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Two Different Methods of Botulnium Toxin A Injection for Releasing of Hip Adductor Spasticity in Diplegic Children

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Authors' contributions

This work was carried out in collaboration between both authors. Author RAM designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript and managed literature searches. Author RKE managed the analyses of the study and literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Aim: To compare the effects of Botulnium Toxin A injection of hip adductor muscles (adductor longus and brevis) and gracilis muscle on motor function, balance and gait parameters of the children with diplegic cerebral palsy.
Study Design: Prospective, randomized controlled study.
Place and Duration of Study: National Institute for Neuro-Motor System, Out-patient Clinic, Faculty of Physical Therapy, Cairo University and Kasr El Aini Hospital from June 2013 to September 2014
Methodology: Thirty diplegic cerebral palsied children of both sexes were selected. Their ages ranged from 8 to 10 years. They were assigned randomly into two equal study groups. Group I received Botulnium Toxin A injection of bilateral adductor longus and brevis muscles, while group II received Botulnium Toxin A injection of bilateral gracilis muscles. In addition, both groups received the same designed physical therapy program three times per week for three successive months. Gross Motor Function Measure-88 standing and walking subsections, stability indices, kinematic

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gait parameters were evaluated before and after three successive months of treatment.
Results: Significant differences were observed in both groups when comparing their pre and post treatment mean values of all measuring variables ($P < 0.05$) except non significant differences of mediolateral stability index in group I was recorded ($P > 0.05$). Also, significant differences were recorded when comparing the post treatment mean values of all measuring variables of both groups in favor of group II ($P < 0.05$).
Conclusion: Botulnium Toxin A injection of the gracilis muscle is an excellent supplement to regularly scheduled physical therapy intervention for children with diplegic cerebral palsy.

Keywords: Botox; adductor muscles; spasticity; diplegic cerebral palsy.

1. INTRODUCTION

Cerebral palsy (CP) that can be defined as a movement and posture disorders that appear at an early age, is secondary to a lesion or dysfunction of the central nervous system and is not caused by any known progressive or degenerative brain disease [1]. Motor disorders of children with CP are related to primary deficits such as spasticity, muscle weakness, reduced coordination, and a loss of selective motor control, and secondary deficits such as muscle contracture and bone deformities [2]. Of all primary problems, spasticity is the main cause of the development of secondary problems [3]. Spastic diplegia affects nearly 35 percent of CP. children and is the most common form of CP. All four limbs are affected; both legs as well as mild effects in the arms are present [4]. Spasticity of the adductors forms part of the clinical picture diplegia [5]. In diplegia, motor deficits and spasticity typically produce a walking pattern characterized by equinus ankle position, exaggerated knee flexion with genu valgus, as well as increased hip adduction and internal rotation [6]. These children are at great risk of deterioration in their walking ability as they grow up [7].

School-age children with diplegic CP were less physically active than normal children. Decreased physical activity in children with CP may be related to gait capacity. These characteristic features influence quality of life of children with CP by reduction of daily life activities and independent mobility [8]. Impaired balance, gait disturbances and frequent falls are common problems in CP children [9]. Because of motor weakness and poor voluntary motor control, crouched gait or diplegic gait is an important functional biomarker in children with spastic diplegic CP [10].

A treatment program should, therefore, focus the reduction or normalisation of tone to prevent the development of secondary problems and delay or obviate the need for surgical intervention [3]. Specific treatment choices include oral medications in the form of centrally acting muscle relaxants, interventional treatment like intrathecal baclofen pump and neurolysis, as well as surgical interventions [11]. The use of muscle relaxant drugs is usually considered for spasticity with severe impairment in global motor function, but is associated with side effects like nausea, diarrhea, sedation, fatigue, dizziness, lowering of the seizure threshold, hepatotoxicity, withdrawal symptoms, and cognitive dysfunction [12].

