Improvement of Ambulatory Function with Multilevel Soft Tissue Surgery in Children with Spastic Diplegic Cerebral Palsy

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Abstract: *Single Event Multilevel soft tissue surgery in spastic diplegic children also was effective for improving ambulatory function obviously as multilevel bone and soft tissue surgery. Just muscle and tendon surgery seem to be enough for better lever arm dysfunction of the lower extremity. It has safe, simple and rapid recovery.*

Objective: *Gross Motor Functional Classification System (GMFCS) improvement after single event multilevel soft tissue surgery had been observed in these study groups of patients.*

Material and Method: *Retrospective review in 93 spastic diplegic children who were more than 3 years old, had ability to understand communication, at least leaned sitting and one-hand gross function ability had been operated on by single event multilevel soft tissue surgery. GMFCS was assessed at the time of pre-operation and 6- 12 months after operation. Analyzing GMFCS change was performed by statistics.*

Results: *Average 7 site surgery per one patient, 84% GMFCS level improvement and 16% GMFCS level non-improvement were reported. Nine cases (9.7%) were improved 2 level of GMFCS and 74% improved 1 level. GMFCS level compared between pre- and post surgery had changed by the significant statistic ($p < 0.001$). The average GMFCS level improvement for all groups was 0.93 level. The average age in the improved group (75 months old) was less than the non-improved group (92 month old), was a trend difference in statistic ($p = 0.032$).*

Conclusion: *Single Event Multilevel Soft tissue surgery was effective in improving the GMFCS level average 1 level. It changed ambulatory function of spastic diplegic CP children obviously, immediately and safely. Younger age might get more benefit than older children.*

Keywords: *Single event multilevel soft tissue surgery, SEMLS, Multilevel soft tissue surgery, MLS, Gross motor functional classification system, GMFCS, Ambulatory function, Spastic diplegic, Cerebral palsy*

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Obviously Single Event Multilevel surgery (SEMLS) was able to improve ambulatory function in spastic cerebral palsy children. By correcting deformity of hip level, knee level and ankle foot level the SEMLS improved immediately the lower extremity lever arm, gait function, Gross Motor Function Measurement (GMFM) and temporal gait parameter that were measured and proved in many studies, were upgraded significantly after surgery[1-4].

Also the kinematic and kinetic parameters had been better after the multilevel soft tissue surgery (MLS) by measuring three dimension gait measurement. Furthermore the SEMLS in young spastic CP would be able to prevent fixed joint deformity, subluxation and dislocation that were difficult to handle[5-7].

With deformity due to bone and joint it was hard and difficult to get the excellent result but deformity from soft tissue imbalance had easier, safe and more rapid recovery after surgery. The authors have believed that MLS night also be able to improve ambulatory function in spastic diplegic cerebral palsy children. The SEMLS was safe, simple and helpful to improve gait motor function in spastic CP obviously.

Actually the mobile ability of CP children would naturally develop better in 3-6 years of life. An intervention that was supposed to improve the mobility function better than natural improvement was considered the effective method. Gross Motor Functional Classification System (GMFCS) had been developed for classifying motion ability of spastic diplegic patients that the level of GMFCS wasn't

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changed in time[8]. This system had been stable from aged 2 years old to 18 years old; certainly whatever intervention had been able to better GMFCS was effective. The GMFCS had been developed for leveling the gross motor function of the spastic CP children by based on self- initiated movement with emphasis on sitting, transfers and mobility. It was a good inter rater and intra rater reliability and stable on time[9,10]. The intervention could change the GMFCS level; it means that the procedure altered the ambulatory function obviously.

Could the multilevel soft tissue surgery on young age spastic diplegic CP improve the motor function by GMFCS measurement?

Material and Method

The present study was approved by the ethic committee of QSNICH (Queen Sirikit National Institute of Child Health).

The present study began by reviewing retrospectively the out patient database of the spastic CP children who had the condition that was matched to the assigned inclusion criteria since 2004 and 2007 in QSNICH.

