Original Article

Evaluation of Gross Motor Function Classification System (GMFCS) Improvement after Selective Myofascial Release for the Treatment of Cerebral Palsy

Eamsobhana P, MD[1], Chalayon O, MD[2], Luanglert T, MD[1]

[1] Department of Orthopaedic Surgery, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand
[2] Orthopedic John Hopkins Hospital Baltimore, USA

Background: Cerebral palsy (CP), which results from a non-progressive injury that occurs during brain development, is the most common movement disorder in children.

Objective: To evaluate the improvement in Gross Motor Function Classification System (GMFCS) status after orthopedic surgical intervention in children with spastic CP.

Material and Methods: This retrospective chart review included spastic cerebral palsy patients aged 7 to 11 years who underwent lower extremity soft tissue release during 2009 to 2014. All patients had complete pre-operative and post-operative data with a minimum follow-up of 2 years. Patients were re-evaluated at 2-years postoperatively for GMFCS level, and those results were compared with pre-operative function.

Results: Of the 92 study participants, the pre-operative GMFCS level was II in 48, III in 14, and IV in 30 patients. The mean age at first evaluation was 7.61±1.93 years. Seventy-five percent of patients with GMFCS level II remained at their preoperative level at surgery. Fifty-seven percent of patients with GMFCS level III improved to GMFCS level II. Twelve patients (40%) with GMFCS level IV improved to level III, and 2 patients (6.67%) improved from GMFCS IV to GMFCS II. However, none of the aforementioned improvements in GMFCS category were statistically significant. No significant association was observed between improvement in GMFCS level and gender, pre-operative or postoperative popliteal angle, and number or type of operation.

Conclusion: In the present study, 42.9% of patients in GMFCS III and 53.3% of patients in GMFCS IV showed improvement in GMFCS level after soft tissue surgery at the lower extremities. Almost half (44.12%) of patients who had multilevel operations demonstrated improvement in GMFCS, but the improvement was not statistically significant.

Keywords: Evaluation, Gross motor function classification system, GMFCS, Improvement, Selective myofascial release, Treatment, Cerebral palsy

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Cerebral palsy (CP) comprises a group of non-progressive disorders that primarily affect the movement and posture of children due to abnormal development of or damage to the immature brain. The goal of CP management has shifted from correcting a deformity, such as spasticity in a particular limb, to improving the patient's ability to become ambulatory and achieve overall independence. The therapeutic program focuses mainly on improving gait and walking. To achieve this goal, many methods have been proposed, including physical therapy, stretching, botulinum toxin injections, orthotic, and surgical intervention[1-6]. Some studies reported that orthopedic interventions, either soft tissue or bone surgery, could improve posture in this group of patients[7-11].

The authors selected the Gross Motor Function Classification System (GMFCS) to evaluate patients because it is the most widely published and recognized classification for measuring function in CP patients. This system is simple and can be reported by any level of healthcare provider, as well as by parents and caregivers. It has also been proven to have excellent inter- and intra-observer reliability[12-18].

This 5-level classification system evaluates patients on the basis of their self-initiated movement with particular emphasis on sitting, walking, and wheeled mobility.

The GMFCS levels are defined, as follows: GMFCS I is able to walk without limitations. GMFCS II patients are able to walk in most terrains, but they have limitations with distance and/or uneven surface. GMFCS II patients may use wheeled mobility for long distances, can climb stairs with the help of the railing, but they can perform no or only minimal running and jumping. GMFCS III patients

Correspondence to:
Eamsobhana P.
Department of Orthopaedic Surgery, Faculty of Medicine Siriraj Hospital, Mahidol University, 2 Wanglang Road, Bangkoknoi, Bangkok 10700, Thailand.
Phone: +66-2-4197968-9
E-mail: peerajite@gmail.com

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are able to walk with a handheld mobility device indoors and they use wheeled mobility (either manual or powered) for distance. They require assistance to move between floors and for sitting and standing, and stairs must be negotiated with assistance. GMFCS IV patients require adapted seating and assistance in most settings. Many children can have independent floor mobility with crawling or rolling, or may walk short distances with assistance. GMFCS V patients are impaired in all areas of motor function, and they require complete assistance.

The GMFCS was originally designed to be used in children aged 2 to 18 years[19]. However, studies found that the level of mobility changes dramatically during the age range of 2 to 4 years. In most children aged from 6 to 12 years, they are constant in gross motor function and most of the level at the ages of 12 to 18 years were the same as ages 6 to 12 years[14,20].