It became clear that the use of Botulnium Toxin A (Botox A) was a major advance in the treatment of CP and it is now widely accepted in the management of paediatric posture and movement disorders. Children who received Botox A demonstrate several advantages such as less loss of muscle strength, less financial costs, better objective gait data and less absence in school, compared to patients who already underwent a surgical intervention at a young age. Moreover, soft tissue surgery also has a high recurrence rate and a higher risk of lengthening muscles or tendons which were in fact dynamically not too short at all (objective gait data) [3]. Following intramuscular injection, the neurotoxin causes a reversible neuromuscular blockade, creating both muscle weakness and a reduction in tone [13]. Botulnium Toxin A injection is safe and effective when used in a single session of injections and produces a sustained structural modification of the lower limbs [1]. The Botox A efficacy period is known to be of 3 months [14]. Thus, treatment is usually desirable, but it is difficult to treat spasticity successfully. The aims of treatment should be to improve function, to reduce the risk of unnecessary complication, to alleviate pain, and to assist with the maintenance of hygiene, dressing, and transferring [15]. Physical therapists are involved in numerous aspects of

management of children who have been identified as candidates for Botox A therapy [16].

There is little evidence to show that injection for adductor spasticity results in improvement of gait, although such injection is often included in a multilevel approach in these conditions [17]. So, the purpose of this study was to compare between the effects of Botox injection on hip adductor muscles (adductor longus and brevis) and gracilis muscle on motor function, balance and gait parameters of the children with diplegic cerebral palsy.

2. SUBJECTS, RANDOMIZATION AND METHODS

2.1 Subjects

Thirty children with diplegic CP from both sexes were recruited to participate in this study via National Institute for Neuro-Motor System, Out-patient Clinic, Faculty of Physical Therapy, Cairo University. The children were selected with inclusion criteria including age, height and weight: they were between 8 and 10 years (yrs); their height ranged between 120 and 125 cm and their weight ranged between 24 and 27 kilograms (kg). Children had sufficient cognition and were able to understand commands given to them. They had no previous history of surgery on the lower limbs or Botox injections of the lower limb muscles within the preceding 6 month. They had level II on Gross Motor Functional Classification Scale (GMFCS) [18]. They were able to walk independently without the use of walking aids but with crouch gait. Children had dynamic hip adduction deformity (dynamic deformities were considered to be those in which the limb could return to the neutral position with maximal or submaximal passive manipulation). The degree of spasticity was grade 2 according to Modified Ashowrth Scale [19]. They had grade 3 on spasticity scale for thigh adductors. Spasticity scale for thigh adductors: 0–normal muscle tonus; (1) increased tonus, thighs easily abducted up to 45º by only one examiner; (2) thighs abducted up to 45º by only one examiner with minor effort; (3) thighs abducted up to 45º by only one examiner with moderate effort; (4) two examiners were needed to abduct thighs up to 45º [1].

Children who had one or more of the following criteria were excluded from the study: any medical conditions that would severely limit a child's participation in the study as vision or hearing loss, cardiac anomalies, athetotic type, surgical intervention to correct lower-extremity orthopedic abnormalities, previous history of fracture, severe muscle contracture or the presence of subluxation or dislocation.

The children were randomly assigned into two study groups of equal number: group I (adductor longus and brevis muscles group including: 8 boys and 7 girls), and group II (gracilis muscle group including: 7 boys and 8 girls). All procedures involved for evaluation and treatment, purpose of the study, potential risks and benefits were explained to all children and their parents. This work was carried out in accordance with the code of Ethics involving humans. Parents of the children signed a consent form prior to the participation. The study was approved by an Ethical Committee of the Cairo University.

*2.*2 Randomization

Thirty-four children were assessed for eligibility. Four children were excluded as they did not meet the inclusion criteria. Following the baseline measurements, randomization process was performed using closed envelopes. The authors prepared 30 closed envelopes with each envelope containing a card labeled with either group I or II. Finally, each child was asked to draw a closed envelope that contained one of the two groups. The study design is demonstrated as a flow chart demonstrated in Fig. 1.

2.3 Methods

2.3.1 For evaluation

Motor function, stability indices and gait parameters were evaluated by using Gross Motor Function Measure (GMFM–88), Biodex Stability System and Balance Master System respectively. The evaluation was done before and after three successive months of treatment.

