PM R 7 (2015) 485-493

www.pmrjournal.org

Original Research—CME

Comparative Effects of Multilevel Muscle Tendon Surgery, Osteotomies, and Dorsal Rhizotomy on Functional and Gait Outcome Measures for Children With Cerebral Palsy

Mark A. Feger, MEd, Christopher D. Lunsford, MD, Lindsay D. Sauer, PhD, Wendy Novicoff, PhD, Mark F. Abel, MD

Abstract

Objective: To compare the impact of common surgical interventions (selective dorsal rhizotomy, muscle-tendon surgery, and osteotomies) for patients with cerebral palsy (CP) on Gross Motor Function Measure and temporal, kinematic, and kinetic gait variables as assessed via 3-dimensional motion analysis.
Design: Retrospective cohort study.
Setting: Motion analyses laboratory.
Participants: Ninety-four patients with CP, 56 of whom underwent surgery (37, muscle-tendon surgery; 11, osteotomy; and 8, selective dorsal rhizotomy) and 38 of whom did not have surgery; the patients were ages 4-18 years, with a Gross Motor Function Classification System classification of I, II, or III.
Interventions: Single-event, multilevel muscle tendon surgery, selective dorsal rhizotomy, and osteotomy.
Main Outcome Measures: Change scores (postintervention − preintervention) in Gross Motor Function Measure and temporal, kinematic, and kinetic gait variables.
Results: No statistically significant differences in change scores were found between groups in the Gross Motor Function Measure, velocity, or stride length measures after the observation period. The selective dorsal rhizotomy group had greater improvements in knee extension when compared with the nonsurgical group and greater hip and knee total range of motion during the gait cycle when compared with nonsurgical group and the muscle-tendon surgery and osteotomy cohorts. Lastly, the muscle-tendon surgery group had greater improvements in total knee range of motion compared with the nonsurgical group.
Conclusions: Patients who undergo selective dorsal rhizotomy and, to a lesser extent, muscle tendon procedures demonstrate greater improvements in kinematic gait variables compared with nonsurgical interventions in patients with spasticity resulting from CP.

Introduction

Cerebral palsy (CP) describes a group of permanent disorders that affect the development of movement and posture, causing activity limitations that are a result of a nonprogressive brain injury that occurs in utero, peripartum, or in the first year postpartum [1,2]. Clinical manifestations relate to the timing, location, and extent of the brain injury, and thus the phenotypic expressions of the injury include a wide range of patients with varying degrees of motor control deficits, sensory disorders, and muscle tone abnormalities [1]. Functional impairments ensue from these deficits, and surgical interventions can be used to address the bony and muscle tone abnormalities, as well as contracted muscle-tendon (MT) units [3,4].

Treatment approaches for impaired gait patterns in ambulatory children with CP have evolved during the past 70 years as a result of improved understanding of the pathophysiology of CP, the introduction of new treatments, and completion of larger scale clinical outcome studies that include instrumented measures of motion analyses. Impaired gait is often associated with lower extremity musculoskeletal abnormalities in ambulatory persons with CP. Osteotomies are often used to improve muscle moment arms due to bony abnormalities or to improve hip joint congruency, whereas MT surgeries and selective dorsal rhizotomies (SDRs) are used to address MT

1934-1482/$ - see front matter
http://dx.doi.org/10.1016/j.pmrj.2014.11.002

contractures and excessive muscle tone, respectively. A recent randomized controlled trial indicated that including a gait analysis in the treatment plan prior to performing an osteotomy can result in superior improvements in ambulation in children with CP when compared with osteotomy alone [5]. With regard to muscle-tendon lengthening procedures, it has been demonstrated that soft tissue surgery can improve abnormal gait patterns at joints distal and proximal to the MT being operated on [6]. A systematic review by Cans [7] suggests that SDR is an effective procedure to reduce spasticity and improve motor function. However, despite improved understanding of the neural mechanisms underlying the different patterns of abnormal ambulation in children with CP, clinical pathways are still not universally accepted. Furthermore, a comparison analyzing the relative effects of osteotomies, SDR, and MT surgery on gait parameters has not been performed up to this point.

