Original Article

Exploring Treatment Modalities for Foot Equinus in Cerebral Palsy: A Comparative Analysis of Surgical Release and Botulinum Toxin Injections

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Abstract

Objective: In order to provide important insights into the relative efficacies of these two therapy techniques for controlling foot equines in the context of cerebral palsy patients, the study intends to compare and contrast their distinct outcomes.

Methodology: The effectiveness of the intervention was examined in two separate groups (A & B), based on gender and age, using a cross-sectional study methodology. There were thirty volunteers in each group out of the total sixty for the study. The distribution of genders, age groups, and the effectiveness of the interventions were methodically documented. Potential correlations and variations were investigated using statistical analysis, such as chi-square tests and mean computations. Participants were informed about the nature and goal of the intervention, and the study complied with ethical guidelines.

Results: There was no discernible difference between groups (A and B) according to the gender distribution analysis (Table 1), suggesting that the proportion of men and women in both groups was pretty balanced. However, there were slight variations in the efficacy assessments for both the male and female categories. There were no statistically significant differences between groups (A & B) in the age distribution (Table 2). Notably, Table 3's overall effectiveness of the intervention showed a significant difference ($p = 0.029$) between the two groups. Subsequent examination of age-specific efficacy (Table 4) did not show any discernible variations throughout age groups.

Conclusion: This study indicates that age does not seem to be a relevant determinant, even though gender may have some bearing on the intervention's efficacy. There were differences in the overall effectiveness of the intervention between groups A and B. These findings highlight the significance of taking age and gender into account when evaluating treatment outcomes and offer insightful information about the complex elements of the intervention's influence across various demographic parameters. Larger sample numbers in future studies could lead to a deeper comprehension of these connections.

Keywords: Botulinum toxin, Foot equinus, Lower limb spasticity, Surgical release, Surgery

Introduction

Toxins from microorganisms such as Clostridium botulinum and Clostridium barati combine to generate botulinum neurotoxins. The seven distinct kinds of animal antisera that are used to select botulinum neurotoxins are arranged alphabetically from A to G. The botulinum toxin's mechanism of action is categorized as follows: (1) Forming bonds with nerve terminals (2) A reduction in the interchain disulfide bond. In addition to acting as an anti-inflammatory, botulin acts on nerve end plates to prevent the release of neuropeptides. Neurological disorders such as stroke, multiple sclerosis, amyotrophic lateral sclerosis, cervical dystonia, head trauma, and brain injury can benefit from botulinum toxin injections as they effectively reduce muscle stiffness by blocking acetylcholine's effects and synaptic transmission. In addition to neurological disorders, myofascial pain syndrome, congenital torticollis, knee osteoarthritis, myofascial pelvic pain, stroke, burns, and cerebral palsy (CP) are among the illnesses for which botulinum toxin injections are used. Because of its high potentiality, reversible activity, and limited diffusion time period when injected locally, botulinum toxin is regarded as a safe invasive treatment for humans.[1-4] Damage sustained during the immature stage of brain development, such as premature birth, difficult birth, hypoxia, jaundice, etc., can result in cerebral palsy, a non-progressive brain injury. There are many subtypes, the most prevalent of which is the spastic type, which makes up between 60% and 70% of cases. Trauma to the brain's cone system, particularly following cerebral cortex trauma, results in stiffness, hyper-retentive reflexes, raised limb tone, and muscle spasms.[5] Since the 1990s, children with cerebral palsy have benefited from the use of botulinum toxin type A (BoNT-A), a protein neurotoxin made by Clostridium botulinum (Blasi et al., 1993; Pirazzini et al., 2017), in the context of individualized rehabilitation programmes.[6] For three to six months, a medical intervention using BoNT-A in the limb muscles decreases over-activity in the muscles while also increasing the range of motion in the distal joints.[7] The toxin's therapeutic usefulness has been proven. However, there is an ongoing discussion on the best time to administer injections and how to reduce the adverse effects on muscle.[8] It is becoming more and clearer that when evaluating CP children, joint deficiencies related to muscles, such as stiffness and decreased strength, should be considered. Previous studies have recommended a multidisciplinary approach to decrease stiffness and, specifically, muscle strength in children receiving therapy. Nevertheless, the data bolstering this strategy is lacking.[9-10]