2.3.1.1 Gross Motor Function Measure (GMFM–88)

The children's motor functions were measured by the Gross Motor Function Measure (GMFM–88) [20]. Gross Motor Function Measure is a criterion reference tool that is designed to measure

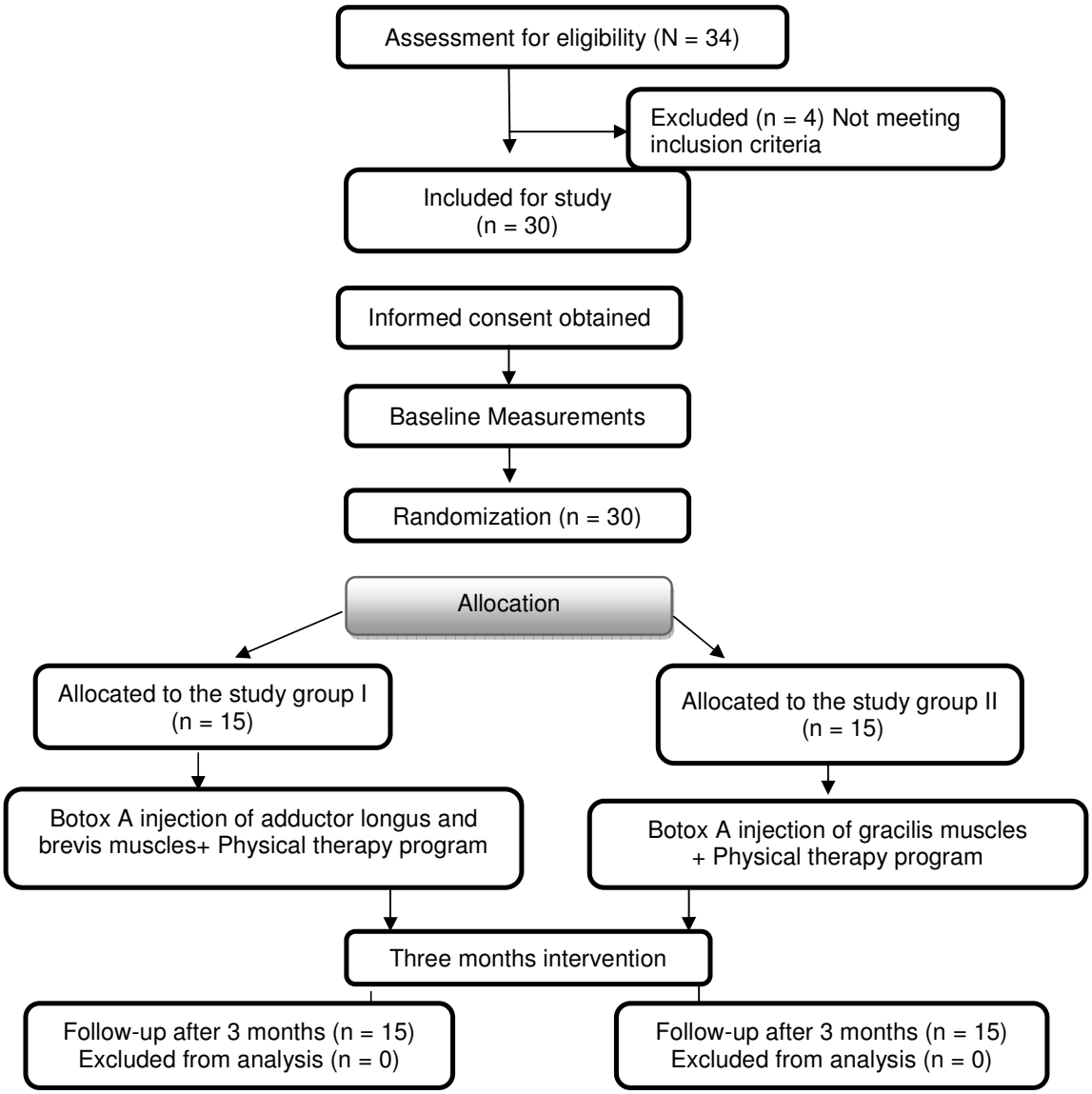

Fig. 1. Flow chart of the study design

changes in gross motor function over time in children with motor impairment and has been validated for sensitivity to changes in children with CP. Measures of function and ability were essential to consider when evaluating the effects of Botox for all children with CP [16]. The reliability of scores obtained with the 88-item was sufficiently high (intraclass correlation coefficient [ICC] 5.90). The 88 items of the GMFM were measured by observation of the child and scored on a 4-point ordinal scale (05 does not initiate, 15 initiates 10% of activity, 25 partially completes 10–100% of activity, 35 completes activity). The items were weighted equally and grouped into 5 dimensions: (1) lying and rolling (17 items), (2) sitting (20 items), (3) crawling and kneeling (14 items), (4) standing (13 items), and (5) walking, running, and jumping (24 items) [21]. The last two dimensions were tested in this study prior to initiating intervention and immediately at the end of intervention. Scores for each dimension were expressed as percentage of the maximum score for that dimension. This test was done with the same examiner pre and post treatment assessment.

2.3.1.2 Balance evaluation

Biodex Stability System was used in balancing lab of Faculty of Physical Therapy, Cairo

University. It was used for balance evaluation using dynamic limit of stability which was performed on stability level 8. This agrees with Revel et al. [22] who reported that, balance assessment should attempt to stimulate dynamic condition in order to stress the postural control system fully and reveal the presence of balance disorder. At first, certain parameters were fed to the device including: child's weight, height, age and stability level (platform firmness). Each child in the two groups was asked to stand on the center of the locked platform within the device with the two legs stance while grasping the handrails. The display screen was adjusted, so he could look straight at it. Then the child was asked to achieve a centered position, in a slightly unstable platform, by shifting his feet position until it was easy to keep the cursor (representing the center of the platform) centered on the screen grid while standing in comfortable upright position. Once the child was centered, the cursor was in the center of the display target, he was asked to maintain his feet position till stabilizing the platform. Heels coordinates and feet angles from the platform were