The inclusion criterion

1. Spastic diplegic CP children were more than 3 years old.
2. Ability to understand communication.
3. Exclude the cases having dislocated hip.
4. At least have leaned sitting.
5. At least one hand gross function, (for holding the walking aids).

The selected patients all had been assessed by GMFCS measurement at the time of multilevel soft tissue surgery during 6 months to 1 year after surgery.

Gross Motor Functional Classification System (GMFCS) score sheet was downloaded from www.canchild.ca owned by the Can Child Centre for childhood Disability Research Institute for Applied Health Sciences, McMaster University. 2 range of age band (between 4th and 6th, between 6th and 12th) were selected compatible with the patient age range.

GMFCS form for children age 4-6 years old. see the appendix Fig. 1.

GMFCS Form for children age 6-12 years old. See the appendix Fig. 2.

The physical examination and gait observation were performed in all cases for getting information and deciding which structures would be released.

The detail of structure was released and shown in Table 1.

GMFCS (Gross Motor Functional Classification System)
Between 4th and 6th Birthday

Level I Children get into and out of, and sit in, a chair without the need for hand support. Children move from the floor and from chair sitting to standing without the need for objects for support. Children walk indoors and outdoors, and climb stairs. Emerging ability to run and jump.

Level II Children sit in a chair with both hands free to manipulate objects. Children move from the floor to standing and from chair sitting to standing but often require a stable surface to push or pull up on with their arms. Children walk without the need for any assistive mobility device indoors and for short distances on level surfaces outdoors. Children climb stairs holding onto a railing but are unable to run or jump.

Level III Children sit on a regular chair but may require pelvic or trunk support to maximize hand function. Children move in and out of chair sitting using a stable surface to push on or pull up with their arms. Children walk with an assistive mobility device on level surfaces and climb stairs with assistance from an adult. Children frequently are transported when travelling for long distances or outdoors on uneven terrain.

Level IV Children sit on a chair but need adaptive seating for trunk control and to maximize hand function. Children move in and out of chair sitting with assistance from an adult or a stable surface to push or pull up on with their arms. Children may at best walk short distances with a walker and adult supervision but have difficulty turning and maintaining balance on uneven surfaces. Children are transported in the community. Children may achieve self-mobility using a power wheelchair.

Level V Physical impairments restrict voluntary control of movement and the ability to maintain antigravity head and trunk postures. All areas of motor function are limited. Functional limitations in sitting and standing are not fully compensated for through the use of adaptive equipment and assistive technology. Children have no means of independent mobility and are transported. Some children achieve self-mobility using a power wheelchair with extensive adaptations.

Fig. 1 GMFCS form for chidren age 4th-6th

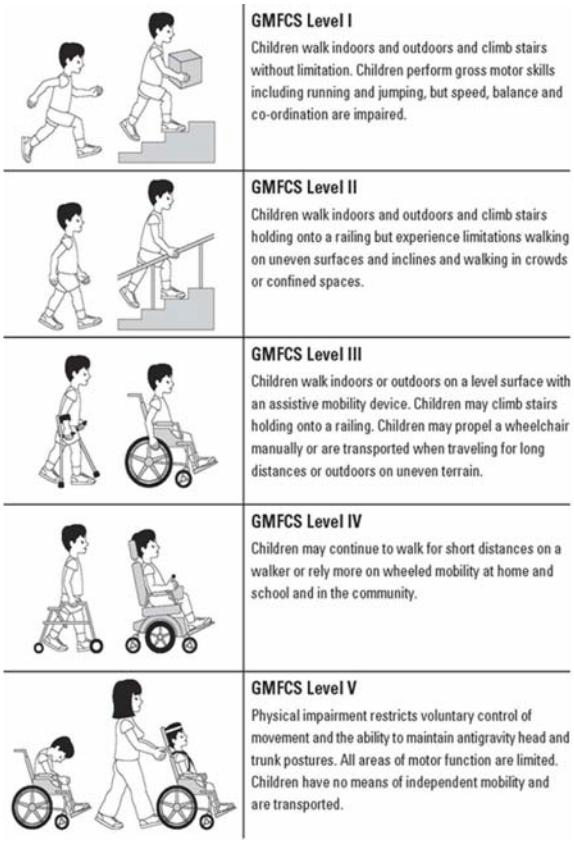
Operative procedure

Most cases had been operated in one scene. The common pattern was the 8 site soft tissue release that consisted of 2 poses, 2 hip adductor, 2 medial hamstrings, 2 Tendoachillis recession. The operative time was about 1-2 hr. There wasn't any complication on operative time.