Methodology

The purpose of this prospective comparison study was to evaluate and compare the effectiveness of Botulinum Toxin injections and surgical release in treating foot equines in individuals with cerebral palsy between January 2023 and November 2023. The study involved patients with cerebral palsy who showed signs of foot equinus and was conducted at Mardan Medical Complex and Teaching Hospital. The hospital's review board granted ethical approval prior to the study's launch. After receiving their guardians' informed agreement, patients who met the inclusion criteria—which included having a verified diagnosis of cerebral palsy and having foot equines—were included. Two groups of study participants were formed: one group got a surgical release, and the other group received injections of botulinum toxin. Skilled medical practitioners with a focus on orthopedic and rehabilitation services executed both interventions. Throughout the trial period, the patients underwent routine follow-up, and baseline examinations were carried out to document the degree of foot equines. The gait analysis, range of motion, and any negative impacts were all considered evaluating factors. The gathered data were carefully recorded, and statistical analysis was done to contrast the results of the two treatment methods.

The purpose of this study was to add to the body of knowledge and help clinicians choose the best course of treatment for patients with cerebral palsy by shedding light on the relative efficacy of surgical release and Botulinum Toxin injections in the management of foot equinus.

Results

Males constituted a slightly higher proportion of participants (55%) compared to females (45%), with no significant difference between the groups ($p = 0.795$). Regarding efficacy, males showed higher rates of efficacy in group "a" (94.1%) compared to group "b" (68.8%), indicating a potential trend towards better outcomes in group "a," though the p-value of 0.07 suggests this difference is not statistically significant. Among females, efficacy was also higher in group "a" (84.6%) than in group "b" (64.3%), with a non-significant p-value of 0.22. While these findings suggest a trend of greater efficacy in group "a" for both genders, the lack of statistical significance indicates further investigation with larger samples may be needed.

The age distribution indicates the majority of participants were between 6 and 15 years (73.3%), with an overall mean age of 11.47 years. There were no statistically significant differences in age distributions between groups "a" and "b" ($p = 0.698$). In terms of overall efficacy (Table 3), group "a" demonstrated significantly higher effectiveness (90%) compared to group "b" (66.7%), with a p-value of 0.029. Age-wise efficacy analysis (Table 4) showed higher efficacy rates in the group "a" across all age categories, particularly in the <5 and 16+ age groups (100%). However, differences between groups "a" and "b" were not statistically significant across age categories ($p > 0.05$). This suggests that group "a" may offer

more consistent benefits, but further targeted research is warranted to confirm these findings.

Discussion

Damage to the cerebral cortex and downstream inhibitory conduction pathways in the brain is the mechanism underlying muscle spasm. This damage weakens the gamma motor neurons' inhibitory effect, increases the gamma motor fibers' excitability, increases the sensitivity of the muscle shuttle, produces abnormal discharge, and excites alpha motor neurons, which in turn causes muscle spasm.[11] The research population's gender distribution and the effectiveness of a certain

Table 1. Gender distribution with their efficacy

Gender		Groups				total	p-value
		A		b			
Male		17 (56.7%)		16 (53.3%)		33 (55%)	0.795
Female		13 (43.3%)		14 (46.7%)		27 (45%)	
Efficacy	Male	Present	absent	present	absent		0.07
		16 (94.1%)	1 (5.9%)	11 (68.8%)	5 (31.2%)		
	Female	Present	absent	present	absent		0.22
		11 (84.6%)	2 (15.4%)	9 (64.3%)	5 (35.7%)		

Table 2. Age distribution

Age in years	Groups		total	p-value
	A	b		
<5	4 (13.3%)	2 (6.7%)	6 (10%)	0.698
6-10	9 (30%)	11 (36.7%)	20 (33.3%)	
11-15	13 (43.3%)	11 (36.7%)	24 (40%)	
16 above	4 (13.3%)	6 (20%)	10 (16.7%)	
Total	30	30	60	
Mean ±sd	11.03yrs+4.02	11.63yrs +4.06	11.47yrs +4.01	

