Functional Re-education after Selective Dorsal Rhizotomy in Diplegic Cerebral Palsied Children

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ABSTRACT

This study aimed to investigate the effect of functional physical therapy program, following dorsal rhizotomy on reduction of spasticity in diplegic cerebral palsied children. Ten subjects were selected randomly, following pre-set criteria. They represented the sample of this study. They were evaluated before the operation and six months after the operation and the physical therapy program. Evaluation included muscle tone assessment utilizing Ashworth s scale and range of motion assessment using electronic goniometer. The muscle tone assessment included hip extensors and adductors, knee flexors and extensors in addition to ankle planter-flexors. On the other hand, the range of motion comprised hip flexion and abduction, knee flexion and extension in addition to ankle dorsi-flexion. The physical therapy program consisted of three parts: first of all, guidelines following the operation, then home instructions and finally, therapeutic exercises aiming for stretching and mobilizing tightened structures and strengthening weakened muscles. The results revealed significant improvement in both muscle tone and range of motion. A significant reduction occurred in muscle tone, showing the best results in the hip extensors and adductors ($P<0.001$). Similarly, the best increase in range of motion was in the hip flexion and abduction ($P<0.001$).

INTRODUCTION

Cerebral palsy is a neuromuscular disorder that has an incidence of 1.5 to 2 per 1000 live births[2]. It is caused by non-progressive peri-natal damage to the developing central nervous system and is characterized by impaired motor movement and posture. It is classified according to the extent and location of the neuromuscular involvement into three major types: spastic, athetoid and ataxic[21].

The spastic form is the most common type of cerebral palsy and has become more prevalent due to the survival rates of pre-term infants [8]. Spasticity develops as the descending motor nerve tracts are damaged and normal muscle movements are resisted or limited[4]. The resulting muscle contractures limit joint movement and hence, create abnormal motor pattern[22]. Until recently, treatment of muscle spasticity in children with cerebral palsy has consisted of physical therapy, bracing and surgery to release and lengthen tight tendons of contracted muscles and correct muscle contractures[7].

Selective dorsal rhizotomy (SDR) is a neurological intervention, being used increasingly to reduce spasticity in children with cerebral palsy[1,19]. It was first described by Foester[9], modified to be selective by Fasono et al.,[6]. The goal of this procedure for spastic diplegic children was to increase functional activity[9]. It does not change other features of cerebral palsy such as weakness, lack of motor control, poor balance, severe contractures of muscles and joints, tonic neck reflexes or

involuntary movements. It has been recommended that individualized therapy goals with specific functional objectives should be determined before surgery[6].

Neuro-physiological evidence supports the view that spasticity is the result of decreased inhibition from multiple upper motor neuron and inter-neuron inputs and possible increased excitability of alpha motor neurons[11,24]. Sensory afferents from the muscle, thought to provide the primary input for the stretch reflex, have a predominantly excitatory effect on alpha motor neurons. The developers of SDR reasoned that excitatory sensory input to the anterior horn could be diminished without impairing sensory function[14]. Electro-physiological measurement criteria were introduced by Fasono et al.,[6] and modified by Peacock et al.,[18] to optimize the selectivity of the rhizotomy.

The success of SDR depends on the careful selection of children. Children, whose principal impairments are due to spasticity, benefit the most, whereas those with other problems (i.e. rigidity, dyskinesia or ataxia) do not benefit. Specific post-operative care and intensive therapy retaining are said to be essential to successful outcome[1].

The reduction of spasticity gives the therapists a better opportunity to facilitate normal movement patterns and makes it possible for children to progress more rapidly[22]. The functional consequences of SDR are more important and contentious than the changes in spasticity[14]. Uncontrolled clinical series describe improvements in musculo-skeletal alignment, ambulation, upper extremity control, speech and even recognition[4,16]. It is important for such a child to have physiotherapy before and after surgery[22].

AIM OF THE STUDY

To evaluate quantitatively the effect of a specific non-invasive physical therapy program on improvement of functional activity in diplegic cerebral palsied children after selective dorsal rhizotomy.

