus and sectioning was up to 80% in 83% of cases of soleus branch only and tibialis posterior branch was included in 66%. While in El-Mahdy study sectioning was done for 75% of branch thickness in 84% of cases and 50% thickness in 15.3% according to the preoperative degree of spasticity.

Selective obturator neurotomy was done in 9 patients (25.7%) bilaterally for adduction deformity of the hip joint leading to scissoring during walking.

A transverse skin incision is made in the hip flexion fold centered over the prominence of the adductor longus tendon. This incision facilitated adductor longus tenotomy when considered in the same surgical procedure.

Hamstring neurotomy (sciatic neurotomy) was done bilaterally in 30 patients (85.7%) and on right side in one patient (2.9%). Sciatic neurotomy counters flexion deformity of the knee.

The transverse incision is performed in the gluteal fold centered over the groove between the ischium and the greater trochanter. Therefore, a total of about 147 neurotomies were performed in 35 patients (group A).

Regarding complications following neurotomies, immediate, postoperative weakness (MRCS decreased by 1-2 grades in the operated limb) was found in almost all patients which may be related to surgical manipulations of the nerves or may be the preexisting weakness (due to UMNL) became unmasked after resolving of spasticity, power and selective motor control is found to be improving later especially on regular rehabilitation. This issue was not clarified in most of published series. One case (2%) developed transient paresthesia following tibial neurotomies and 3 cases (6%) with superficial wound infection necessitated debridement and secondary sutures. In **Buffenoir, Roujeau and Lapierre**[11] study, 5.45% of patients developed transient paresthesia and 1.8% superficial wound infection.

In **Maarrawi, Mertens and Luaute**[9] prospective study of 31 patients undergoing upper limb neurotomy, 3.2% developed transient hypothesia, 3.2% transient weakness and 6.4% developed postoperative hematomas.

All published reports of recurrence were concerning selective tibial neurotomies. No recurrence was reported in our study, following selective neurotomy ± complementary orthopedic procedure(s) either clinically or electrophysiologically all through follow up over mean follow-up period of 6 months (we did ≤ 50% resection for both soleus and gastrocnemius ± other branches). Our result was the same as **Decq, Shin and Carrillo-Ruiz**[13], they performed less than 50% resection for both soleus and gastrocnemius branches ± other branches and they reported no recurrence in their patients. While recurrence occurred in two patients (33%) in **Roujeau, Lefaucheur and Slavov**[12] series; he did 80% resection for soleus branch only, which was considered insufficient by him and patients underwent 2nd procedure for gastrocnemius branches. The highest recurrence was reported by **Berard, Sindou and Berard**[14], 65.5% of patients showed recurrence of equines deformity, they did 70-80% resection, they concluded that “the greater the neurotomy, the larger the motor units reinnervated by the surviving motor neurons”, the higher the recurrence.

The mean operative duration for group A patients was 1.28 hours. The mean duration of hospital stay for patients with selective neurotomy was 1.7 days.

Selective dorsal rhizotomy has become accepted as a standard neurosurgical procedure for the treatment of spasticity associated with cerebral palsy. Further indications were also reported[15], 15 children in this work were treated with selective dorsal rhizotomy for lower limb spasticity. All have spastic diplegia with MRI evidence of normal basal ganglia structures. There is no doubt that the procedure of selective rhizotomy has an obvious effect on muscle tone of lower limbs. At the first postoperative month, all children in our group showed a very high significant ($p < 0.001$) reduction of tone. The reduction in the muscle tone is maintained throughout the follow-up period of 3 patients (20%) showed decrease of their tone by 4 grades and 8 patients (53.3%) showed decrease musacle tone by 3 grades, 4 patients (26.6%) showed decrease of muscle tone by 2 grades. But, all patients (100%) showed immediate postoperative muscle tone improvement.

The mean Hmax/Mmax for the right lower limb was 0.631 and for the lift lower limb was 0.662 6 months postoperatively. They were 0.146 for the right lower limb and 0.133 for the left lower limb.