recorded as follows: heels coordinates were measured from the center of the back of the heel, and foot angle was determined by finding a parallel line on the platform to the center line of the foot. The test began after introducing feet angles and heels coordinates into the Biodex System. The platform advanced to an unstable state, then the child was instructed to focus on the visually feedback screen directly in front of him. While both arms at the side of the body, he attempted to maintain the cursor in the middle of the bulls eye on the screen. Duration of the test was 30 seconds (sec.). The result was displayed on the screen at the end of each test including overall stability index, antero-posterior stability index, and medio-lateral stability index. The mean of the three repetitions was determined. The high values mean was that the child had balance difficulty [23].

2.3.1.3 Balance master system

Balance Master System (NeuroCom ® International Inc., 2004) was used in Kasr El Aini Hospital. It quantified the characteristics of gait as the child walked across the length of the force plate. Each child of both groups was demonstrated about his / her position, how to start and perform the test before starting. The child stood off the long force plate at starting end. Each child was instructed to "Hold" "Steady" away of the force plate until the "Go" appeared at the top of the screen and got walk across force plate and stayed off force plate at the other end. The test measured the following parameters: Step width (centimeters), step length (centimeters) and speed (centimeters / second).

2.3.2 For treatment

Children in Group I were injected in bilateral adductor muscles (adductor longus and brevis) while Group II in bilateral gracilis. One hour before the injection, all children were given oral paracetamol (40 mg/kg) and a topical anesthetic cream was applied at the injection sites. Neuro-pediatric specialist injected the children by Botox A (Allergan, USA) with a total of 6 units/kg of bodyweight at 2 injection sites in each side [1,24]. After the injection, the parents were instructed to use standing, walking and sitting hip orthosis (S.W.A.S.H brace) for 23 hours per day for two successive weeks to maintain the flexibility that has been gained with previous treatment by Botox [25,3]. All the children wore bilateral ankle foot orthosis (AFO_S) for 7 hours during the day in addition to using it as a night splint [26]. The effects of Botox A generally began after 1 to 3 days and reached its peak in about 21 days [27]. The children in both groups started the designed physical therapy program on the fourth day post injection. The program lasted for 1 hour, three times / week for 3 successive months. This program the following:

- Gentle stretching of bilateral calf muscles, knee flexor, hip adductor and hip flexor muscles were applied. Stretching maneuver was conducted for 10 seconds followed by 10 seconds rest and repeated for 5 times/ session.
- Isometric muscle contraction of bilateral anterior tibial groups, Knee extensor, hip abductor and hip extensor muscles for 15 min. Each contraction was maintained for five seconds followed by relaxation for another five counts of seconds. It was performed five times initially, building up to 10 repetitions as tolerated.
- High step standing and trying to keep balanced. The child was asked to lift his/her leg and put it at a step (small blocks) while he was standing and maintaining this position for 5 min for each leg alternately while the therapist sat behind.
- Standing on a declined surface" by using wedge". The child stood on a wedge towards the descending direction. The

therapist asked the child to maintain balance for 5 min.
- Standing with manual locking of the knees then trying actively to stoop and recover for 5 min.
- Open environment gait training: Forward, backward, and sideways walking with obstacles including rolls and wedges with different diameters and heights for 10 min.

2.4 Statistical Analysis

The collected data of the motor function, balance and gait parameters of both groups were statistically analyzed. Descriptive statistics were done in the form of mean and standard deviation (SD) of all measuring variables in addition to the age, weight and height. Paired t-test was conducted to compare between pre and post treatment mean values in each group. Unpaired t-test was conducted to compare between pre and post treatment mean values of all measuring variables between both groups. The level of significance for all statistical tests was set at $p < 0.05$. All statistical analysis was conducted through SPSS (Statistical Package for Social Sciences, version 20).

3. RESULTS

3.1 Pre-intervention Demographics and Scores, by Group

The children characteristics are presented in Table 1. The two groups were compared on demographic variables and baseline scores. There were no significant differences between both groups before treatment ($p > 0.05$) suggesting proper sample subdivision.

3.2 Post Treatment Results

Regarding the GMFM-88 score, paired t-test showed statistically significant differences ($p < 0.05$) in both groups at post treatment with respect to the pre treatment condition in both standing and walking dimensions (scores) as presented in Table 2. The obtained results in this study revealed statistically significant differences when comparing pre and post-treatment mean values ($p <0.05$) in the form of significant reduction in all stability indices of group II. While statistically significant differences in overall stability index, antero-posterior stability index for group I ($p <0.05$) were with no significant differences in medio-lateral stability index ($p >0.05$), as presented in Table 3. Mean values and standard deviations of gait parameters (step width, step length and speed) in both groups before and after treatment are presented in table 4. Statistically Significant differences were observed for both study groups at the end of treatment as compared with the corresponding mean values before treatment ($p <0.05$).

Regarding between-group difference revealed significant differences in all measuring in both groups in favor of group II ($p < 0.05$), as demonstrated in Figs. 2-5.

4. DISCUSSION

Spasticity in children with CP is a serious problem that affects daily life activities. It also prevents them from achieving the rehabilitation goals. Stiffness, restricted movement and a serious potential for joint complications are associated with muscles affected by spasticity [28]. Adductor spasticity is the predominant risk factor for hip dislocation which frequently requires surgical intervention [29]. Adductor spasticity impairs motor function and development [30]. The large majority of children with CP have difficulty in walking. Improving the ability to walk or perform other functional activities are often the primary therapeutic goals of CP [31]. Botulinum toxin A is a practical neuromuscular blocking agent that causes a clinical reduction in spasticity in working muscles [32].

However, numerous studies evaluated the effects of Botox A injection of adductor longus and brevis muscles on CP children but to our knowledge, this study is the first to compare between the effects of Botox A injection of hip adductor muscles (adductor longus and brevis) and gracilis muscle on motor functions, balance and gait parameters of the children with diplegic CP.