SUBJECTS, MATERIALS AND METHODS

SUBJECTS

Ten diplegic cerebral palsied children, ranging in age from 5 to 7 years were selected as the sample for this study. They were 8 boys and 2 girls, who met the following criteria:

- They had a diagnosis of spastic diplegia, from grade 1 to grade 3, according to Ashworth s Scale[3].
- Their intelligence quotient (IQ) was not less than 70.
- They were not suffering from any other neurological motor abnormalities (e.g. athetosis, dystonia or ataxia).
- They were free of fixed musculo-skeletal problems (contractures of hips, knees and ankles of either lower limbs, or hip subluxation).
- They had the ability to participate for the duration of the study.
- They had no medications that might interfere with treatment program.

MATERIALS

1. For evaluation:

- Ashworth s Scale[3].
- Electronic goniometer.

2. For treatment:

- Gymnastic mats, balls, rolls, wedges and walkers.
- Standing frames.
- Parallel bars.

METHODS

1. For evaluation

Physical therapy evaluations were done 48 hours before surgery and 6 months after surgery. Differences between preoperative and post-operative evaluation scores in both lower limbs spasticity and ROM for hips, knees and ankles were evaluated.

(a) Ashworth s scale[3] was used to measure the degree of spasticity (hip extensors and adductors, knee flexors and extensors and ankle dorsi-flexors) of both lower limbs.

(b) Electronic goniometer was used to measure ROM (hip flexion and abduction, knee flexion and extension and ankle dorsi-flexion) of both lower limbs.

2. For treatment:

Postoperative routine rhizotomy protocol was performed immediately from the first day after the operation.

A) Physiotherapy Guidelines following Selective Posterior Rhizotomy[7]:

- During the first few postoperative weeks, passive trunk rotation, lateral flexion and flexion were avoided. These were gradually introduced actively as tolerated.
- Passive range of motion exercises. Straight leg raising began to 30 degrees only and was gradually increased as tolerated.
- Dorsi-flexion with knee extended. Planter-flexion with knee flexed or extended. Add inversion, eversion, toe motion and combinations of motion.
- Knee flexion in prone with hip extended. Hip extension in prone with knee flexed. Knee extension: activation of quadriceps in various positions with control (i.e. supine, sitting, supported standing).

B) Home Instructions for Rhizotomy Patients[7]

The following precautions were given for the first 3-4 weeks:

- No bending at the waist, or excess twisting.
- Keep knees with or lower than hips in sitting.
- The child was allowed to move actively as tolerated (limited by discomfort or pain).
- Not to get the incision wet until 2 weeks following surgery unless otherwise instructed.

C) Physical Therapy program included:

- The outpatient physiotherapy began 2 weeks, following surgery.
- Proprioceptive training in the form of slow rhythmic approximation, touch and weight bearing.
- Stretching exercises for Achilles tendon and hamstring muscles.
- Facilitation of postural reactions (righting, equilibrium and protection).
- Gait training programs e.g. between parallel bars, using walkers and climbing stairs.
- The treatment program was conducted for 6 successive months, 5 times per week for 3 hours per sessions.

RESULTS

The collected data were statistically treated to show the mean value of muscle tone and range of motion pre and post-operatively, as well as the mean difference and the percentage of change. The results were also analyzed using t-test to obtain the significance of the present study.

