ORIGINAL ARTICLE

Single Event Multilevel Soft Tissue Release in Spastic Diplegic Cerebral Palsy

Hussien T. H. Mohammed [a,*], Ahmed A. Shamma [b], Mohamed G. Abdelkader [b]

[a] Department of Orthopedic Surgery, National Institute of Neuromotor System, Giza, Egypt
[b] Department of Orthopedic Surgery, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt

Abstract

Background: ***Single Event Multilevel Surgery (SEMLS) considered the main approach for correcting the deformities concerning the cerebral palsy patients.***

Aim: ***Correct the contracture and deformities in hip, knee, ankle and foot in CP children to improve movement, gait, quality of life and increase independency of the patient.***

Patients and methods: ***This was a prospective interventional study carried out on 12 CP spastic diplegic patients attending in Al-Hussein university hospital and National Institute of Neuromotor System (NINMS) outpatient clinic and managed by lower limb single event multilevel soft tissue release. Assessment was done using GMFCM-88, ROM score and spasticity score at 3 months and 6 months postoperative.***

Results: ***SEMLS performed on spastic diplegic CP patients generated a positive outcome, with a significant difference from preoperative 32.0 (IQR=28.5-34.0) and 42 (IQR=38.5-44.75) at 3 months follow-up and 46 (IQR=41.25-50.25) at 6 months follow-up with p value < 0.05. Spasticity score significantly decreased from preoperative (m= 23.08, SD=3.605) and (m=14.08, SD=4.379) at 3 months follow-up, and (m=10.33, SD=3.284) at 6 months follow-up, with p value < 0.05. ROM score significantly decreased from preoperative (m=3.67, SD=8.15) and (m=25.17, SD=7.27) at 3 months follow-up, and (m=20.42, SD=6.11) at 6 months follow-up, with a p value < 0.05.***

Conclusions: ***SEMLS is considered effective in correcting deformities with only soft tissue release in spastic diplegic CP patients with minimal complications.***

Keywords: Spastic Diplegic; Cerebral Palsy; Single Event Multilevel Surgery; Soft Tissue Release

1. Introduction

The most common motor disability in children is Cerebral palsy (CP). It affects the individual's ability to control muscles and his or her capacity to maintain balance and posture.[1] CP is a neurodevelopmental disorder that is the result of an injury to the developing brain and is characterized by abnormalities in motor skills, movement, and muscle tone.[2] CP is present in 2 to 3 out of every 1000 surviving births. CP is more prevalent in low- or middle-income countries than in high-income countries. In Egypt, the prevalence of CP is approximately 3.6 per 1000 children.[3] It is associated with either abnormal brain development or brain injury during the developmental phase. Hence, it's either congenital, which contributes about 85% to 90% of CP patients, or acquired CP, which contributes about 10% to 15% of patients .[4] CP could be classified into Spastic, Ataxic, Dyskinetic, and Mixed CP. Impairments such as muscle weakness, aberrant muscle tone, static or dynamic muscle contracture, abnormal joint alignment, or reduced range of motion are the result of the inability to control movement.[5] Spastic CP is the most common type of CP; however, the diplegic group is the smallest.[6] The Gross Motor Function Classification System (GMFCS) is the standard classification system for CP, which is based on self-initiated movements and ranges from I to V. [7]

Accepted 19 January 2025.
Available online 31 March 2025

* Corresponding author at: Orthopedic Surgery, National Institute of Neuromotor System, Giza, Egypt.
E-mail address: drhussienortho@outlook.com (H. T. H. Mohammed).

https://doi.org/10.21608/aimj.2025.446494

Gait patterns that are aberrant may be observed in children with CP. At various life stages, many of these impairments necessitate both surgical and nonsurgical interventions.[8] Various surgical and non-surgical treatments are currently employed to address abnormal gait patterns. These interventions aim to enhance the patient's functionality and either correct or slow the progression of musculoskeletal issues. Musculoskeletal deformations may be prevented by a more "normal" walking pattern, which is believed to normalize skeletal loading.[9] SEMLS is regarded as the standard approach to enhance gait and functioning in ambulant children with CP. This procedure involves correcting all musculoskeletal deformities causing gait deviations in a single session.[10] SEMLS offers the benefit of a single hospitalization, anesthesia, and rehabilitation period. Furthermore, the utilisation of SEMLS can assist in the prevention of secondary impairments, such as muscle contractures, that may arise when a surgeon exclusively addresses a single problem. [11] To enhance the function and gait of ambulant individuals with CP, SEMLS has emerged as the definitive standard of care. Rapid mobilization of the patient is facilitated by these advancements, which in turn reduce the recovery time. [12]

This study aimed to correct the contracture and deformities in hip, knee, ankle and foot in CP children to improve movement, gait, quality of life and increase independency of the patient.

