Multilevel Surgical Outcome in Cerebral Palsy: A 30 Month Follow Up Study

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Introduction: The evaluation of treatment outcome based on Gait Analysis is difficult due to the quantity and variety of data produced. The Normalcy Index (NI) is a single number, derived from 16 clinically relevant kinematic measures, that gives a global assessment of a subject's gait pathology [1]. The NI has been validated at several clinical gait centers in North America and Europe, and has been found to be objective and repeatable [2]. The NI has also been shown to have strong correlations to functional outcome measures such as the Gross Motor Function Measure and the Gillette Functional Assessment Questionnaire [3]. As a result, the NI is an appropriate outcome measure for summarizing and comparing patients who underwent different types of treatments. This study focuses on one treatment modality for the correction muscle contractures and bony deformities in cerebral palsy (CP) – the "Single event multilevel surgery" [4]. Multilevel surgery includes treatment of multiple muscles, tendons and bones in a single session. Most of previous studies of multilevel surgery have analyzed the outcome only once, with a typical follow-up time of only one year [5,6]. In this study, we evaluate the effects of multilevel surgery longitudinally up to a 30 month time period.

Statement of Clinical Significance: Single event multilevel surgery results in significant and persistent improvements in overall gait as measured by the normalcy index.

Methodology: A medical team from the "V. Buzzi" Children's Hospital in Milan selected 51 subjects affected by CP (31 males, 20 females; mean age = 9 years, age range = 5 – 22 years). Of these patients 40 were diplegic, 8 left hemiplegic and 3 right hemiplegic. None of the subjects had any prior surgery. The surgical intervention is summarized in Table 1. Pre- and post-operative gait analyses were conducted using an 8 camera opto-electronic system operating at 100 Hz (ELITE, Bts, Milan, Italy). Pre-operative gait analysis occurred approximately one week prior to surgery. A first post-operative gait analysis (POST1) was performed on all subjects between 4 and 32 months following surgery (mean follow-up time = 15 months). A second post-operative gait analysis (POST2) was performed on 20/51 randomly selected subjects after an average time interval of 30 months post surgery. Global gait pathology was measured using each subject's mean normalcy index (NI) [1]. A Reference Group consisting of 25 healthy subjects (mean age =14, age range: 7 - 28 years) was included to represent a pathology-free baseline.

Table 1. Multilevel Surgical Treatment		
Surgery	***Bilateral***	***Unilateral***
Iliopsoas lengthening	30	2
Medial hamstring lengthening	29	7
Lateral hamstring lengthening	2	0
Rectus femoris transfer	11	7
Strayer or Achilles tendon lengthening	8	15
Adductor lengthening	2	1
Tibialis Posterior lengthening	0	1
Femoral derotational osteotomy	13	3
Tibial derotational osteotomy	2	1

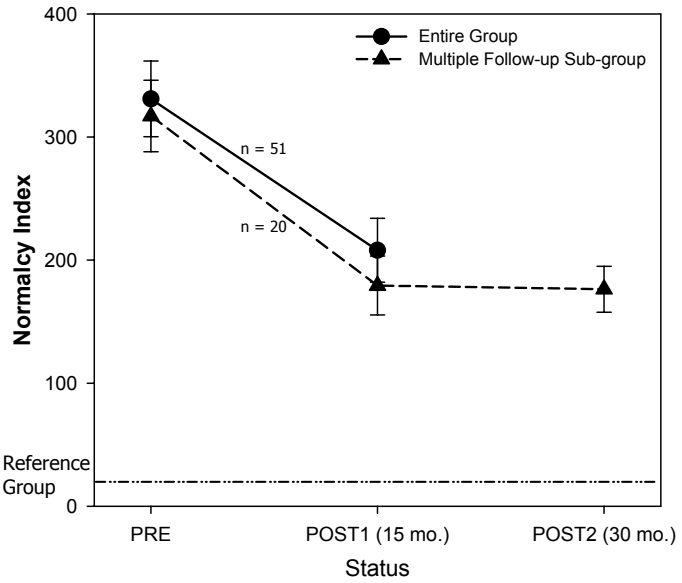

Figure 1. Group NI before and after surgery show significant improvements (decrease). These improvements were maintained by a sub-group that was followed for 30 months.

Results: The results of the study are summarized in Figure 1. The mean NI value for the entire group decreased by 122.8 following surgery ($p < 0.001$, PRE-POST1). There was no change in NI from the first to the second post-operative gait analysis for the 20 multiple follow-up subjects ($\Delta NI = -3.0$, $p > 0.05$, POST1-POST2). The NI values for the multiple follow-up sub-group were equal to those of the entire group at the PRE and POST1 time points, supporting the hypothesis that these 20 subjects were representative of the entire population.

Individually, 74.5% (38/51) of the subjects exhibited a decrease in NI (improvement) during the PRE-POST1 interval (mean $\Delta NI = -47\%$). Only 7.8% (4/51) of the cases exhibited an increase NI (mean $\Delta NI = +28\%$). The remaining 17.6% (8/51) of subjects were considered to exhibit no significant change in NI (mean $\Delta NI = -2.5\%$). Although post-operative NI values were improved, signifying the realization of a more normal locomotor pattern, they were still far from the reference values ($p < 0.001$, POST1-Reference Group). This confirms the typical clinical finding that residual pathology persists following multilevel surgical treatment.

Discussion: The results of this study demonstrate the safety and efficacy of multilevel surgery performed in a single session; a technique that is now widely applied for subjects affected by CP. This approach is deemed by many to be preferable to a series of separate operations [7]. The results obtained for the subjects who underwent two post-operative evaluations show that the post-operative gait improvements persist over time. The follow-up time in this study is quite long compared to studies in the existing literature. This fact notwithstanding, it would be valuable to examine these patients at a truly long-term time point, such as five years or subsequent to their adolescent growth spurt, to see how much of the improvement can be maintained.

The fact that very few individuals worsened following surgery is testimony to the safety of a treatment philosophy that includes pre-operative gait analysis as an aid in the planning of the multilevel intervention. This study focuses on only one outcome measure; the normalcy index. While the NI has been correlated to functional outcome, care must be taken in generalizing the quantitative results of this study to improvements in overall patient function.

References: **1.** Schutte LM *et al*. Gait Posture 2000; 11: 25-31. **2.** Romei *et al*. Gait Posture 2002; 16(suppl 1): 116-7. **3.** Tervo *et al*. Dev Med Child Neurol 2002; 44: 185-90. **4.** Gage, JR and Novacheck, TF J Pediatr Orthop B 2001; 10:265-74. **5.** DeLuca PA *et al*. J Pediatr Orthop 1998; 18:712-718. **6.** Ounpuu S *et al*. J Pediatr Orthop 1993; 13: 331-35. **7.** Molenaers G *et al*. Eur J Neurol 2001; 8(suppl 5): 88-97.