Postoperative Program

All patients had been admitted for 3-5 days. The first day was for preoperative preparing, MLS on the second day and postoperative hospitalization for 1-3 days. Most patients would get below knee cast after surgery for 1-2 month and had been supported to move the hip the knee and trunk as soon as the surgical pain of the patients gradually was better. After the cast removal the patients had been encouraged to stand and walk by themselves or with a caregiver. Some patients might be taken care of by a physiotherapist but many who had problems about a long distance journey and no physical therapy center near home were taken care of by parents who had limited time.

Some patients might have received an assistive mobility device (anterior wheel walker, elbow crutch) if the devices would be assessed that could support patients walking balance. All cases were



GMFCS by Palisano et al. Palisano RJ, Rosenbaum P, Walter S, Russell D, Wood E, Galuppi B. Development and reliability of a system to classify gross motor function in children with cerebral palsy. Dev Med Child Neurol. 1997; 45: 113-120. Illustrated by Kerr Graham and Bill Reid, The Royal Children's Hospital, Melbourne. Distribution of the Gross Motor Function Classification System for Cerebral Palsy has been made possible by a grant from the United Cerebral Palsy Research and Educational Foundation, USA.

Fig. 2 GMFCS form for children age 6^{th}-12^{th}

monitored in the orthopedic outpatient department and some in the physiotherapy department. Some cases would receive physical therapy at the physical therapy center near their home however about half of the cases had no physical therapy. All patients were assessed for GMFCS at 6 months after surgery.

Statistical analysis focused on GMFCS changing after surgery.

Results

There were 59 boys and 34 girls in 93 selected spastic diplegic CP patients.

The average age at the time of surgery was 6.49 years (range 3-14 years). The follow-up time was 19.3 months (6-40 months).

Table 1. Details of Surgical Procedures

Procedure	Total/limb (limb = 186)	Average/ patient (n = 93)
Intrapelvic psoas release	148	1.59
Hip adductor release	116	1.24
Medial Hamstring release	140	1.5
Medial and Lateral Hamstring release	6	0.06
Rectus release	24	0.25
TendoAchillis lengthening	78	0.83
TendoAchillis Recession	88	0.94
Split Tibialis posterior tendon transfer	47	0.5
Anterior Tibialis tendon transfer	7	0.08
Total	654	7.03

The number of patients in each GMFCS level before and after MLS intervention is shown in Table 2.

Before Surgery: 40 patients (43%) were classified in GMFCS level V, 19 patents (20%) in GMFCS level IV, 22 patients (23%) in Level III, 12 patients (13%) in Level II.

After Surgery : 7 patients (8%) were classified in GMFCS level V, 29 patients (31%) in level IV, 27 patients (29%) in level III, 17 patients (18%) in level II and 13 patients (14%) in level I.

The average GMFCS level improved was 0.93.

The average surgical procedure per one patient was 7 sites 78 cases (84%) had got GMFCS improvement and average improvement was 0.93 level. All changed GMFCS cases were positively improved. Paired t-test compared pre-operative and post operative GMFCS level.

The difference was significant $p < 0.001$.

GMFCS level III and V pre surgery have a tendency to get improvement more than GMFCS level II and IV pre surgery but statistic comparing wasn't significantly changed, $p = 0.48$, unpaired t-test.

78 cases (84%) had got GMFCS improvement and 15 cases (16%) had the same GMFCS level (non-improvement).

In GMFCS improvement group, 9 cases (9.7%) were 2 level improved, 69 cases (74.2%) were 1 level improved see Table 3.