2. Patients and methods

This is a prospective interventional study to evaluate the use of soft tissue release in spastic diplegic CP patients according to GMFM-88, ROM score, and spasticity score at intervals of 3 and 6 months.

Study population:

The study carried out on 12 spastic diplegic CP children attending to outpatient clinic in Al-Hussien University hospital and the outpatient clinic of National Institute of Neuromotor System.

Inclusion criteria:

CP patients, GMFCS I-III, aged 4-12 years old, spastic, diplegic with lower limb deformity, and need soft tissue release.

Exclusion criteria:

Children who were younger than 4 years or older than 12 years old, ataxic type of CP, GMFCS IV-V, and need bony procedures, or are complaining of other associated syndromes.

All the patients evaluated at the outpatient clinic were as follows:

A full history was taken from the patient and the caregivers, including the patient's complaints and present, past, and family history.

Full examination of the patient including Thomas test, abduction ROM, popliteal angel, silfverskiold test, Duncan Ely's test, assessing the gait, assessing the type of CP and grading according to GMFCS.

The patient examined twice: first time in the clinic and the second on in the OR under GA and muscle relaxant as many patients can't relax in the clinic then decide the appropriate procedure to be done.

Each patient underwent three assessments: one the week prior to surgery, three months after surgery, and six months after surgery. The assessments included GMFM-88 score for evaluation of the motor functions and ability among children who had CP 7, The Spinal Alignment and Range of Motion (ROM) Measure was utilized to quantify ROM restrictions 8; The ROM score was calculated by adding the scores from the hips (12 items), knees (4 items), and ankles (2 items) (4 items). Numbers from 0 to 80 were used for the score. Utilizing the modified Ashworth scale, a higher score indicated a more severe restriction in ROM, while spasticity was identified 9. The severity of spasticity was measured on a scale from 0 to 30, where higher scores indicated more severe symptoms.

Operative documentation:

Operative approach, level of management, technique of operation, and intraoperative complications were recorded.

Ethical consideration:

Informed consent with risk explanation was obtained from the child's family.

Operative technique:

All patients were operated under general anesthesia and a muscle relaxant.

Adductor tenotomy was applied by placing the patient in a supine position through a 2-3 cm incision parallel to the groin crease. Then, dissect the subcutaneous tissue and incise the fascia in line with the skin incision. Palpate and isolate the adductor longus from the surrounding tissue with a clamp, then use a dissector under the muscle. Then perform the tenotomy using the electrocautery. Figure 1

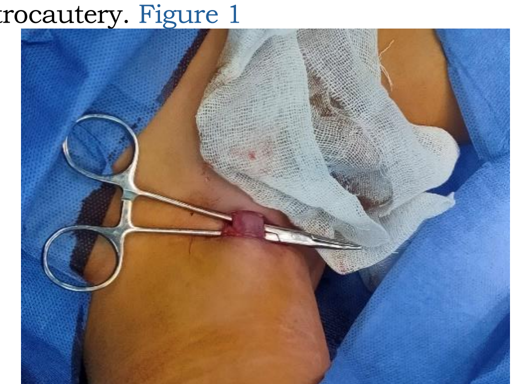

Figure 1. Adductor tenotomy

Iliopsoas release was performed by making a 3-

4-cm incision distal to the ASIS. Incision was extended distally and medially. The tensor fascia lata/Sartorius interval was identified and opened. The lateral femoral cutaneous nerve was isolated and protected. Dissection was performed medially to the rectus femoris tendon, which is situated deep to the interval. The pelvic brim was palpated. The hip was then flexed, and the psoas tendon and muscle were identified. The fascia over the psoas tendon was opened, and a right-angle retractor was placed around the psoas tendon to isolate it from the muscle. The tendon was then divided using electrocautery, leaving the muscle intact. Figure 2

