International Journal of Orthopaedics Research
www.orthopaedicsjournal.in
E-ISSN: 2663-0923, P-ISSN: 2663-0915
Received Date: 16-02-2019 Accepted Date: 19-03-2019; Published: 26-03-2019
Volume 1; Issue 2; 2019; Page No. 34-38

Single event multilevel soft tissue release in lower limb surgical intervention in patients with spastic cerebral palsy

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Abstract
Introduction: Cerebral palsy is the non-progressive injury to immature brain that results in change in muscle tone and posture, both at rest and with voluntary activity. Spastic CP is the most common subtype. Single Event Multiple Level Resections (SEMLR) in the lower limb is to improve the gait of children with spastic CP.
Methods: 25 patients (M: F 16:9) were included in this study with a mean age of 9.45 ± 3.78 years (4–15 years). Children with dyskinetic or mixed CP, those requiring bony surgeries, and those with severe or profound mental retardation were excluded from the study. The lower extremities assessment was done with physical examination and Gross Motor Functional Classification Scale (GMFCS) scores.
Results: In total, 106 operative procedures were done in the patients with average of 4.24 procedures per child. All children attained complete or nearly complete correction of deformities after surgery. . There was significant improvement GMFCS score following surgery (P = 0.05).
Conclusion: Single-stage multilevel soft-tissue surgery in the lower limbs in patients with spastic CP and good trunk control produces good outcomes for movement and locomotion. This is a cost-effective and logical approach in developing countries like India, where the patients would not turn up for multistage surgery and follow-up.

Keywords: cerebral palsy, SEMLS, GMFCS, movement, locomotion, gait

Introduction

Cerebral Palsy (CP) affects two to four children per 1000 live births and is the most frequently managed neurological condition in children [1]. Although CP being defined as a solo insult to the developing brain it is a permanent diagnosis, which results in a child with CP gaining access to health care forever [2].

In CP, it is the non-progressive injury to immature brain [3] which results in change in muscle tone and posture, both at rest and with voluntary activity [4]. The most common subtype is the Spastic CP, which constitutes around 70–80% patients of total CP population.

The main aim to perform multilevel surgeries or Single Event Multiple Level Resections (SEMLR) in the lower limb is to improve the gait of children with spastic CP [5].

During the last two decades, much focus has been given on the correction of all fixed musculoskeletal deformities with single-event multilevel surgery [5-15]. Improvement of gait is the primary target of single-event multilevel surgery in children with cerebral palsy [5-16]. Second aim may include progress in gait efficiency [6] and appearance, gross motor function [11, 15], independence [17], quality of life [15, 18], and gross motor function [11, 15].

The treatment of a patient with CP must be individualized and prearranged according to the patient's needs. In patients with total body involvement or quadriplegia, maintaining hygiene, independence and balanced sitting would be very important consideration.

The age group for SEMLS varies from [4–8] years [19] to just before the period of increased growth in adolescence [20]. Various studies suggest that children in whom surgical intervention is advised are not a homogeneous group.

We did a retrospective study that analyse the data on 25 patients with spastic CP who were operated for lower limb deformities to attain enhancement in, gait, personal hygiene and independent ambulation with assistive devices alone or with orthoses.

Materials and Methods

This study was conducted in the department of Orthopaedics of a tertiary care hospital. In total 25 patients (M: F 16:9) were included in this study with a mean age of 9.45 ± 3.78 years (4–15 years). All patients were admitted in the Orthopaedics unit for corrective over a period of 28 months (June 2016 to September 2018). Informed consent was obtained from the

Parents. None of the patients had fixed spinal deformity or prior surgery for correction of lower limb deformity. Exclusion criteria included children with dyskinetic or mixed CP, those requiring bony surgeries, and those with severe or profound mental retardation.

The lower extremities assessment was done with physical examination and Gross Motor Functional Classification Scale (GMFCS) scores [15]. Soft-tissue contractures in the lower limbs were assessed with special tests and joint examinations. Thomas Test and Prone-Rectus Test was used to assess Hip flexion deformity, and deformities were measured using goniometer. Popliteal angle and Phelps-Becker Test were used to assess Hamstring tightness. Popliteal angle was measured with the patient in supine position and the hip in 90° of flexion. Assessment of Equinus deformity at ankle was done using Silverskiold Test. Gait patterns such as scissoring, crouching, toe-to toe gait, jump knee gait, and toe-to-heel gait were examined in all the patients clinically.

Data analysis done using the SPSS 15.0. Patients' pre-and postoperative scores on the GMFCS were analysed.