Conducting the study on children aged from 8 to 10 years may be attributed to the fact that preschool children around 5-6 yrs are expected to reach maturation of gait [33] and patients with CP between 7 and 14 yrs show defect in agility and balance tasks [34]. This also comes in agreement with Westcott et al. [35] who confirmed that, infant and young children (aged 4 months to 2 yrs) are dependent to the visual system to maintain balance, while at 3–6 yrs of age children begin to use somatosensory information appropriate. Finally, at 7– 10 yrs of age, children are able to resolve a sensory conflict and appropriately utilize the vestibular

system as a reference. He added that, postural control is essentially adult like by about 7 to 10 years of age. This age group was chosen as they had significant practice of their functional activities and changes in anthropometrics would have been fairly steady for several yrs [36].

The pre-treatment mean values of GMFM–88 score in standing and walking as well as gait parameters (step width, step length, step width and speed) in both groups showed no significant differences but revealed a significant decrease in their values in comparison to the normal values of the children in the same age group [37] which indicated that they had standing and gait problems. This is supported by Johnson et al. [38] who stated that, gait in children with CP is characterized by a slower walking speed, a shorter-stride length, and more time spent in double support.

Because of motor weakness and poor voluntary motor control, children with CP use a wider step width than normal children [39], suggesting that children with CP may choose a wider base of support in order to stabilize the center of mass. In addition, step width showed correlation with walking velocity, cadence, and stride length. Thus, children with a wider step width tend to have greater difficulty in gait performance [40].

Table 1. Pre-intervention demographics and scores, by group

Variable	Group I	Group II	*t*-value	*p*-value
Age (yrs)	8.50±0.57	8.60±0.39	0.56	0.58
Weight (Kg)	25.33±1.21	25.90±1.36	1.21	0.24
Height (cm)	121±1.73	121.80±1.62	1.32	0.20
Mean GMFM (score)				
-Standing	8.87±1.36	29.40±1.45	-1.84	.09
-Walking	30.80±1.27	31.20±1.37	-1.07	0.31
Stability indices				
-Overall	1.71±0.22	1.62±0.12	1.46	0.17
-A/P	1.36±0.27	1.40±0.24	-0.39	0.72
-M/L	1.47±0.22	1.37±0.14	1.42	0.18
Gait parameters				
-Step width (cm)	16.07±1.79	15.60±1.84	1.97	0.07
-Speed (cm/sec.)	71.53±3.58	71.73±2.71	-.25	0.81
-Lt Step length (cm)	35.07±1.79	35.33±2.38	-0.56	0.58
-Rt Step length(cm)	34.40±1.88	35.07±2.55	-1.38	0.19

Data are expressed as mean ± SD; P-value: Level of significance yrs: Years kg: kilogram cm: centimeter; sec.: Second GMFM: Gross Motor Function Measure A/P: Antero-posterior M/L: Medio-lateral; Group I: received injection of adductor longus and brevis Group II: received injection of gracilis

Table 2. GMFM-88 for standing and walking dimension scores for both groups

	Group I		Group II	
	Standing	**Walking**	**Standing**	**Walking**
Pre	28.87±1.36	30.80±1.27	29.40±1.45	31.20±1.37
Post	31.33±1.49	33.47±1.19	33.20±.42	36.33±1.29
***t*-value**	-10.43	-10.58	-9.67	-13.21
***p*-value**	< 0.05	< 0.05	< 0.05	< 0.05

Data are expressed as mean ± SD; Group I: received injection of adductor longus and brevis; Group II: received injection of gracilis, P-value: Level of significance

Table 3. Stability indices for both groups

	Group I			Group II		
	Overall SI	**A/P SI**	**M/L SI**	**Overall SI**	**A/P SI**	**M/L SI**
Pre	1.71±0.22	1.36±0.27	1.47±0.22	1.62±0.12	1.40±0.24	1.37±0.14
Post	1.27±0.25	0.98±0.09	1.45±0.20	1.01±0.11	0.85±0.06	0.88 ±0.08
t-value	23.13	6.66	0.26	51.33	9.69	16.92
p-value	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

Data are expressed as mean ± SD; SI: Stability index; A/P: Antero- posterior; M/L: Medio-lateral P-value: Level of significance Group I: received injection of adductor longus and brevis; Group II: received injection of gracilis