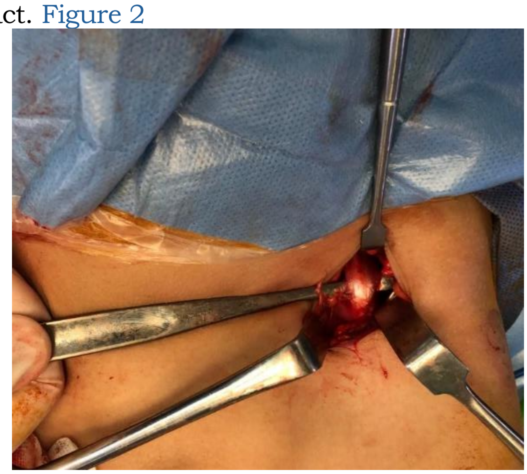

Figure 2. Iliopsoas release

Hamstring lengthening was performed in the supine or prone position through a 2 cm incision just above the semitendinosus. Dissect and isolate the semitendinosus muscle, a small opening in the paratenon. Isolate the semitendinosus muscle and cut it using a blade, leaving the paratenon intact. Figure 3

Figure 3. Hamstring lengthening

Gastrocnemius recession was performed in supine or prone position through a 3-4 longitudinal posteromedial incision at the level of the musculotendinous junction to protect the sural nerve and divide the gastrocnemius aponeurosis from lateral to medial, while preserving the soleus. The ankle is forced in dorsiflexion with separation of the cutting edges that expose the soleus muscle, which is maintained intact. Figure 4

Figure 4. Gastrocnemius recession

Postoperative care and follow-up:

A bilateral above-knee cast with the knees in full extension was applied for all cases and maintained for 6 weeks, and in cases that had performed adductor tenotomy, a pillow was applied between the lower limbs. Immediately following the removal of the cast, physiotherapy or occupational therapy was initiated, with a focus on active exercises. An above-knee night splint and AFO were employed during the day after the cast was removed.

In the first 2 weeks postoperative, physical therapy included standing and balance training, strengthening of the back and hip muscles, and ROM exercise. After the first 2 weeks, physical therapy focused on strengthening of the knee and hip muscles, ROM exercise, and gait training using a walker.

They returned every 2 weeks for a follow-up examination for the first 6 weeks, then after 3 and 6 months to reassess GMFM-88, ROM, and spasticity scores. After 6 months, regular physiotherapy was recommended.

3. Results

The study included 12 spastic CP patients with lower limb deformities. Eight of them were males (67%) and four were females (33%). The age of children ranged from 4 to 12 with mean age 7.5 years old. All included children suffered from spastic diplegic cerebral palsy. According to GMFCS, 10 of cases were GMFCS III (83%) and only 2 cases were GMFCS II (17%).

Regarding preoperative assessment, GMFM score was 32. Preoperative ROM score was 38.67±8.15. Preoperative spasticity score was 23.08±3.6.

Regarding surgical procedures, all procedures were conducted under general anesthesia and muscle relaxant. Bilateral medial hamstring lengthening was performed in 50%. Bilateral Hip adductors lengthening was performed in 50% of included patients. Bilateral gastrocnemius recession was performed in 41.6%. Bilateral Psoas muscle lengthening was performed in 41.6%. (table 1)

Table 1. Operative Data

	FREQUENCY	PERCENT
ANESTHESIA		
GENERAL ANESTHESIA & MUSCLE RELAXANT	12	100%
SURGERY DONE		
BILATERAL MEDIAL HAMSTRING LENGTHENING	6	50%
BILATERAL HIP ADDUCTORS LENGTHENING	6	50%
BILATERAL GASTROCNEMIUS	5	41.6%
BILATERAL PSOAS MUSCLE LENGTHENING	5	41.6%
RIGHT PSOAS MUSCLE LENGTHENING	2	16.6%
RIGHT MEDIAL HAMSTRING LENGTHENING	1	8.3%
LEFT MEDIAL HAMSTRING LENGTHENING	1	8.3%
LEFT GASTROCNEMIUS	1	8.3%

Data is presented as frequency (%).