The improvement in the muscle power was very obvious and highly significant 6 months postoperatively ($p < 0.001$), 5 patients (33.3%) showed increase of their motor power by 2 gradesd and 9 patients (60%) showed increase of their muscle power by one grade. One patient (6.7%) showed no improvement in the muscle tone, but a total of 14 patients (93.3%) showed improved muscle tone.

The improvement of joint range of motion was obvious at the first month and was statistically significant ($p = 0.001$) and tends to decrease during the period of follow up.

The mean H/max/Mmax for the right lower limb was 0.631 and for the left lower limb was 0.662 postoperatively. The mean Hmax/Mmax was significantly reduced ($p < 0.001$) to be in the right lower limb (0.146) and in the lift lower limb (0.133).

In our study, significant improvement in gait and pain was obvious ($p = 0.05$). In **Steinbok**[16] series of 20 patients with spastic diplegia showed significant improvement in pain and gait ($p = 0.01$).

In our cases, meticulous preoperative, intraoperative and postoperative medication with bronchodilators ensured smooth postoperative course regarding bronchospasm which was recorded in **Steinbok**[16] study to occur in 8.3% of cases. Complications were 26.7% in the form

OCSF leakage in two children which required exploration and dural repair.

Four patients (26.7%) of the patients developed postoperative wound infections, 2 patients (13.3%) needed debridement and wound repair. Transient paralytic ileus occurred in 5 patients (33.3%).

None of our patients had postoperative urinary retention owing to proper identification of roots at exit foramina and intraoperative monitoring for sphincter costimulation.

The mean operative duration for selective dorsal rhizotomy was 292.2 minutes. This may be due to bilateral dorsal rhizotomy from L_1 to S_1 sparing L_3 in all cases.

The mean duration of hospital stay was 6.2 days. This is due to postoperative complications.

In our study, improvement in the physical, functional and electrophysiological parameters was significantly in both groups with nearly no significant difference between both groups. Except for that selective dorsal rhizotomy is associated with high complication rate requiring more operative time and more hospital stay. Selective neurotomy cannot be applied in proximal lower limb muscle spasticity (iliopsoas).

CONCLUSION

Both neurotomies and dorsal rhizotomies utilized for alleviating symptoms of lower limb spasticity included were safe surgical procedures and were provided with good improvement in respect of: muscle power, severity of spasticity, patient's ambulation, gait, range of joint movement, associated pain, functional disability and nerve excitability (H/M ratio) with no significnat diffference between both procedures. However, neurotomies had shorter operative duration and hospital stay which is of significant value.

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العلاج الجراحى للتقبض العضلى المستعصى

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تم إختيار خمسين طفلاً يعانون من تقبض عضلى مستعصى على مدار ثلاثة أعوام وتم تقسيمهم إلى مجموعتين: مجموعة (أ) : تشمل 35 طفلاً تم علاجهم بطريقة الإتلاف الإنتقائى للأعصاب الطرفية. مجموعة (ب): تشمل 15 طفلاً تم علاجهم بطريقة القطع الإنتقائى المحدود للجذور العصبية وتم متابعتهم على مدى ستة أشهر. وكان الهدف من الدراسة هو تقييم النتائج للعمليات الجراحية المستخدمة
وقد ثبت من الدراسة أن إستخدام الإتلاف الإنتقائى للأعصاب الطرفية والقطع الإنتقائى المحدود للجذور العصبية لعلاج أعراض التقبض العضلى فى الطرف السفلى من الطرق الجراحية الآمنة مع تحسن ملحوظ فى القوة العضلية وتراجع شدة التقبض العضلى وتحسن المشى ومدى حركة المفاصل وتحسن الأداء الحركى والوظيفى وتراجع الألم المصاحب للتقبض وتراجع نسبة (H/M) والتوتر العصبى مع عدم وجود إختلاف واضح بين نتائج الطريقتين فيما عدا أن الإتلاف الإنتقائى للأعصاب الطرفية أقل فى وقت إجراء الجراحة وأقل فى مدة البقاء بالمستشفى.