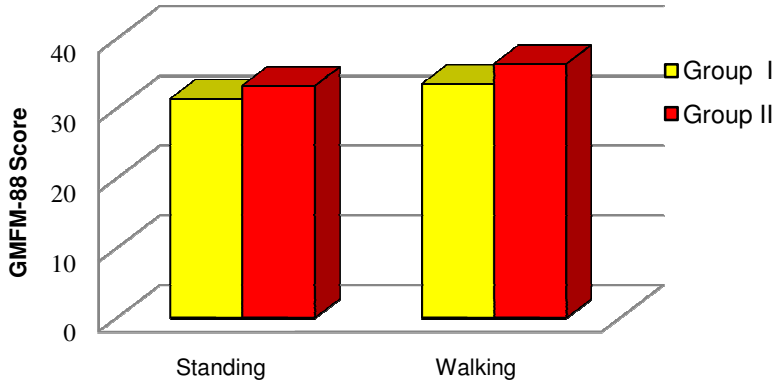

Fig. 2. Post-treatment GMFM-88 score of both groups

Group I: received injection of adductor longus and brevis
Group II: received injection of gracilis

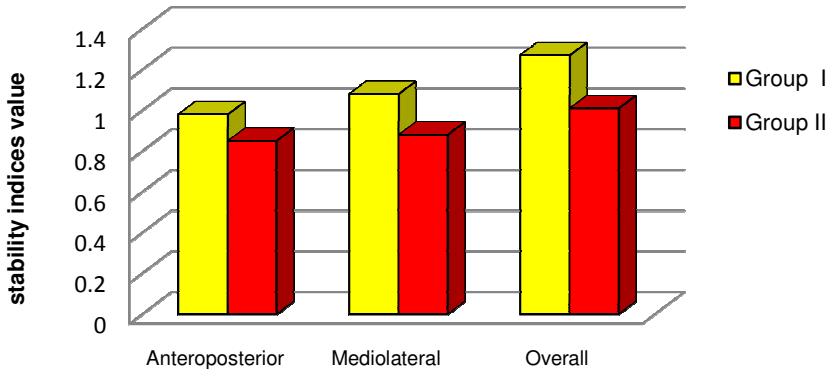

Fig. 3. Post-treatment stability indices of both groups

Group I: received injection of adductor longus and brevis
Group II: received injection of gracilis

Fig. 4. Post-treatment speed of both groups

Group I: received injection of adductor longus and brevis
Group II: received injection of gracilis

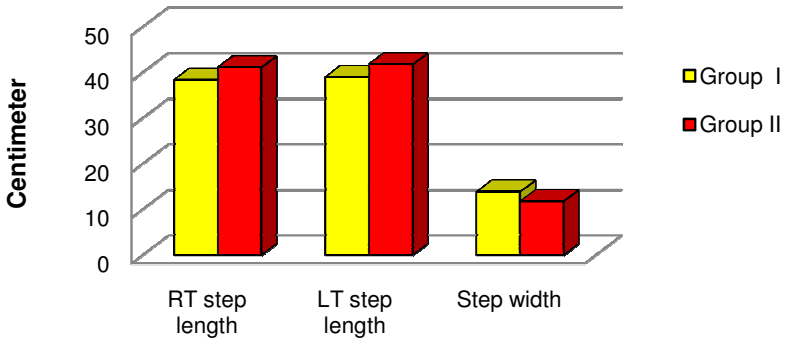

Fig. 5. Post-treatment step length and step width of both groups

Group I: received injection of adductor longus and brevis
Group II: received injection of gracilis

Table 4. Gait parameters pre and post treatment for both groups

	Group I				Group II			
	Step width (cm)	**Rt step length (cm)**	**LT step length (cm)**	**Speed (cm/ sec.)**	**Step width (cm)**	**Rt step length (cm)**	**Lt step length (cm)**	**Speed (cm / sec.)**
Pre	16.07±1.79	34.40±1.88	35.07±1.79	71.53±3.58	15.60±1.84	35.07±2.55	35.33±2.38	71.7±2.71
Post	13.87±1.51	38.40±1.84	39±2. 01	77.67±2.87	11.73±1.39	41.07±1.91	41.73± 2.22	83.8 0± 2.01
t-value	15.19	-14.49	-12.46	-8.26	14.13	-8.61	-8.94	-12.86
p-value	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

Data are expressed as mean ± SD, cm: Centimeter, sec.: Second , P-value: level of significance
Group I: received injection of adductor longus and brevis Group II: received injection of gracilis

comparing between mean values of pre-treatment results of the balance test including overall stability index, antero-posterior stability index and medio-lateral stability index in both groups revealed no significant differences and showed significant increase in their values indicating that they had balancing disorder as well [23].