The results showed a significant improvement in ROM from pre to post surgery at 3 and 6 months follow-up with a mean score preoperative 3.67 (SD=8.15) and 25.17 (SD=7.27) at 3 months follow up and 20.42 (SD=6.11) at 6 months follow up. The ROM at 6 months was better than that obtained at 3 months follow-up ($P < 0.05$). (table 2)

Table 2. repeated measurements for ROM preoperative and during follow-up.

ROM	MEAN ±SD	
PREOPERATIVE	38.67±8.15	
3 MONTHS FOLLOW-UP	25.17±7.27	
6 MONTHS FOLLOW-UP	20.42±6.11	
	Mean Difference	P value
3 MONTHS FOLLOW-UP VERSUS PREOPERATIVE	13.500*	0.000
6 MONTHS FOLLOW-UP VERSUS PREOPERATIVE	18.250*	0.000
6 MONTHS FOLLOW-UP VERSUS 3 MONTHS FOLLOW-UP	4.750*	0.000

Data is presented as Mean ±SD, ROM: Range of Motion, *: significant p value ≤ 0.05. General linear model.

There was a significant improvement in spasticity score from pre to post surgery at 3 and 6 months follow-up with a mean score preoperative 23.08 (SD=3.605) and 14.08 (SD=4.379) at 3 moths follow up and 10.33 (SD=3.284) at 6 months follow up. The spasticity score at 6 months was better than that obtained at 3 months follow-up ($P < 0.05$). (table 3)

Table 3. repeated measurements of spasticity score preoperative and during follow-up.

SPASTICITY SCORE	MEAN ±SD	
PREOPERATIVE	23.08±3.605	
3 MONTHS FOLLOW-UP	14.08±4.379	
6 MONTHS FOLLOW-UP	10.33±3.284	
	Mean Difference	P value
3 MONTHS FOLLOW-UP VERSUS PREOPERATIVE	9.000*	0.000
6 MONTHS FOLLOW-UP VERSUS PREOPERATIVE	12.750*	0.000
6 MONTHS FOLLOW-UP VERSUS 3 MONTHS FOLLOW-UP	3.750*	0.000

Data is presented as Mean ±SD and *: significant p value ≤ 0.05. General linear model.

The results revealed a statistically significant improvement in GMFM score from pre to post surgery at 3 and 6 months follow-up with a mean score preoperative 32.0 (IQR=28.5-34.0) and 42 (IQR=38.5-44.75) at 3 months follow up and 46 (IQR=41.25-50.25) at 6 months follow up. The GMFM score at 6 months was better than that obtained at 3 months follow-up ($P < 0.05$). (table 4)

Table 4. Boxplot for the repeated measurements for GMFM score preoperative and during follow-up.

GMFM SCORE	MEDIAN	IQR
PREOPERATIVE	32.0	28.5-34.0
3 MONTHS FOLLOW-UP	42	38.5-44.75
6 MONTHS FOLLOW-UP	46	41.25-50.25
	Test value	P value
FRIEDMAN TEST	24	0.000
3 MONTHS FOLLOW-UP VERSUS PREOPERATIVE	-2.44	0.043
6 MONTHS FOLLOW-UP VERSUS PREOPERATIVE	-4.889	0.00
6 MONTHS FOLLOW-UP VERSUS 3 MONTHS FOLLOW-UP	-2.449	0.043

GMFM: Gross Motor Function Measure and IQR: interquartile range. Not normally distributed data represented as median and interquartile range (IQR); Friedman test followed by pairwise comparison.

Case presentation:

Case 1: Female patient, 9 years old, spastic diplegic CP (GMFCS II), preoperative GMGM score: 66%, ROM score: 25, Spasticity score: 18.

She underwent bil. hamstring lengthening, lt gastrocnemius recession. The postoperative GMGM score: 76%, ROM score: 14, Spasticity score: 8 (figure 5).