1- Muscle tone

As shown from table (1) and fig. (1), the mean value of muscle tone grades of the hip extensors pre-operatively was 2.4 0.84, which

decreased after 6 months of treatment to be 1.1 0.74. The mean difference was 1.3 0.67, which forms a percentage of change of 54.17%, which indicated a highly significant decrease (t=6.19, P<0.001). Meantime, the mean value of the muscle tone of hip adductors decreased from 2.1 0.74 before operation to 1.2 0.92 after operation, forming a mean difference of 0.9 0.57 and a percentage of change of 42.86%. The results showed a highly significant change (t=5.00, P<0.001). Concerning the knee flexors, the mean value of muscle tone was 1.5 0.97, which underwent a decrease post-operatively to be 0.8 0.92, with a mean difference of 0.7 0.67 and a percentage of change of 46.67%, which was statistically significant (t= 3.33, P<0.01). Pre-operatively, the mean value of knee extensors muscle tone was 2.1 0.88, which decreased after the suggested period of treatment to be 1.2 0.79. The mean decrease in the muscle tone of the knee extensors was 0.9 0.74, representing a percentage of change of 42.86%. A significant improvement was noted in the muscle tone of knee extensors (t=3.91, P<0.01). Furthermore, a similar decrease occurred in the mean value of ankle planter-flexors muscle tone from 2.0 0.67 before the operation, to be 1.0 0.82 after 6 months of physical therapy program, following the surgical interference. The mean difference during this period was 1.0 0.82, forming a percentage of change of 50.00%, which was statistically significant (t=3.85, P<0.01).

Table (1): Shows mean values and standard deviations of muscle tone (in grades) pre- and post-operatively, percentage of change and t-test.

Muscle		Mean	MD	% of change	SD	SE	t	P
Hip extensors	(Pre)	2.4 0.84	1.3 0.67	54.17%	0.67	0.21	6.19	<0.001
Extensors	(Post)	1.1 0.74						
Adductors	(Pre)	2.1 0.74	0.9 0.57	42.86%	0.57	0.18	5.00	<0.001
Adductors	(Post)	1.2 0.92						
Knee flexors	(Pre)	1.5 0.97	0.7 0.67	46.67%	0.67	0.21	3.33	<0.01
Flexors	(Post)	0.8 0.92						
Extensors	(Pre)	2.1 0.88	0.9 0.74	42.86%	0.74	0.23	3.91	<0.01
Extensors	(Post)	1.2 0.97						
Ankle planterflexors	(Pre)	2.0 0.63	1.0 0.82	50.00%	0.82	0.26	3.85	<0.01
Planterflexors	(Post)	1.0 0.82						

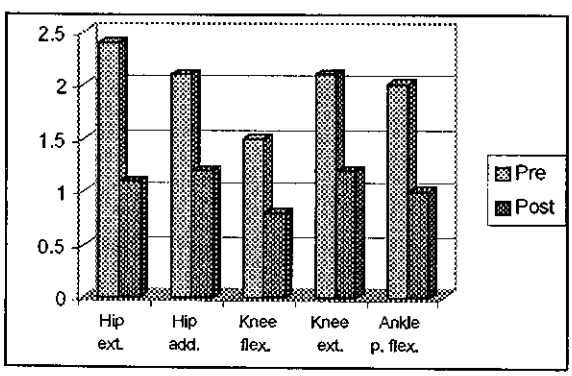

Fig. (1): Shows mean values of muscle tone grades pre- and post-operatively.

2- Range of Motion

As shown from table (2) and fig. (2), the mean value of ROM of the hip flexion pre-operatively was 97.0 14.68, which increased after 6 months of treatment to be 108.5 10.55. The mean difference was 11.5 5.30, and the percentage of change was 11.86%, which indicated a highly significant increase (t=6.85, P<0.001). Meantime, the mean value of ROM of hip abduction increased from 33.6 2.46 before operation to

37.2 2.57 after operation, forming a mean difference of 3.6 1.51 and a percentage of change of 10.71%. The results showed a highly significant change (t=7.5, P<0.001). Concerning the knee flexion, the mean value of ROM was 109.5 9.26, which underwent an increase post-operatively to be 118.0 10.06, with a mean difference of 8.5 6.69 and a percentage of change of 7.76%, which was statistically significant (t=4.01, P<0.01). Pre-operatively, the mean value of knee extension (diminished last degrees of knee extension) ROM was 14.0 9.66, which decreased after the suggested period of treatment to be 11.3 8.38. The mean decrease in the ROM of the knee extension was 2.7 2.26, representing a percentage of change of 19.29%. A significant improvement was noted in the ROM of knee extension (t=3.75, P<0.01). Furthermore, a similar increased occurred in the mean value of ankle dorsi flexion ROM from 3.8 2.25 before the operation, to be 4.9 2.28 after 6 months of physical therapy program, following the surgical interference. The mean difference during this period in dorsi-flexion ROM was 1.1 0.99, forming a percentage of change of 28.95%, which was statistically significant (t=3.55, P<0.01).