Postoperative evaluation for GMFCS improvement is very important in cerebral palsy patients. However, studies in and reports about the change in GMFCS level after orthopedic surgery are scarce. A systematic review of surgical and non-surgical treatments to improve crouching gait in cerebral palsy patients found limited data regarding improvement in gait speed and/or gross motor function[19]. In contrast, the reported evidence argues against hamstring transfer or revision hamstring release; however, that study focused on gait and posture -not on GMFCS improvement. Hong, et al[20] studied intensive physical therapy in cerebral palsy patients and found the main factor affecting the impact of intensive physical therapy on gross motor function to be GMFCS. Hong, et al[20] reported that ambulatory children had a better response than non-ambulatory children.

The purpose of the present study was to evaluate the improvement in GMFCS status after orthopedic surgical intervention in children with spastic CP.

Materials and Methods

After receiving approval from the Siriraj Institutional Review Board (SIRB) to do so, we conducted a retrospective chart review of spastic cerebral palsy patients who underwent lower extremity soft tissue release during 2009 to 2014 All patients had complete pre-operative and postoperative data with a minimum follow-up of 2 years. Patients were re-evaluated at 2-years postoperatively for GMFCS level, and those results were compared with preoperative function. All subjects were categorized by Gross Motor Function Classification System (GMFCS), as follows: Level II in 48 patients; Level III in 14 patients, and Level IV in 30 patients (Table 1). The number of surgical procedures per subject ranged from 1 to 2 procedures (Table 2). A pediatric physical therapist determined the GMFCS score for each patient at 1 year after the orthopedic procedure.

Patients aged 7 to 10 years were selected for this study because children in this age group have mature brain development, they have already reached their standing and walking development milestones, they have good communication and cooperation, and the fact that many studies have reported GMFCS reliability in patients aged 6 to 12 years[19].

Statistical analysis

All data analyses were performed using SPSS Statistics (SPSS, Inc., Chicago, IL, USA). Patient characteristics were summarized using descriptive statistics. Categorical data are presented as frequency and percentage, and continuous data are shown as mean ± standard deviation. Comparison of categorical data and test for homogeneity was performed using Chi-square test or Fisher's exact test, and comparison of continuous data was performed using Student's t-test or Mann-Whitney U test. A *p*-value of less than 0.05 was considered statistically significant for all tests.

Results

Ninety-two spastic diplegia CP patients with GMFCS level II, III, or IV who underwent soft tissue surgery at lower extremity were included. Forty-six patients were male, and 46 patients were female. The mean age of patients was 7.61±1.93 years (range: 7 to 11). The GMFCS level was II in 48 patients, III in 14 patients, and IV in 30 patients. The popliteal angle was significantly improved post-operatively at both the right and left side ($p = 0.002$, $p = 0.046$, respectively) (Table 1).

There was no significant post-operative

Table 1. Demographic and clinical characteristics (n = 92)

Characteristics	n	*p*-value
Gender		
Male	46 (50.0%)	0.999
Female	46 (50.0%)	
Age (years)	7.61±1.93 (7 to 11)	NA
Days in hospital	2.54±1.60	NA
Side		
Right	18 (19.6%)	<0.001
Left	4 (4.3%)	
Bilateral	70 (76.1%)	
Preoperative GMFCS		
2	48 (52.2%)	0.009
3	14 (15.2%)	
4	30 (32.6%)	
Postoperative GMFCS		
1	12 (13.0%)	0.001
2	46 (50.0%)	
3	16 (17.4%)	
4	18 (19.6%)	
Popliteal angle (right)		
Preoperative	53.61±21.3	0.002
Postoperative	30.56±17.14	
Popliteal angle (left)		
Preoperative	50.15±26.88	0.046
Postoperative	30.81±22.28	

GMFCS = Gross Motor Function Classification System; NA = not applicable

Table 2. Factors affecting improvement in GMFCS level

Parameters	Improvement	No improvement	*p*-value
Gender			
Male	18 (19.6%)	28 (30.4%)	0.760
Female	16 (17.4%)	30 (32.6%)	
Popliteal angle			
Right			
<60 degrees	12 (33.3%)	22 (61.1%)	0.999
≥60 degrees	0 (0.0%)	2 (5.6%)	
Left			
<60 degrees	12 (37.5%)	16 (50.0%)	0.5
≥60 degrees	0 (0.0%)	4 (12.5%)	
Number of operations			
1	18 (32.1%)	38 (67.9%)	0.399
2	16 (44.4%)	20 (55.6%)	
Adductor tenotomy/release	0 (0.0%)	0 (0.0%)	NA
Hamstring tenotomy/release	2 (33.3%)	4 (66.7%)	0.999
TAL	2 (12.5%)	14 (87.5%)	0.115
Multilevel	30 (44.1%)	38 (55.9%)	0.090
Other	0 (0.0%)	2 (100%)	0.999