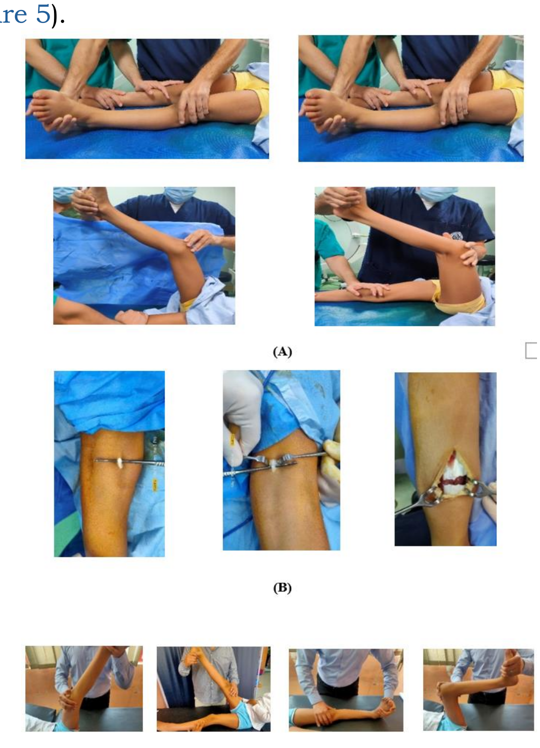

Figure 5. (A) examination under general anesthesia. (B) hamstring lengthening & GC

recession. (C) postoperative 6 moths follow up

Case 2: Male patient, 5 years old, spastic diplegic CP (GMFCS III), preoperative GMGM score: 30%, ROM score: 37, spasticity score: 22. He underwent rt. iliopsoas release, bil. hamstring lengthening. The postoperative GMGM score: 45%, ROM score: 18, spasticity score:10 (figure 6).

Figure 6. (A) examination under general anesthesia. (B) hamstring lengthening & iliopsoas release. (C) postoperative 6 months follow up

4. Discussion

This study prospectively evaluated the effect of SEMLS in improving gait and function in 12 children with spastic diplegic CP.

A prospective cohort study followed nineteen children with bilateral spastic CP for five years, assessing the impact of SEMLS. The study found that SEMLS resulted in significant, lasting improvements in gait and functional abilities. These enhancements, observed in measures like the Gait Profile Score (GPS) and Gross Motor Function Measure (GMFM-66), were maintained for at least five years postoperatively, underscoring the long-term effectiveness of SEMLS in this population.[13]

Another study was conducted comparing conventional SEMLS with minimally invasive SEMLS techniques in children with spastic diplegic CP. The study involved ten children who underwent minimally invasive surgery and ten children who had conventional surgery. Both groups showed significant improvements in gait post-operatively. Notably, the minimally invasive group experienced enhanced muscle strength, faster mobilization, decreased operation time, and decreased blood loss, without any complications. The study concluded that minimally invasive SEMLS offers significant benefits over conventional techniques.[14]

Another retrospective study was conducted on the long-term effects of SEMLS in children with bilateral spastic CP. The study followed thirteen children over more than 10 years, collecting three-dimensional gait data at various intervals. Post-surgery, significant improvements were noted in the movement analysis profile (MAP) and gait profile score (GPS), particularly in knee extension during the stance phase. However, there was deterioration in knee flexion during the swing phase and pelvic tilt. Despite these mixed results, the outcomes of SEMLS were generally sustained over the long term with continued care, including orthoses, physiotherapy, and additional surgeries. The study highlighted that while SEMLS is effective, ongoing and comprehensive care is essential for maintaining the benefits.[15]

In this study, all soft tissue release surgeries performed in the children with CP generated positive outcomes in the GMFM which changed significantly from (28.5-34.0) in the preoperative assessment to (38.5-44.75) in the first follow up after 3months and (41.25-50.25) in the second follow up after 6 months postoperative with P value < 0.05.

This is also in agreement with Thomason et al., who reported an increase of 3 3% in the GMFM between the preoperative and the postoperative assessments.[13]

The results of our study noted a marked improvement in the ROM as determined by the ROM score, which changed from (38.67±8.15) preoperatively to (25.17±7.27) after 3 months and (20.42±6.11) after 6 months, with a P value < 0.05, which means significant improvement in the ROM.

There's also improvement in the spasticity as noted from changes in the modified Ashworth score before and after single-event multilevel release surgery, as the mean score decreased from (23.08±3.605) preoperatively to (14.08±4.379) at three months postoperative and (10.33±3.284) at six months postoperative with P value <0.05.

Regarding the recent studies talking about SEMLS, different methodology types used like: prospective, case control and retrospective.