Table 3. Effectiveness distribution

Age in years	Groups		total	p-value
	A	b		
Yes	27 (90.0%)	20(66.7%)	47 (78.3%)	0.029
No	3 (10.0%)	10 (33.3%)	13 (21.7%)	

Table 4. Age-wise efficacy

Gender	Groups				p-value
	A		b		
	Efficacy		efficacy		
	Yes	no	yes	no	
<5	4 (100.0%)	0 (0%)	1 (50%)	1 (50%)	0.698
6-10	8 (88.9%)	1 (11.1%)	8 (72.7%)	3 (27.3%)	0.374
11-15	11 (84.6%)	2 (15.4%)	8 (72.7%)	3 (27.3%)	0.414
16 above	4(100.0%)	0(0%)	3(50%)	3(50%)	0.166

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intervention by separating it into groups of men and women. The proportion of participants in each gender category is displayed by the percentages in each subgroup (a and b). Notably, there are no statistically significant differences in the gender distribution between the two groups, according to the p-values. However, when it comes to efficacy, there is a slight variation, especially between males (p = 0.07) and females (p = 0.22). The thorough analysis of effectiveness within each gender group provides insight into the effect of the intervention on particular groups of people. Through exercise, the antagonist muscles gain strength and get used to the proper motor posture and actions. In order to rectify improper motions and postures, the brain can establish the proper movement pattern. This movement pattern will improve even if the spasm is reintroduced.[12-13] The intervention's efficacy and age distribution in relation to other age groups. The percentages show how common it is for participants in each subgroup (A & B) across various age ranges. A central tendency statistic that sheds light on the study's general age distribution is the mean age with standard deviation. The age distributions of groups A and B do not differ statistically significantly, according to the non-significant p-values (all above 0.05). This implies that there is little variation in the impact of the intervention between age groups. Muscle spasms are lessened when a muscle is fixed in an extended position because it lengthens and increases the number of muscle segments. Plaster immobilization of the ankle joint in the lower limb can also improve the lower extremity deformity by increasing the dorsiflexion angle.[14-15] Examine how well the intervention worked overall and how it affected different age groups. The overall efficacy rates for groups (A and B) are shown in Table 3, and a significant difference (p = 0.029) indicates that the two groups' levels of benefit from the intervention differ. A more detailed analysis is given in Table 4, where efficacy is broken down by age group. No age range shows a statistically significant difference in efficacy between groups (A & B), despite fluctuation among age categories with varying p-values for each group. All of these results point to the possibility that gender may have a minor influence on the effectiveness of the intervention, although age does not appear to have a major effect on the results.

Conclusion

Our study comparing the efficacy of surgical release and Botulinum Toxin injections for treating foot equinus in cerebral palsy patients revealed important insights. Both interventions demonstrated effectiveness in addressing foot equinus, with varying degrees of success. The outcomes were assessed based on factors such as range of motion and gait analysis. Surgical release showed positive results, offering improvement in the range of motion and gait patterns among the patients. On the other hand, Botulinum Toxin injections also exhibited efficacy, contributing to ameliorating foot equinus, although to a slightly lesser extent compared to surgical intervention. Notably, the decision between Botulinum Toxin injections and surgical release should take into account a number of parameters, such as the degree of foot equinus, the unique characteristics of each patient, and any possible hazards related to each technique. Clinicians can use the study's findings to help them make decisions that are well-suited to the unique requirements of patients with cerebral palsy. To increase the evidence basis and offer more thorough guidance for treatment strategies in this patient population, more research with larger sample sizes and longer follow-up periods is advised.

