A New Procedure for the Design of a Dynamic Pedorthosis for Children with Clubfoot

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INTRODUCTION:

Ponseti’s method, which implements a series of castings and physical therapy, has become popular in the treatment of clubfoot. Despite this fact, there is still an 11% to 47% rate of deformity relapse reported in the literature. However, the technique to make a traditional orthosis is still dependent upon a non-weight bearing casting or foot imprint.

Since the level of clubfoot deformity can be characterized by measuring plantar pressure distribution and obtaining the trajectory of the center of pressure (COP). The purposes of this research were 1) to use this pressure data, along with modern computer aided engineering tools to develop pedorthotics for the treatment of clubfoot deformity, 2) develop a set of analytical tools (pressure data from gait analysis, computer design and analysis methods) that will predict the required orthotic to correct the deformity.

METHODS:

Five normal children with average age of 7.2 years (2 girls and 3 boys) and five clubfoot patients with average of 6 years (1 girl and 4 boys) were recruited to obtain dynamic plantar pressure using EMED Pressure System (Novel Electronics, SP, MN), and three-dimensional geometry from CT scan (GE, Milwaukee, WI). All patients were diagnosed as bilateral clubfoot deformities. Treatment history included a posterior medial release for two patients, series casting for two patients, and a complete subtalar release for one patient. Data from the normal children were employed to generate average values for the COP trajectory.

Pro/Engineer (PTC, Needham, MA) a computer aided design (CAD) program was used to develop a customized orthotic for each of the five children, based upon the plantar pressure and the CT. The CAD model of the orthotic and wedge was imported into a finite element (FE) software package (Patran/Natran, MSC, Santa Ana, CA). The plantar pressure was used in the FE analysis to evaluate the effect of the wedge on the trajectory of the COP.

RESULTS:

In the CAD model, the size and shape of the orthotic was determined from the plantar pressure (see Figure 1) and the evaluation of key anatomic markers on CT scans of the patient’s foot. The CAD models incorporate size and geometry of the various arches in the foot. The orthotic is a 2 layer design incorporating a soft, foam like layer and a hard polymer stiffening layer (Figure 2a).

After the CAD model sized to fit the patient, geometry modeling a soft foam wedge was added to the model (Figure 2b). The size and location of this wedge was determined by examining the deviation of the pressure COP from that of the normal COP, as in Figure 1.

The wedge geometry was changed and the CAD model reanalyzed until the effect of the wedge was maximized and the deviation of the COP from the normal COP was minimized.

Figure 3 shows the results of the analysis of the orthotic CAD model with an optimized wedge and shape geometry. The results shown are for the patient whose plantar (uncorrected) pressure distribution is given in Figure 1. The term “stress” is used to indicate the trajectory of the COP for the orthotic.

DISCUSSION:

Following the use of the newly designed pedorthosis, a maximum deviation of the COP from the normal COP trajectory of 22% in the midfoot and adjacent forefoot reduced to a maximum of 10% deviation of the Stress COP from the normal COP trajectory in the midfoot region (Figure 1 and 3). The use of this orthotic design allows us predict the correction of the foot deformity, which entirely differs from the traditional pedorthosis static casting and manufacturing process.

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