Table (2): Shows mean values and standard deviations of range of motion pre- and post-operatively, percentage of change and t-test.

Muscle		Mean	MD	% of change	SD	SE	t	P
Hip flexion	(Pre)	97.0 14.68	11.5 5.3	11.86%	5.30	1.68	6.85	<0.001
flexion	(Post)	108.5 10.55						
abduction	(Pre)	33.6 2.46	3.6 1.51	10.71%	1.51	0.48	7.50	<0.001
abduction	(Post)	37.2 2.57						
Knee flexion	(Pre)	109.5 9.26	8.5 6.69	7.76%	6.69	2.12	4.01	<0.01
flexion	(Post)	118.0 10.06						
extension	(Pre)	14.0 9.66	-2.7 2.26	19.29%	2.26	0.72	-3.75	<0.01
extension	(Post)	11.3 8.38						
Ankle planterflexion	(Pre)	3.8 2.25	1.1 0.99	28.95	0.99	0.31	3.55	<0.01
Planterflexion	(Post)	4.9 2.28						

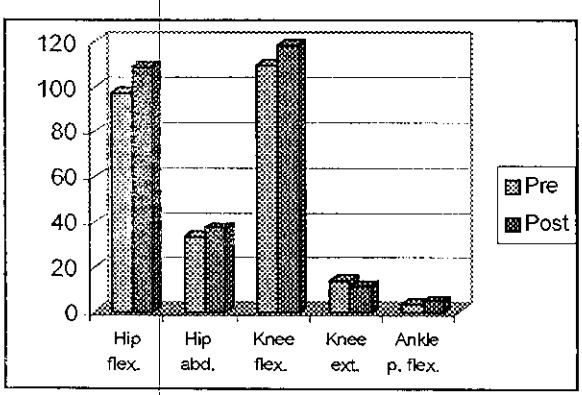

Fig. (2): Shows mean values of range of motion pre- and post-operatively.

DISCUSSION

In the present study, selective dorsal rhizotomy and physical therapy program were utilized to investigate the changes produced in muscle tone and range of motion for both lower limbs in spastic diplegic cerebral palsied children.

Cerebral palsied children are hampered in performing a variety of motor tasks because of the inappropriate muscle action as well as secondary contractures and deformities. Because of the wide variation in the nature of the underlying neurological deficit, the abnormal movements observed in patients

with cerebral palsy can be attributed to many factors. For some, spasticity is the major finding[4].

Sectioning of the posterior roots to reduce tone is not a new idea. Fasono et al.,[6] and Peacock et al.,[17] reported that one could achieve good tone reduction with a less-extensive dorsal-root section, thereby minimizing sensory loss.

The results obtained from the present study demonstrated the evidence of inhibition of spasticity. This finding is in agreement with Mc Laughlin et al.,[14], who reported that SDR is safe and can reduce spasticity in children with spastic diplegia. They evaluated the effectiveness of the combined treatment, including SDR plus physical therapy (PT) on 38 diplegic children through 24 months. After the recommended period of treatment, they concluded that the results of the combined-treatment group were better than that of the physical therapy only group in mean reduction of spasticity, utilizing the spasticity measurement system.

The present study suggests that children with spastic diplegia have the most to gain in terms of improved range of motion (ROM) and functional mobility after SDR and post-operative PT. These findings are consistent with other reports, regarding selection of children most likely to benefit from such procedure[17]. Landau and Hunt[12] argued that children with spastic diplegia and milder forms of cerebral palsy are those children most likely to improve with time and therapy. Steinbok et al.,[20] and Wright et al.,[23] observed a decrease in Ashworth s scale score of approximately one full grade after SDR and physical therapy, which is very near to the results of this study.