The non-improved group had 15 cases that consisted of GMFCS II 2 cases, III 4 cases, level IV 2

Table 2. The number of patients in each GMFCS level before and after MLS intervention

Group of GMFCS	Preoperative Number	Postoperative Number	GMFCS averageimprove	Average number of procedure
I	0	13 (14%)		
II	12 (13%)	17 (18%)	0.83	3.3
III	22 (23%)	27 (29%)	0.95	6.9
IV	19 (20%)	29 (31%)	0.89	6.9
V	40 (43%)	7 (8%)	0.97	7.8
Total	93 (100%)	93 (100%)	0.93	7

Table 3. Number of GMFCS level improvement

GMFCS level Improvement	Number of cases
Improve 2 level	9 (9.7%)
Improve 1 level	69 (74.2%)
Improve 0 level	15 (16.1%)

Table 4. Compares the age at surgery of the improved and non improved groups

GROUP	Average age at surgery	p
Improved (78 cases)	75 (months)	
Non improved(15 cases)	92 (months)	0.032

cases, level V 7 cases.

Between the non-improved group and improved group the average age at surgery was different with p = 0.032, unpaired t-test see Table 4.

The improved group was younger than the non-improved group.

Discussion

Although the ability to control skeletal muscle of spastic cp children had been up to 6 years old, the spastic muscle that caused the limb deformity also grew strong too. The skeletal bone had continued to be longer whereas the brain motor potential was nearly end. Bone deformity and joint subluxation, dislocation might have happened. Both static and dynamic deformity correction that decreased lever arm dysfunction had benefit to improve motor gait function in spastic CP children.

Single Event Multilevel Orthopedic Surgery corrects multilevel deformity at the same time including hip, knee and ankle foot level. One deformity correction might result to another deformity so multilevel correction or multilevel limb balance in one event would prevent other surgery later and sometime another new deformity might be more difficult to correct than one time correction. Multilevel orthopedic surgery has been proved about improving mobility function by many methods (Gait labs, Gait parameter) in all aged groups spastic CP[7,11-13].

Surgical correction of bone deformity that usually would be in older children had more time to recover or return the muscle function. Muscle and Tendon surgery were more rapidly to recover and return muscle function but it mightn't be effective as both bone, muscle and tendon surgery to correct the lever arm dysfunction. However, just soft tissue surgery the authors believed that it also would be effective to improve the gross motor function. From the study of Zorer, G[14] they performed multilevel bone and soft tissue surgery and report the effective in GMFCS improvement. They had just 23 spastic cerebral palsy cases not a specific diplegic group and not all soft tissue surgery. For the present study the authors have collected 93 spastic diplegic children and done multilevel soft tissue surgery.

GMFCS was created for classifying grossly the spastic diplegic CP by motion ability. This form is stable even later or child growing. GMFCS from multicenter study have been tested both for reliability, validity and correlate with many instrumentation, PODCI (Pedicatric orthopedic Data collection instrument), temporal -spatial gait parameters, oxygen cost and other quality of life FAQ[15-17].

The present retrospective review had collected the series that have got the inclusion criteria. More than 3 years old in ages, ability to lean sitting and at least one hand gross function patients were included into the present series. 84% (78 cases) of cases had GMFCS level improvement, 16% no improvement and no one got worse.

The GMFCS level changed significantly statistically when compared pre and post surgery level. The average improvement was 0.93 level or 1 level actually. The pre-surgical GMFCS V group had the most improvement but it wasn't significantly statistic when compared with other groups. This might be from the selected criteria. Pre-surgical GMFCS level V in the present study had good potential to stand because it had some trunk balance and gross hand function to grasp the walker. 15 cases who were the non improvement group had improved motor function but not enough for leveling up GMFCS. The age of the improvement group and non improvement group was significantly different in statistics. The GMFCS non improved group was older than the GMFCS improved group. The younger patients might have a natural potential to improve, good tissue healing and less bone joint deformity than the older group.

Conclusion

1. Multilevel soft tissue surgery of lower limbs in spastic diplegic children immediately changes the GMFCS Level in 6-12 months about 1 level.