Results

Preoperatively, all the children had static deformities in the lower limbs. Deformities in all the joints were recorded. There were 36 static equinus deformities, [22] static hip flexion deformities, three hip adductor deformities, and 48 hamstring static deformities (medial and lateral hamstrings) in 25 patients (50 legs). Mean hip flexion deformity was 25.340 ± 7.59°, mean popliteal angle was 97.09 ± 14.53°, and mean equinus deformity was 29.49 ± 9.27° preoperatively. Overall, 106 operative procedures which included adductor release, gastrocnemius recession, hamstring release etc.(Figure 1, 2, 3) were done in the patients with average of 4.24 procedures per child. All children attained complete or nearly complete correction of deformities after surgery.

Improvement in functional abilities and locomotion was assessed in all patients preoperatively and postoperatively using GMFCS scores and by physical examination. GMFCS was not applicable in 7 patients in this study, as they were more than 12 years of age at the time of surgery. Number of patients with improvement in GMFCS scores post-surgery as depicted in Table 1. Preoperatively, 8 and 10 patients were falling under the Level III and Level IV Category of GMFCS score respectively. Following surgery, there was a significant improvement (Figure 4) in GMFCS score, with 6 patients improving to Level II and 11 patients improving to Level III.

No complications were noticed at hip (both for flexion and adductor sites) and knee at the operated site. Two children (four legs) with equinus deformity developed wound dehiscence at the suture line with loss of skin. Their length of stay was prolonged, antibiotics and daily wound dressing was done, and wounds healed with no further complications.

Ten children with spastic diplegia were advised bilateral AFO for locomotion postoperatively. Out of these, 6 children also received bilateral knee gaiters. Three children with spastic diplegia were advised bilateral KAFO for ambulation. Three children each required axillary and elbow crutches as assistive device for walking.

Mean duration of follow-up in the study was 14.04 ± 5.59 months (3–24 months). 15 (60%) were ambulatory in the household/functional ambulators, at the time of follow-up. All parents and children were satisfied with the results of surgery and reported improvement in functional abilities and locomotion in the follow-up. Their quality of life was better, and many of the children who were not at all able to stand before surgery were standing and walking with orthosis and assistive devices.

Table 1: Number of patients with improvement in GMFCS scores post-surgery

GMFCS score	Number of Patients	
	Preoperative	Postoperative
Level I - Walks without Limitations	-	-
Level II - Walks with Limitations	-	6
Level III - Walks Using a Hand-Held Mobility Device	8	11
Level IV - Self-Mobility with Limitations; May Use Powered Mobility	10	1
Level V - Transported in a Manual Wheelchair	-	-

Note: The score was not applicable on 7 patients out of a total of 25 patients since they were of age>12 years

Fig 1: Adductor tendon release for adductor longus tendon contracture

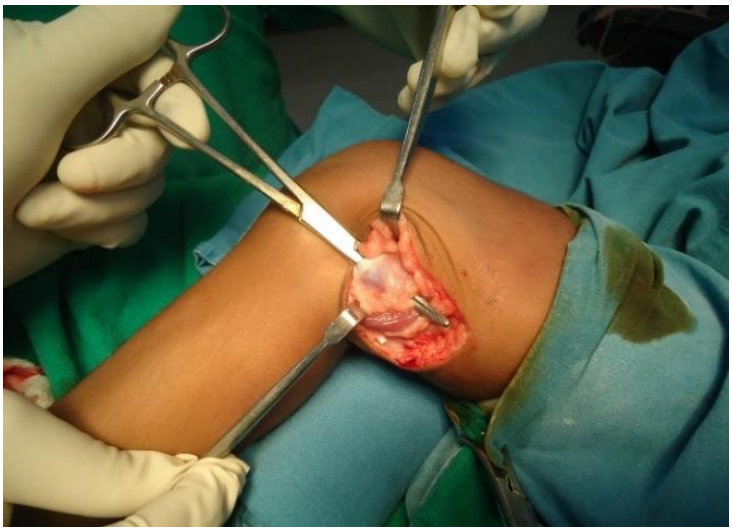

Fig 2: Gastrocnemius recession (involving release of the gastrocnemius tendon and subsequent lengthening of the calf muscle) for equinas contractures

