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Correlation of technical surgical goals to the GDI and investigation of post-operative GDI change in children with cerebral palsy

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ABSTRACT

Aim: The purpose of this study was to introduce a standardized set of surgical technical achievement goals (TAGs) as part of a comprehensive outcome assessment model for children with spastic cerebral palsy (CP) undergoing orthopaedic surgical intervention to improve gait. Examination of relationships of these surgical goals to the Gait Deviation Index (GDI) and use of two assessments in tandem provided a thorough picture of technical surgical outcomes.

This study also investigated changes in GDI in children with spastic CP after surgery.

Methods: Data from 269 participants with spastic CP, aged 4 to 19 years with Gross Motor Function Classification System (GMFCS) levels I, II, and III who underwent lower extremity orthopaedic surgical intervention to improve gait were retrospectively analyzed. Data were examined as one heterogeneous group and sub-grouped based on pattern of involvement and GMFCS level to determine change in GDI and relationships between GDI and TAGs.

Results: Differences in TAG achievement and GDI change by GMFCS level suggest a pairing of GDI with another technical measure to be beneficial. Analysis of the outcome tools individually revealed a significant difference between the pre-operative GDI and post-operative GDI mean for the entire group, as well as each of the subgroups. A significant difference in TAG achievement by GMFCS level was also noted.

Conclusion: This paper provides evidence that lower extremity orthopedic intervention for the ambulatory child with spastic diplegic or hemiplegic CP improves gait and that a pairing of the GDI and TAGs system is beneficial to capture an accurate technical outcome assessment in both higher and lower functioning patients.

Many ambulatory children with Cerebral Palsy (CP) require orthopaedic intervention to improve their ability to stand, to balance, and to walk with the ultimate purpose of improved function. Lower limb management can range from stretching, botulinum toxin injections, orthotic intervention and surgical intervention [1–6]. Orthopaedic surgery may be utilized in children with CP to address skeletal deformity and, or muscle imbalance in order to improve standing and walking ability [1–3,5–10]. Outcome assessment of these surgeries attempts to determine the degree of change in mobility and function. Comprehensive post-operative assessment to determine effectiveness of selected surgical interventions is important for the child with CP and advocated in the literature [1,2,8,11–14]. There are differing opinions on the most effective surgical plan for the ambulatory child with CP [8]. Increased literature on surgical outcome assessment will lead to improved patient care by allowing for greater discrimination and evaluation of surgical interventions.

Orthopedic surgical outcome assessment in the Motion Analysis Laboratory (MAL) of Shriners Hospitals for Children (SHC) in Houston follows the surgical outcome model as set forth by Dr. Michael Goldberg, which includes technical, functional, and patient satisfaction components [14]. This model of surgical outcomes assessment supports the belief that a single measure cannot provide an accurate assessment of the effects of surgical intervention on the mobility of the child with CP; and, supports the use of a composite of technical, functional, and patient satisfaction measures to obtain a comprehensive outcome assessment.

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Table 1
Patient Demographics.

Subject Group	Entire Cohort n = 269	Diplegic Group n = 208	Hemiplegic Group n = 61	GMFCS Level I n = 57	GMFCS Level II n = 123	GMFCS Level III n = 89
Gender						
Male	167	131	36	37	75	55
Female	102	77	25	20	48	34
Pre-Op GMFCS level						
I	57	26	31			
II	123	94	29			
III	89	88	1			
Age at pre-op study	10.9 ± 3.6	10.7 ± 3.7	11.6 ± 3.2	12.4 ± 3.2	11.2 ± 3.6	9.4 ± 3.4
Age at surgery	11.1 ± 3.6	10.9 ± 3.7	11.8 ± 3.2	12.6 ± 3.1	11.4 ± 3.6	9.6 ± 3.4
Age at post-op study	12.3 ± 3.6	12.0 ± 3.7	13.0 ± 3.1	13.8 ± 3.1	12.6 ± 3.6	10.8 ± 3.4

The GDI is a validated pathological gait index commonly used in motion analysis which quantifies the segmental kinematics or motion ranges of the lower extremities during gait and measures the degree of deviation from normative values using a standardized set of selected kinematic parameters [15–18]. To calculate the overall GDI, the left and right limb GDI values are averaged to produce a single number. A GDI score of 100 and above refers to an absence of atypical ranges of motion during gait [15]. Each 10 points the GDI falls below 100 translates to one standard deviation (SD) from the mean [15]. Therefore, subjects that demonstrate GDI scores lower than 80 are greater than 2 SDs away from the mean.