Different parameters and indices used to describe the improvement before and after surgery for instance: MAP, GPS, modified Ashworth score and finally GMFM 66 – 88.

Lastly, there is consensus in most studies that SEMLS results in clinically and statistically significant improvements in gait and functional abilities in children with bilateral spastic CP.

Limitations of the study: There are several limitations to our study. The most significant is the small sample size and the short follow-up. Further research is needed to assess GMFM changes beyond the first six months. Certain complications, such as the recurrence of deformities, were not detected in this study.

Recommendations for Future Research: Expand the sample size to include a larger cohort of patients. Prolong the follow-up duration to capture long-term outcomes. Employ advanced techniques, such as 3D gait analysis, for a more precise assessment of gait improvements, rather than relying solely on clinical evaluations.

4. Conclusion

SEMLS is considered a satisfactory and effective intervention for managing deformities in CP, leading to better functional outcomes and enhanced quality of life for patients.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article

Funding

No Funds : Yes

Conflicts of interest

There are no conflicts of interest.

References

1. Christensen D, Van Naarden Braun K, Doernberg NS, Maenner MJ, Arneson CL, Durkin MS, et al. Prevalence of cerebral palsy, co-occurring autism spectrum disorders, and motor functioning –Autism and Developmental Disabilities Monitoring Network, USA, 2008. Developmental Medicine & Child Neurology. 2014;56(1):59-65.
2. Gulati S, Sondhi V. Cerebral Palsy: An Overview. The Indian Journal of Pediatrics. 2018;85(11):1006-1016.
3. Abd Elmagid DS, Magdy H. Evaluation of risk factors for cerebral palsy. The Egyptian Journal of Neurology, Psychiatry and Neurosurgery. 2021;57(1)doi:10.1186/s41983-020-00265-1
4. Basics about cerebral palsy. Centers for Disease Control and Prevention. . Accessed July 5, 2023
5. Narayanan UG. Management of Children With Ambulatory Cerebral Palsy. Journal of Pediatric Orthopaedics. 2012;32(Supplement 2):S172-S181.
6. Odding E, Roebroeck ME, Stam HJ. The epidemiology of cerebral palsy: Incidence, impairments and risk factors. Disability and Rehabilitation. 2006;28(4):183-191.
7. Palisano R RP, Bartlett D, Livingston M. Gross Motor Function Classification System Expanded and Revised. California Perinatal Quality Care Collaborative. Accessed July 5, 2023
8. Feng J, Wick J, Bompiani E, Aiona M. Applications of gait analysis in pediatric orthopaedics. Current Orthopaedic Practice. 2016;27(4):455-464.
9. Galey SA, Lerner ZF, Bulea TC, Zimbler S, Damiano DL. Effectiveness of surgical and non-surgical management of crouch gait in cerebral palsy: A systematic review. Gait & Posture. 2017;54:93-105.
10. Bache CE, Selber P, Graham HK. (ii) The management of spastic diplegia. Current Orthopaedics. 2003;17(2):88-104.
11. Wren TAL, Otsuka NY, Bowen RE, Scaduto AA, Chan LS, Sheng M, et al. Influence of gait analysis on decision-making for lower extremity orthopaedic surgery: Baseline data from a randomized controlled trial. Gait & Posture. 2011;34(3):364-369.
12. Ferrari A, Brunner R, Faccioli S, Reverberi S, Benedetti MG. Gait analysis contribution to problems identification and surgical planning in CP patients: an agreement study. Eur J Phys Rehabil Med. Feb 2015;51(1):39-48.
13. Thomason P, Selber P, Graham HK. Single Event Multilevel Surgery in children with bilateral spastic cerebral palsy: a 5 year prospective cohort study. Gait Posture. Jan 2013;37(1):23-8.
14. Thompson N, Stebbins J, Seniorou M, Wainwright AM, Newham DJ, Theologis TN. The use of minimally invasive techniques in multi-level surgery for children with cerebral palsy: preliminary results. J Bone Joint Surg Br. Oct 2010;92(10):1442-8.
15. Visscher R, Hasler N, Freslier M, Singh NB, Taylor WR, Brunner R, Rutz E. Long-term follow-up after multilevel surgery in cerebral palsy. Archives of Orthopaedic and Trauma Surgery. 2022/09/01 2022;142(9):2131-2138.