References

1. Marvulli R, Megna M, Citraro A, Vacca E, Napolitano M, Gallo G, et al. Botulinum toxin type A and physiotherapy in spasticity of the lower limbs due to amyotrophic lateral sclerosis. Toxins (Basel) 2019;11(7):381. DOI: 10.3390/toxins11070381.
2. Rezasoltani Z, Azizi S, Najafi S, Sanati E, Dadarkhah A, Abdorrazaghi F. Physical therapy, intra-articular dextrose prolotherapy, botulinum neurotoxin, and hyaluronic acid for knee osteoarthritis: randomized clinical trial. Int J Rehabil Res 2020;43(3):219-27. DOI: 10.1097/MRR.0000000000000411.
3. Nasb M, Li Z, Youssef ASA, Dayoub L, Chen H. Comparison of the effects of modified constraint-induced movement therapy and intensive conventional therapy with a botulinum-a toxin injection on upper limb motor function recovery in patients with stroke. Libyan J Med 2019;14(1):1609304. DOI: 10.1080/19932820.2019.1609304.
4. Vidal X, Martí-Fàbregas J, Canet O, Roque M, Morral A, Tur M, et al. Efficacy of radial extracorporeal shock wave therapy compared with botulinum toxin type A injection in treatment of lower extremity spasticity in subjects with cerebral palsy: a randomized, controlled, crossover study. J Rehabil Med 2020;52(6): jrm00076. DOI: 10.2340/16501977-2703.
5. Wang L, Xu L, Liu G, et al. Meta-analysis of selective posterior rhizotomy in children with cerebral palsy. Orthop J China 2022;30(15):1372-6.
6. Eleopra R, Rinaldo S, Montecucco C, Rossetto O, Devigili G. Clinical duration of action of different botulinum toxin types in humans. Toxicon 2020; 179:84-91. DOI: 10.1016/j.toxicon.2020.02.020.
7. Francisco GE, Bandari DS, Bavikatte G, Jost WH, McCusker E, Largent J, et al. High clinician- and patient-reported satisfaction with individualized onabotulinumtoxin A treatment for spasticity across several etiologies from the ASPIRE study. Toxicon X 2020;7: 100040. DOI: 10.1016/j.toxcx.2020.100040.
8. Mathevon L, Bonan I, Barnais JL, Boyer F, Dinomais M. Adjunct therapies to improve outcomes after botulinum toxin injection in children: a systematic review. Ann Phys Rehabil Med 2019;62(4):283-90. DOI: 10.1016/j.rehab.2018.06.010.
9. Jia X, Qiang M, Chen Y, Zhang K, Chen S. The influence

of selective arthrodesis on a three-dimensional range of motion of the hindfoot joint: a cadaveric study. Clin Biomech (Bristol, Avon) 2019;69:9-15.

10. Lennon N, Church C, Chua T, et al. Is standing function improved after orthopaedic surgery in children with cerebral palsy at GMFCS levels III/IV? J Pediatr Orthop 2023;43(1): e48-53.
11. De Beukelaer N, Weide G, Huyghe E, et al. Reduced cross-sectional muscle growth six months after botulinum toxin type-A injection in children with spastic cerebral palsy. Toxins 2022;14(2):139.
12. Liu JJ, Zhang Y, Qi J, Zeng FY, Li NL. Effect of rehabilitation on the long-term efficacy of botulinum toxin-A for spastic cerebral palsy. Eur Rev Med Pharmacol Sci 2022;26(11):3927-32.
13. Gao BQ, Yang WL, Wang YJ, Tian ZX, Deng YX. Clinical study of CBTX-A in the treatment of spastic cerebral palsy. Chin J Neuromed 2005; 5:488-90.
14. Peeters N, Hanssen B, Cenni F, et al. O 019 - do botulinum toxin-A and lower leg casting alter calf muscle and tendon lengths in children with spastic cerebral palsy? Gait Posture 2018; 65:36-8.
15. Peeters N, Van Campenhout A, Hanssen B, et al. Joint and muscle assessments of the separate effects of botulinum neurotoxin-A and lower-leg casting in children with cerebral palsy. Front Neurol 2020; 11:210.

Authors' Contribution Statement

ASK conceived the idea and assisted in critical appraisal and discussion writing. AK assisted in data collection and manuscript writing. KK assisted in the overall compilation of the study. TA Assisted in data collection, compilation of the results, and formatting of the article. AZ assisted in manuscript writing and bibliography. HDK assisted in supervising and critical appraisal. All authors made substantial intellectual contributions to the study.

Confilct of Interest

Authors declared no conflict on interest

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None

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.