A standardized set of surgical technical achievement goals used for this study were initially developed in 1994 by a team of orthopaedic surgeons and MAL physical therapists at SHC in Houston to objectively evaluate the technical outcomes of commonly used orthopaedic surgical procedures aimed to improve the gait of the ambulatory child with CP. Through a review of the literature; questionnaires to surgeons; and, a survey of surgical goals used by other well respected MALs, this team established a set of Technical Achievement Goals, referred to as TAGs. TAGs are both procedure-specific and limb-specific surgical goals based on anticipated post-procedure physical examination and kinematic data changes (Supplemental Table). Each patient has an individual single set of surgical goals based on the total number and type of procedures being performed per limb. The number of goals per procedure varies. For example, a hamstring lengthening can have up to five goals whereas a rectus femoris transfer has three goals. A patient's TAG list can have as few as one goal for a single, unilateral procedure or several goals for a bilateral, multi-level surgery. Since it is common for the ambulatory child with CP to undergo multiple orthopaedic surgical procedures during a single surgery, referred to as Single Event Multi-Level Surgery, or SEMLS, a typical TAG list usually contains multiple goals [8].

The TAGs goals have been carefully developed to reflect the expected physical (clinical) exam and kinematic changes from each surgical procedure within the overall surgical event. A "met" or "not met" rating is assigned to each individual goal based on a pre-determined set of criteria that compares pre-operative and post-operative clinical and kinematic data (Supplemental Table). The scoring of each goal is completed by the clinician at the time of the post-operative evaluation. On occasion, one of the goals may not be applicable, such as the *Resolve Knee Flexion Contracture* goal for the hamstring procedure (Supplemental Table). If no pre-existing knee flexion contracture exists, then this goal becomes not applicable (N/A). Although the goals for each procedure are a standardized base set, there is the ability to individualize. It is also important to note that not all surgical goals require a change to be classified as "met". Maintaining strength or gait kinematics may also be an appropriate surgical goal for select surgical procedures. The final TAG score, known as the TAG percentage (TAG%), is the total number of goals assigned a met status divided by the total number of goals within the TAG list.

The goal of this study was to investigate two technical outcome measures used within the surgical outcomes assessment at SHC in Houston: the GDI and the TAGs. An examination of these two measures was undertaken by reprocessing twenty years of historic data utilizing the current TAGs criteria and calculating the GDI values for all pre and post-operative gait studies. This study allowed us to analyze the utility of these two technical outcome measures individually by examining changes in children with spastic CP after lower extremity surgery. We also studied the relationships between these two measures and how their use in tandem may provide a more thorough picture of the technical surgical outcomes in the child with ambulatory cerebral palsy.

1. Method

After obtaining local institutional review board approval, a retrospective chart review of 623 subjects was conducted on MAL records for patients with CP seen between the years 1994 and 2011 that underwent lower extremity orthopaedic surgical procedures. Two hundred sixty nine patients, with spastic diplegic or hemiplegic CP, between the ages of 4 and 19 years (mean = 10.9 ± 3.6) having complete pre-operative and post-operative data (mean time to post-op = 14 months, min 8/max 27) in the MAL database met the inclusion criteria. The majority of subjects had spastic diplegic CP (77%) and were categorized by Gross Motor Function Classification System (GMFCS) as follows: Level I − 57 (21%); Level II − 123 (46%); Level III − 89 (33%) (Table 1). The number of surgical procedures per subject ranged from 1 to 14 (mean = 5.5 ± 2.9). See Table 2 for a listing of procedures.

2. Statistical analysis

All statistical analysis was performed with either Microsoft Excel

Table 2
Surgical Procedures.

Procedure	Per Patient	Overall (limbs)
Medal & Lateral Hamstring Lengthening	110	188
Medial Hamstring Lengthening	98	170
Adductor Tenotomy	124	229
Iliopsoas Lengthening	18	28
Rectus Femoris Transfers	183	327
Rectus-Femoris Lengthening	1	1
Tendo-achilles Lengthening (zone 1)	39	48
Fractional gastrocnemius lengthening (zone 2 or 3)	182	282
Femoral Rotational Osteotomy	54	81
Tibial Rotational Osteotomy	26	35
Medial Column Lengthening	6	10
Lateral Column Lengthening	17	24
Posterior Tibialis Lengthening	14	14
Peroneal Lengthening	17	25
Split Anterior Tibialis Tendon Transfer	16	17