Significant differences were recorded when comparing between pre and post treatment mean values of GMFM–88 score, balance and gait parameters within both groups except no significant differences in the mediolateral stability index were recorded for the group injected with Botox A in the adductor longus and brevis muscles. This improvement could be attributed to the combined effect of Botox A injection and the designed physical therapy program. This is supported by Molenaers et al. [3] who stated in order to influence all aspects of the child with CP, an ultimate treatment strategy has been set up, in which Botox A is optimally combined with the common conservative treatment options (physiotherapy, orthotic management, casting and even oral medication). Preiss et al. [17] added that all recipients of Botox A should be entered into an intensive program of physiotherapy so that the functional benefits may be extended beyond the clinical effect of the injection.

A number of studies emphasized the importance of physical therapy combined with Botox A treatment [41,42,43,44]. Botox should not be considered a substitute for physiotherapy or orthoses, but rather an additional therapeutic strategy [45].

A primary focus of a study by Wissel et al. [46] was the assessment of dose-response relationships to Botox A treatment in 33 children and adolescents with spastic gait due to CP. Results of gait analysis revealed significant

increases in gait speed and stride length in subjects in both treatment groups over baseline values.

Botox A has a variety of short-term successful outcome parameters, such as an increased range of joint motion [32], improved function through the GMFM [44], a reduction of muscle tone [46], an increased muscle length [47], an improved gait pattern [48].

A clear improvement in the spasticity of the thigh adductor muscles (adductor longus and brevis) was observed after treatment with Botox A, corroborating the findings of other studies [28]. A small, prospective pilot study has suggested that intramuscular injections of Botox A to the hip adductors and medial hamstrings combined with the use of the variable hip abduction orthosis could reduce spasticity and stretch the hip adductor muscles better than the brace alone [49]. The positive effect on the thigh adductor muscles (adductor longus and brevis) was progressive and was sustained throughout the follow-up period [1]. In a prospective, randomized study of 34 gracilis muscles in 27 children with CP (8.5±2.5 yrs) were injected with Botox (fixed dosage and dilution). Botox injection in the gracilis muscle at the sites with a high concentration of motor end plates resulted in improved spasticity [24].

Comparing between the post treatment mean values of all measuring variables for both groups revealed significant differences (P <0.05) in favor of the group that received injection of gracilis muscle. This could be explained as follows: first, gracilis muscle is biarticular muscle which moves the knee joint causing flexion and inward rotation while adductor longus and brevis muscles are monarticular. The spasticity of biarticular muscles is more than the spasticity of monarticular muscles. That is why the gracilis is more responsible for the adduction deformity of the hip joint [50,51]. Secondly, the monoarticular muscles are closely related to the antigravity activity, which keeps body in an upright position. However, careful observations revealed that adductor release including tenotomy of the adductor longus and brevis are likely to destroy antigravity activities of these adductors and induce deteriorating gait without stability [51]. So, adductor longus and brevis are more responsible about stability of the hip joint. Third, previous studies have reported that children with spastic diplegic CP show weakness of the hip abductor muscles [52,53]. Therefore, injection with Botox decreased its tone together with weakness of the abductor muscle resulted in decreasing the stability of the lower limb which reflected no significant improvement in mediolateral stability index of the balancing test.

5. CONCLUSION

Based on the obtained results, it can be concluded that Botox A injection of the gracilis muscle is an excellent supplement to regularly scheduled physical therapy intervention for children with diplegic cerebral palsy. It could improve the degree of stability, gait parameters and functional outcome.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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