2. The spastic diplegic children who had leaned sitting and at least one hand gross function might get to 1 level of GMFCS in 74%, 2 level in 10% and 0 level in 16% after SEMLS.

3. The GMFCS improvement group was younger than the non-improvement group.

Potential conflicts of interest

None.

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การพัฒนาความสามารถในการเดินในเด็กพิการการเคลื่อนไหวโดยวิธีผ่าตัดกล้ามเนื้อและเส้นเอ็นแบบหลายจุด

วีระศักดิ์ ธรรมคุณานนท์

การผ่าตัดแก้ไขความผิดรูปของขาแบบหลายระดับโดยทำเฉพาะเนื้อเยื่อคือ กล้ามเนื้อ และเส้นเอ็นในผู้ป่วยเด็กซีพีแบบ spastic ได้ผลดีอย่างชัดเจนในการเพิ่มความสามารถในการเคลื่อนไหว โดยเฉพาะการเดินเหมือนกับการผ่าตัดแบบหลายระดับ (ผ่าตัดทั้งกระดูกและเนื้อเยื่อ) ซึ่งได้รับการพิสูจน์จากหลายรายงานว่าได้ผลดีชัดเจน การผ่าตัดเฉพาะกล้ามเนื้อและเส้นเอ็น น่าจะเพียงพอที่จะเพิ่มความสามารถผู้ป่วยได้เช่นกัน ซึ่งเป็นวิธีการที่ปลอดภัย ง่าย และผู้ป่วยฟื้นตัวได้เร็วกว่า

วัตถุประสงค์*: การผ่าตัดแบบหลายระดับโดยทำเฉพาะกล้ามเนื้อและเส้นเอ็นสามารถ เปลี่ยนแปลงระดับ GMFCS (Gross Motor Function Classification System) ของเด็ก spastic diplegic CP ได้ในเวลาอันสั้น*

วัสดุและวิธีการ*: ตรวจสอบรายงานย้อนหลัง โดยเลือกผู้ป่วยตามข้อกำหนดที่กำหนด คือ เด็ก spastic diplegic CP ที่อายุมากกว่า 3 ปี, มีความสามารถพอสื่อสารได้, สามารถอย่างน้อยนั่งพิงได้ และมีอย่างน้อย 1 มือที่สามารถจับวัสดุพอได ทุกรายได้รับการผ่าตัด แบบ Multilevel soft tissue surgery และได้รับการตรวจจัดกลุ่มก่อนผ่าตัด ซึ่งทำเป็นประจำ จัดกลุ่ม GMFCS level ก่อนผ่าตัด และหลังผ่าตัด 6-12 เดือน เปรียบเทียบผล GMFCS level ก่อนผ่าตัด และหลังผ่าตัดพิจารณาผล*

ผลการศึกษา*: กลุ่มที่ได้รับการศึกษาทั้งหมด 93 ราย spastic diplegic CP children 84% ของผู้ป่วยได้ GMFCS level ดีขึ้น, 16% ได้ GMFCS เท่าเดิม ไม่มีรายใดได้น้อยลง, เปรียบเทียบระดับ GMFCS ก่อนผ่าและหลังผ่าแตกต่างอย่างชัดเจนทางสถิติ $p < 0.001$ ซึ่งโดยเฉลี่ยดีขึ้น 0.93 หรือ 1 ระดับ กลุ่มที่ดีขึ้น 1 ระดับ มี 74%, ดี 2 ระดับ มี 9.7% อายุของกลุ่มที่ดีขึ้นโดยเฉลี่ยมีอายุน้อยกว่า กลุ่มที่ไม่ดีขึ้น $p = 0.032$*

สรุป*: การผ่าตัดแบบหลายระดับโดยทำเฉพาะเนื้อเยื่อได้ผลดีในการทำให้เด็ก spastic diplegic CP มีระดับความสามรถในการเคลื่อนไหว GMFCS ดีขึ้นเฉลี่ย 1 ระดับ ปู้ป่วยอายุน้อยกว่า มีแนวโน้มได้ผลดีกว่า*