Gait & Posture 52 (2017) 135–139

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Full length article

Does unilateral single-event multilevel surgery improve gait in children with spastic hemiplegia? A retrospective analysis of a long-term follow-up☆

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ARTICLE INFO

Article history:
Received 28 June 2016
Received in revised form 30 September 2016
Accepted 7 November 2016

Keywords:
Gait
Unilateral cerebral palsy
Single-event multilevel surgery
Gait profile score

ABSTRACT

Single event multilevel surgery (SEMLS) has become a standard intervention for children with cerebral palsy (CP). SEMLS proved to improve the gait in bilateral spastic cerebral palsy and those improvements can be maintained in the long term. However there is no evidence on the long-term outcome of unilateral SEMLS in children with unilateral spastic cerebral palsy.

The gait analyses and clinical data of 14 children (9 male/5 female, mean age 12.1) with unilateral CP (6 children Gross Motor Function Classification System Scale level I and 8 children level II) were retrospectively reviewed at four time-points: preoperatively, 1 year, 3–5 years and approximately 10 years after unilateral SEMLS. The Gait Profile Score (GPS) of the affected leg was used as a main and the number of fine tuning procedures as well as complications rate (Clavien-Dindo classification) as secondary outcome measures.

The gait improved postoperatively and the GPS of the affected leg significantly declined by 3.73° which is well above the minimal clinical important difference of 1.6°. No deterioration of GPS occurred throughout the follow-up period. Therefore the postoperative improvement was maintained long-term. However, additional fine-tuning procedures had to be performed during the follow-up in 5 children and three complications occurred (one level II and two level III).

The results indicate that children with unilateral cerebral palsy benefit from unilateral SEMLS and maintain gait improvements long-term.

1. Introduction

Cerebral palsy describes a group of disorders of the development of movement and posture, which result in activity limitation that can be attributed to non-progressive disturbance that occurred in the development of fetal or infant brain. The motor disorders might also be accompanied by disturbances of sensation, cognition, communication, perception and/or behavior [1]. Even if the insult remains stationary, the musculoskeletal pathology is progressive in children with cerebral palsy and leads to gait deterioration over time [2].

The various components of the progressive musculoskeletal pathology often require orthopedic procedures. Recently, single-level surgery has been replaced by the concept of single event multilevel surgery (SEMLS) in which multiple levels of musculoskeletal pathology are addressed during a single surgical procedure. SEMLS minimizes the number of surgical events by combining procedures at multiple joints and patients profit thanks to an improved overall recovery and reduced rehabilitation time [3–5].

There is considerable evidence on the long-term gait outcome after SEMLS in children with bilateral spastic cerebral palsy, from both retrospective and prospective studies. In a retrospective study with a 10 year follow up, Haumont et al. found improvements in gross motor function and flexed-knee gait [6] while a prospective

☆ There are no conflicts of interest. This study received no funding and there were no additional contributors.

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http://dx.doi.org/10.1016/j.gaitpost.2016.11.018
0966-6362/

randomized controlled trial by Thomason et al. showed clinically relevant improvements in gait and function after SEMLS [7]. There is an overall agreement in the literature that SEMLS improves gait and this improvement can be maintained short term as well as long term.

Nevertheless, the evidence on effect of unilateral SEMLS in children with spastic hemiplegia is limited. There are studies that also included children with unilateral cerebral palsy. However, most of those studies have a short follow up, small sample size or hemiplegic group was assessed together with children with bilateral cerebral palsy [8–13]. The few studies that specifically focused on the outcome of multilevel surgery in unilateral cerebral palsy also had a short follow-up and some evaluated only a specific subgroup of patients with unilateral cerebral palsy [14–16]. The aim of the present study is to report long-term outcomes of unilateral SEMLS in children with spastic hemiplegia using a standardized instrumental gait analysis and Gait Profile Score as a main outcome measure.

2. Methods

This is a retrospective analysis of clinical and gait analysis data on a consecutive sample of children with spastic unilateral CP. All children of our database who received a single event multi-level surgery (SEMLS) were reviewed retrospectively. Included children had unilateral spastic cerebral palsy, were able to walk (Gross Motor Function Classification System Scale [17] level I to III preoperatively) and the follow-up time was not less than 5 years. Excluded were children with a botulinum toxin injection in their lower limbs within 6 months before unilateral SEMLS, lower limb muscle/tendon or bony surgery within 12 months before unilateral SEMLS and missing kinematic or other data needed for the calculation of the Gait Profile Score.

The gait analysis data and clinical data were extracted from the gait database and hospital system and checked for completeness. Every child was followed up with 3D gait analysis, before surgery, approximately 1 year after surgery, 3–5 years after surgery and at the last available follow-up (approximately 10 years after surgery).