TAL = Tendon Achilles lengthening

Table 3. Improvement versus no improvement stratified by GMFCS level

GMFCS	Improve	No improve	n	*p*-value
2	12 (25.0%)	36 (75.0%)	48	0.014
3	8 (57.1%)	6 (42.9%)	14	0.705
4	14 (46.7%)	16 (53.3%)	30	0.796
Total	34	58	92	

Table 4. Level of improvement of GMFCS

Preoperative GMFCS	Postoperative GMFCS				Total
	1	2	3	4	
2	12 (25.0%)	36 (75.0%)	0 (0.0%)	0 (0.0%)	48
3	0 (0.0%)	8 (57.1%)	4 (28.6%)	2 (14.3%)	14
4	0 (0.0%)	2 (6.7%)	12 (40.0%)	16 (53.3%)	30
Total	12	46	16	18	92

improvement in patients with GMFCS II. After surgery, 75% of patients in GMFCS II remained at their same pre-operative level. More than half (57.1%) of patients improved from GMFCS III to GMFCS II; however, the level of improvement was not statistically significant. The condition of 2 patients (14.29%) deteriorated from GMFCS III to GMFCS IV. Twelve patients (40%) in GMFCS IV improved to GMFCS III, and 2 patients (16.6%) in GMFCS IV improved to GMFCS II (both $p>0.05$) (Table 3 and 4). Almost half (44.12%) of patients who underwent multilevel operation developed improvement in GMFCS, but the improvement was not significant. None of the evaluated factors, including gender, type of operation, pre-operative popliteal angle, number of operations, and type of operation, were found to significantly associate with improvement in GMFCS (Table 2).

Discussion

Cerebral palsy is the most common movement disorder in children that results from neurological disturbances in the developing fetal or infant brain[1,15]. Many methods have been developed to improve the functional capacity of children with cerebral palsy, including physical therapy, botulinum toxin, and surgery[3-9]. The Gross Motor Function

Classification System (GMFCS) was used to evaluate the functional capacity of cerebral palsy due to excellent inter-intraclass reliability and ease and effectiveness of use by parents and caregivers[12-18]. The development of GMFCS in children with CP can be described by longitudinal measurements of gross motor function. The graph will change dramatically during the age range of 2 to 4 years. Most cerebral palsy children aged 6 to 12 years are constant in gross motor function, and the level of ability of most children aged 12 to 18 years is the same as the level of ability of children aged 6 to 12 years[14,20].

In the present study, the popliteal angle was significantly improved after surgery compared to the preoperative popliteal angle; however, the degree of popliteal angle improvement did not significantly associate with improvement in GMFCS. A systematic review of mostly GMFCS of I, II, and III by Scott, et al reported evidence that argues against hamstring transfers and revision hamstring lengthening. That review found positive effect on knee biomechanics, but there assessment was based on GMFCS improvement[19].

A study by Bickley, et al[12] reported that orthopedic surgical intervention for the ambulatory child with spastic diplegia or hemiplegia improved the gait deviation index; however. that study included only patients with GMFCS II, III, and IV, and main purpose of the study was to report outcome of gait deviation pattern after surgery.

The results of the present study did not reveal any factors that significantly improve GMFCS in spastic cerebral palsy; however, we did find that almost half of patients in GMFCS III and GMFCS IV improved their level of function. The limitations of this study include the fact that we had no control groups with which to compare the result, and that we could not control the postoperative physical therapy program, the frequency of the physical therapy program, or the experience level of the physical therapist because most patients continued their physical therapy program at their family clinic or local hospital.

Conclusion

In the present study, 42.9% of patients in GMFCS III and 53.3% of patients in GMFCS IV showed improvement in GMFCS level after soft tissue surgery at the lower extremities. Almost half (44.12%) of patients who had multilevel operations demonstrated improvement in GMFCS, but the improvement was not statistically significant. Future study to identify the factors that influenced no improvement in GMFCS III, IV patients will help to improve the treatment and outcomes of patients with spastic cerebral palsy.

What is already known on this topic?

Orthopedic surgical intervention for the ambulatory child with spastic diplegia or hemiplegia improved gait deviation index.

What this study adds?

Patients with preoperative GMFCS level III and IV, as well as those who underwent multilevel myofascial release showed a trend towards improvement in motor function level after lower-extremity soft tissue surgery. However, these differences were not statistically significant and there was a large proportion of patients who remained unimproved.

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Potential conflicts of interest

The authors declare no conflicts of interest.

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