The obtained results indicated that children, underwent SDR and PT had more improvement in ROM for both lower limbs. These findings confirmed those of Ferguson and Ortman[7]. They stated that SDR is a surgical intervention that selectively cuts the spinal sensory nerve rootlets, carrying the most abnormal signals, thereby reducing spasticity in all muscle groups of the affected extremities. Children who have this procedure, gain a significant increase in knee and hip ROM and increased strength and muscle control, if they have good family support with an intensive post-operative PT.

Ferguson and Ortman[5] empha-sized the importance of the combined effects of SDR and post-operative PT. They also added that reduction of spasticity alone may be of value but functional gains are determined by the child s response to the change and development patterns. Continued learning and practice by the child are guided through PT.

Montgomery[15] reviewed progress over varying time periods of 14 children, who received rhizotomy and post-operative PT. Changes in upper extremity function and speech were determined by subjective reports, obtained from the parents in post-procedure interviews. Mobility changes were based largely on the physical therapist s clinical impressions prior to and following rhizotomy.

Peacock and associates[10] reported improvements in muscle tone and function from motor segments, following rhizotomy. They stated that reduction of spasticity at other segmental levels, distant from rhizotomy might be related to reduction of stimulation, transmitted by medullary interneurons. Mc Donald[13] referred to such outcomes as supra-segmental effects . Improvement in function, other than in the lower limbs strength, has also been attributed to improved posture, proximal control, transitional movements and balance that would have an attempt on fine motor and oral motor skills.

CONCLUSION

From the previous results, it can be concluded that six months of physical therapy, following dorsal rhizotomy are efficient to improve diplegic cerebral palsy children, through reduction of muscle tone and the subsequent increase in range of motion of lower limb muscles and joints, respectively.

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الملخص العربي

إعادة التعليم الوظيفي للأطفال المصابين بالشلل الدماغي (من النوع المصاب بالطرفين السفليين أكثر من العلويين) بعد عملية قطع للحزمة العصبية الخلفية للنخاع الشوكي

تهدف هذه الدراسة إلى توضيح تأثير برنامج علاج طبيعي وظائفي تم بعد عملية تثبيط للتقلص العضلي بواسطة عملية جراحية للحزمة العصبية الخلفية لإيقاف نشاطها في حالات الأطفال المصابين بالشلل الدماغي (من النوع المصاب بالطرفين السفليين أكثر من العلويين)، وقد اشترك عشرة أطفال في الدراسة تم اختيارهم عشوائيا بما يحقق المعدلات المطلوبة للدراسة، وقد تم اختبارهم قبل إجراء العملية الجراحية وبعد ستة اشهر من إجرائها وتنفيذ برنامج العلاج الطبيعي. أما تقويمهم فقد احتوى على اختبار "أشوار" للنغمة العضلية واختبار لمدى حركة المفاصل بواسطة الجهاز الإليكتروني لقياس مدى حركة المفصل، والنغمة العضلية تم اختبارها في العضلة المادة لمفصل الفخذ والضامة والمادة لمفصل الركبة بالإضافة إلى الضامة لأسفل مفصل الكاحل، أما مدى الحركة فقد تم اختباره في ثنى مفصل الحوض و ثنى ومد مفصل الركبة بالإضافة إلى ضم مفصل الكاحل لأعلى، أما برنامج العلاج الطبيعي فقد تكون من ثلاثة أجزاء هي تعليمات ما بعد الجراحة ثم تعليمات للتنفيذ بالمنزل ومجموعة من التمرينات تهدف إلى شد وتليين الأنسجة الرخوة القصيرة وتقوية العضلات الضعيفة، وتشير نتائج هذه الدراسة إلى تحسن ذو دلالة إحصائية في النغمة العضلية ومدى حركة المفاصل .