Impact of Changing Foot Progression Angle on Foot Pressure Measurement in Children with Neuromuscular Diseases

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Introduction

The peak in external eversion moment at the ankle increases in subjects with greater degrees of an out-toeing gait.[1] Theoretically, the foot pressure measurement should be able to demonstrate higher medial pressure impulse if the subject has a more out-toeing gait. Children with cerebral palsy (CP) have less potential to remodel, and the foot joints are more susceptible to external deforming forces. The purpose of this study was to review the pedobarographs of neurologically involved patients who received derotation osteotomy (DRO) of lower limbs without concomitant ankle or foot procedures to determine the effect of changing FPA on pedobarograph measurements.

Clinical Significance

The rotational profile of the lower limb has substantial impact on foot pressure distribution. Treatment of the rotational malalignment in neurologically impaired children should consider the impact on the force redistribution of the foot in order to maintain the correction and not to worsen or even reverse the deformity of the foot.

Methodology

A retrospective review of the gait laboratory service of our hospital was conducted, focusing on the ambulatory children who were treated for lower-limb malrotation with DRO of femur or tibia without concomitant foot-ankle procedures. Sixteen patients (23 feet) with full preoperative and postoperative foot pressure evaluations were included in the study group. The average age at the time of DRO was 8.7 ± 2.6 years. There were 13 cases diagnosed as CP diplegia, one CP hemiplegia, one traumatic brain injury, and one lumbosacral plexus lesion. All patients were ambulatory with or without assistive devices. Computerized gait analysis of time-distance parameters and dynamic joint rotations was obtained using a six-camera Motion Analysis System. The average FPA from gait analysis (GA) in stance phase was defined as FPA-GA. The foot pressure measurements were taken using Tekscan High Resolution Pressure Assessment System (Tekscan Inc., South Boston, MA, USA) at a rate of 60 Hz on a 61×65 cm^2 floor mat. The FPA from foot pressure study was defined as FPA-FP. The five segments of foot were determined following Bowen's model[2] (Fig. 1). The percentage of medial impulse (PMI) was defined as the percentage of impulse exerted on the medial foot among the total impulse of the mid- and forefoot ($PMI = \frac{(MM + MF)}{(MM + MF + LM + LF)} \times 100$). The PMI represented the relative loading on the medial column of the foot. The normal range of PMI in our gait laboratory measured from 100 normal individuals is from 35% to 56% (mean ± 1 standard deviation). The Pearson correlation coefficient was used to establish relationships between interval changes of the pressure impulse and the FPA. A p value less than 0.05 was considered statistically significant.

Results

The average correction of FPA-GA was 20.6°, ranging from an internal derotation of 55° to an external derotation of 32°. Among the pressure impulse measurements, the four significantly correlated predictors of interval changes of FPA-FP were the PMI (r = .67, p = .001, Fig. 2), LM (r = -.66, p = .001), MF (r = .58, p = .004), and LF (r = -.44, p = .034). One foot changed from planovalgus to varus after internal tibial DRO; otherwise, no video documented dramatic change of foot shape between evaluations before and after DRO.

Discussion

In CP patients with equinovarus foot deformity, there is a high percentage of overcorrection if the treatment includes both split tibialis posterior tendon transfer and concomitant distal tibial DRO.[3] The authors believed that the tibial DRO increases the difficulty of balancing the muscle forces across the foot. The results of this study proved that an increased out-toeing gait will increase the pressure impulse exerted on the medial foot, causes or worsens the planovalgus deformity. The in-toeing gait pattern unloads the medial column of the foot and will potentially increase the severity of varus foot. In conclusion, the rotation profile of lower limb has a substantial effect on foot pressure distribution. Treatment of the rotational malalignment in neurologically impaired children should consider the impact on the force redistribution of the foot in order to maintain the correction and not to worsen or even reverse the deformity of the foot.

Figure 1. Five-segment foot model: heel, medial midfoot (MM), medial forefoot (MF), lateral midfoot (LM), and lateral forefoot (LF).

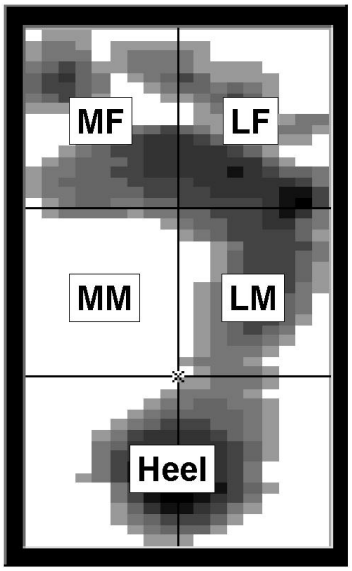
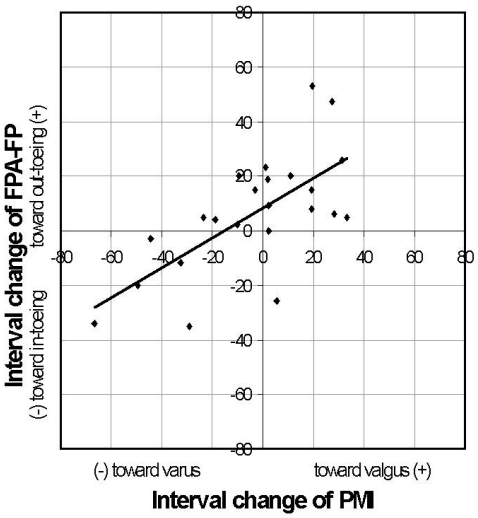


Figure 2. Scatter chart with trend line showing that the interval change of FPA-FP is significantly correlated with interval change of PMI (r = .67, p = .001).



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