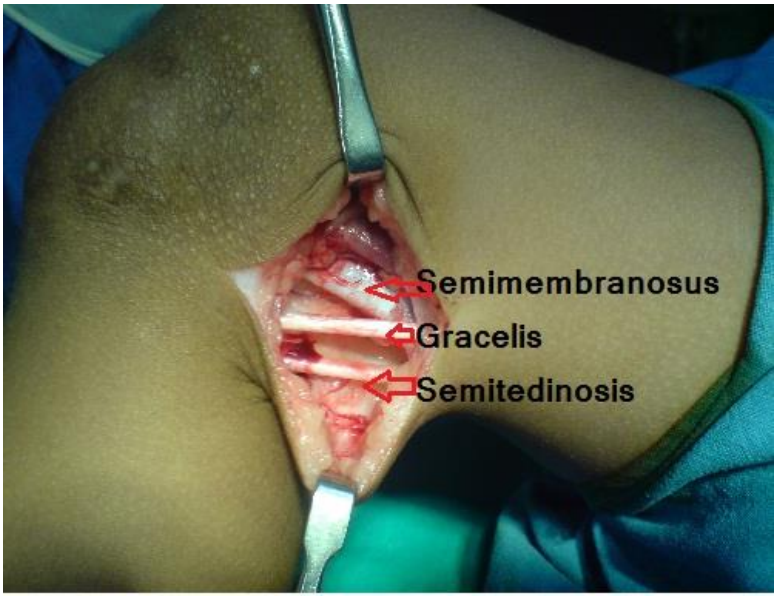

Fig 3: Hamstring tendons (semitendinosus, gracilis and semimembranosus) release for tight hamstrings and knee contracture

Fig 4: Significant improvement in patient post operatively showing patient being able to stand with support and decreased limitations. Knee contracture and equinus of left lower limb was corrected.

Discussion

CP is counted as the most common reason of physical disability in the paediatric group, and it is caused by a non-progressive injury that occurs while the child's brain is under development, which leads to a disorder of movement or posture. There are few associated secondary conditions that may develop or change over time. Hypotonia may be replaced by spasticity during early infancy and involuntary movements, athetosis or a mixed type including signs of both may appear [21]. Almost 70–80% of all CP cases include spastic CP, which is characterized by increased muscle tone. Spastic CP is the most common type of CP. Dyskinetic [athetosis] and hypotonic subtypes are rarely seen. Among the mixed type, the combination of spasticity with athetosis is common.

In developing countries like India, awareness among parents of these children is increasing, and plenty of cases are seen in the dedicated tertiary centers at a very early age. Still, there are many CP cases that are brought only after the child is more than 3–5 years of age and has not started standing or walking [22]. By this time, these cases would already develop static/dynamic deformity across the various joints in the lower limb. Whenever these non-ambulatory patients with multiple static deformities are brought initially to a tertiary care center, a single-stage multilevel corrective surgery along with rehabilitation may be more reasonable than planning multistage surgical procedures with physiotherapy. It has improved the clinical and functional outcome of patients with spastic CP [23]. It is also rational because many of these patients, once ambulant after surgery would not follow-up.

The main indication for surgical intervention for lower extremity soft tissue is to correct contractures and deformities of the joints by lengthening of the spastic muscle. Tenotomy, tendon transfers, fractional or Z plasty lengthening of the

Tendon are few surgical procedures on the soft tissue that can be performed for correcting contractures and deformities. It is recommend by many authors that carrying out numerous soft tissue surgeries and osteotomies, if required, in a single event in patients with CP is beneficial [24]. A study by Rang recommended to resolute all lower extremity hitches in a single event, this can prevent needless lengthening procedures or repeated operative interventions in patients with CP [25]. In a similar way, our study results confirmed that single-event soft tissue release and lengthening surgeries on many joints have noteworthy effects on the range of motion of joints and contractures.

Orthoses are regularly used for the improvement in the gait and to correct or maintain the deformity in patients with CP. Indications and cost must be considered while choosing an orthosis [27]. Orthosis should be chosen in accordance with the needs of the patients and with the aim of maintaining the correction achieved during the surgery and to improve the gait features such as endurance, velocity and cadence. In our study, patients maintained the improvement in gait and range of joint motions during their follow-up visits.

In a case-control study by Zwick *et al.*., which involved 20 patients with spastic diplegia, it was shown that patients who underwent single-stage multilevel surgery walked quicker with

improved stride length and considerably greater than before knee joint range of motion when matched with the control group. It was seen that these children had better knee extension during the stance phase of gait that triggered improved stance limb strength and helped in developing an unrestricted swing phase of the opposite limb after operation [7].

In this study, all soft tissue release surgeries performed in the children with CP generated positive outcomes in the GMFCS. Also, it was established that although single-event soft tissue release and lengthening procedures have drawbacks such as increased anaesthesia time and its complications, increased duration of procedure, increased bleeding, need for repositioning of patient during operation, and deferred rehabilitation due to extended recovery time, it also offers an important benefit such as lack of need for repeated operations.

There are few limitations to our study, the most important one is the small sample size and a short follow-up period. Certain complications like recurrence of deformities could not be detected in the present study. Also, because of non-availability of the equipment during that period, gait analysis was not performed.

Conclusion

Single-stage multilevel soft-tissue surgery in the lower limbs in patients with spastic CP and good trunk control produces good outcomes for movement and locomotion. This is a cost-effective and logical approach in developing countries like India, where the patients would not turn up for multistage surgery and follow-up, almost all patients displayed suitable outcomes with minimal complications after corrective surgery, and their functional capability developed considerably.

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