In accordance with the literature, a single event multi-level surgery was defined as two or more soft-tissue or bony surgical procedures at two or more anatomical levels [3]. Postoperative treatment was similar in all cases. Passive physiotherapy was started 4–7 days after surgery, standing therapy and gait training 7–10 days after surgery. Once they could walk with reasonable confidence they were discharged. Participants required dynamic ankle-foot orthoses until muscle power in the calf was sufficient and they used a rigid night splint until muscle balance at the knee was stabilized [18]. The details on the standardized protocol for postoperative rehabilitation of surgery can be found elsewhere [19].

A computerized gait analysis was performed on all children using a motion capturing system (Vicon, Oxford Metrics, Oxford, U. K.) and force plates (AMTI). Markers were placed according to the "Plug-In Gait" protocol. Vicon Clinical Manager software (Vicon Oxford Metric Oxford, U.K.) was used for data processing. All trials were performed on a 10-m walkway at self-selected walking speed. A minimum of five trials with clear foot force plate contact was captured and averaged for each patient for each leg.

The Gait Profile Score (GPS) has been proposed as an index of overall gait pathology and was used as a primary outcome measure in this study. The GPS represents the root mean square difference of an individual's kinematic data from the reference data across relevant kinematic variables and the whole gait cycle. This value is calculated for multiple joints of the lower limb in multiple planes and then combined into an overall score [20]. The GPS score of the affected side will be used as the outcome measure instead of the overall GPS score, because it is more relevant in children with unilateral cerebral palsy. To evaluate postoperative changes in detail the Movement Analysis Profile will be presented.

The number and types of index as well as fine-tuning surgeries was chosen as a secondary outcome measure. Furthermore, Clavien-Dindo classification [21] was used to assess complication rate and severity.

To evaluate GPS changes over time a repeated measures analysis of variance (ANOVA) was used and the Bonferroni correction was applied to adjust for multiple comparisons. A basic descriptive statistics was used where appropriate. Statistical analysis was performed with SPSS 22 software package (SPSS Inc., Chicago, IL, USA). The significance level was set at 5%. The local ethics committee approved this study (EK 27-340 ex 14/15).

3. Results

Fourteen children with unilateral cerebral palsy (9 male/5 female) were included in this retrospective study. Out of those children, 6 were classified as Gross Motor Classification System level I, 8 as level II and none as level III. Mean (SD) age at the initial SEMLS was 12.1 years (3.3 years) with a range from 6 to 17 years. The average follow-up time was 9.4 years (2.2 years), ranging from 6 years to 13 years. An intermediate gait analysis (3–5 years after the surgery) was available for 12 children.

The mean (SD) preoperative GPS of the affected leg was 11.83° (4.69°), ranging from 6.4 to 20.9. There was a significant improvement of the mean GPS by 3.73° ($p = 0.01$) to 8.11 (2.41°) one year after the surgery and no deterioration occurred throughout the whole follow-up period. The average GPS of the affected leg during the last follow up was 9.13° (4.14°). Therefore, the gait of children with hemiplegia improved postoperatively and they were able to maintain this positive change until the last follow-up. An overview of GPS results for the affected leg during the whole follow-up period can be found in Fig. 1. The preoperative GPS of an unaffected leg was increased (9.8°) as a compensatory mechanism for the affected side. The compensations were postoperative not more necessary and GPS of unaffected leg improved (8.7°). Concerning MAPs of the unaffected leg, the

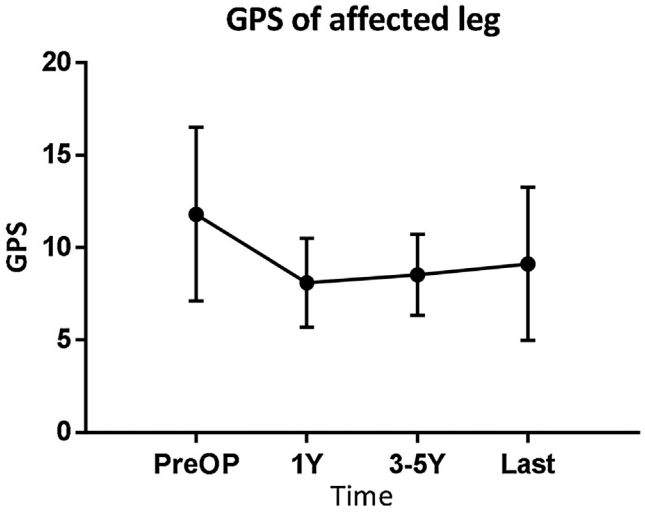

Fig. 1. GPS of the affected leg with standard deviation. GPS – Gait Profile Score; PreOP – preoperative; 1Y –1 year follow-up; 3–5 Y – follow-up after 3–5 years, Last– the last follow-up approximately 10 years after SEMLS.