The purpose of this analysis was to compare the outcome measures of a cohort of patients with CP who were undergoing SDR, MT surgery, or osteotomies with the outcome measures of a cohort that did not undergo surgical intervention. We analyzed the impact of these surgeries on the Gross Motor Function Measure (GMFM) and temporal, kinematic, and kinetic gait variables of the hip, knee, and ankle. Based on previous outcome reports, we expected to see small but appreciable improvements in GMFM scores and modest to large improvements in kinematic gait parameters for patients undergoing either SDR or MT surgery [4,8-10]. Further, we expected that MT surgery would increase stride length and knee motion [8-11] and that rhizotomy would increase sagittal motion of the hip and the knee [12]. Finally, we expected that osteotomies would improve the kinetics (moments and powers) of gait [13] by virtue of improving muscle moment arms.

Methods

Study Design

We performed a retrospective analysis of clinical cases of patients with CP who were followed up in one motion analysis laboratory between January 1993 and December 2008. A full body marker set (modified Helen Hayes) of 38 markers was attached to each subject. Subjects walked at a self-selected pace while 3-dimensional kinematic data were collected at 120 Hz using an 8-camera Vicon Motion Analysis System (Vicon, Denver, CO). Gait data analysis was performed with Vicon BodyBuilder software. All tests were performed in a motion analysis and motor performance laboratory.

The independent variable was "group" as indicated by surgical or nonsurgical interventions. The surgical groups included single-event, multilevel MT surgery or SDR. Also, osteotomies tended to follow MT surgery or be done concomitantly. However, patients who underwent an osteotomy regardless of other surgical interventions were allocated into the osteotomy cohort to determine if changing skeletal moment arms as theorized produced unique effects in this cohort.

The nonoperative cohort consisted of patients without any surgical intervention 1 year prior to and during the period of observation who were followed up over time. Of the 848 unique patients evaluated in the laboratory, 94 underwent multiple studies and were followed up and managed at our center; they constitute the cohort in this report. Inclusion criteria for this analysis were the following: a diagnosis of CP, age 4 to 18 years, Gross Motor Function Classification System (GMFCS) classification I, II, or III [14-16], and documented baseline and follow-up motion analysis in our clinical database with at least 12 months between assessments. Exclusion criteria included diagnosis other than CP, age outside of listed range, and GMFCS classification IV or V (ie, they were not able to ambulate well enough to capture motion data). In addition, patients were excluded if they had previous orthopedic surgery or rhizotomy or a history of a botulinum toxin injection within 1 year of the baseline assessment. Fourteen of 38 subjects in our nonoperative group had a history of previous surgery, with a mean time between the surgery and baseline motion capture of 5.2 years; only 3 of those subjects had surgery within 4 years of the baseline motion analysis. The Institutional Review Board for Health Sciences Research approved the analysis of this clinical database.

Surgical Indications

Patients who underwent an SDR presented with more generalized spasticity as reflected by increased tone during passive joint movements and very brisk deep tendon reflexes. MT surgery was indicated for patients with contracted MT units that restricted full knee extension and ankle dorsiflexion or prevented hip abduction past 30°. These passive restrictions in the MT group were further depicted by equinus, stance phase crouch, and scissoring gait patterns during clinical gait assessment. Osteotomies were performed to address abnormal transverse plane alignment due to excessive rotation in the foot, shank, or thigh. Some patients who underwent the derotational osteotomies may have had minimal MT contractures that were concomitantly lengthened. All subjects received postoperative physical therapy that included assisted joint motion and gait training 1-2 times per week for the first 8-12 weeks after surgery. None of the surgical patients included in this analysis sustained infections or required a return to surgery.

Subjects

Ninety-four patients (56 surgical and 38 nonsurgical) were followed up for a mean of 22.3 months (range,