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The effects of total contact insole with forefoot medial posting on rearfoot movement and foot pressure distributions in patients with flexible flatfoot

Simon Fuk-Tan Tang[a,b], Chien-Hung Chen[a], Chih-Kuan Wu[a], Wei-Hsien Hong[c], Kuan-Jung Chen[d], Chih-Kuang Chen[a,*]

[a] Department of Physical Medicine and Rehabilitation, Chang Gung Memorial Hospital, Linkou, Taiwan
[b] School of Medicine, Chang Gung University, Taiwan
[c] School of Sports Medicine, China Medical University, Taichung, Taiwan
[d] Department of Physical Medicine and Rehabilitation, Chang Gung Memorial Hospital, Taipei City, Taiwan

KEYWORDS

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Rearfoot
Foot pressure
Flexible flatfoot

ABSTRACT

The purpose of this study is to evaluate the therapeutic effect of total contact insole with forefoot medial posting (TCIFMP) orthosis in patients with flexible flatfoot. The TCIFMP insole was custom-mode, made from semi-rigid plastazote and PPT. Using the gait analysis and the plantar-pressure measure systems, we investigate rearfoot motion and plantar pressure redistribution in these patients. The results of this study showed that the excessive valgus movement of the rearfoot can be reduced significantly by the TCIFMP insole in these patients. Besides, there were significant decreases in the peak pressure under the toe, lateral metatarsal, lateral foot and heel areas. Therefore, we suggested that the TCIFMP insole is an effective orthotic device for rearfoot motion control, plantar pressure reduction and re-distribution in patients with flexible flatfoot.

1. Introduction

Foot orthotics had been proven to be clinically effective in reducing symptoms in the lower limbs. Yet, few articles have provided scientific evidence of these effects. Also, debates still exist on applying corrective insoles for children with flexible flatfoot. Some authors claimed that the insole could not alter the natural history of flatfoot within three years of study [1].

The foot arch is one of the major structures of the human foot. It can be divided into longitudinal and transverse arches. The bony components of the longitudinal arch include calcaneus, talus, and navicular, first cuneiform, and first metatarsal bones. Those of the transverse arch, on the other hand, include navicular, all cuneiforms, and cuboid bones. The integration of these two arches provides our feet with structural elasticity while we are walking on various terrains, as well as shock absorption during foot impact with the ground.

Pes planus, or flatfoot, includes deficiency or insufficiency of the longitudinal arch in the midfoot. It is regarded as an anatomical variation in the foot structure. Epidemiological studies have shown that the prevalence rate would approximate 20% of the population. The etiology of pes planus, however, remains controversial. Generally, however, it can be grouped into three major types: 1. Flexible flatfoot (approximate 66% of cases): The range of motion of the subtalar joint is free. 2. Flexible flatfoot with Achilles tendon contracture (approximately 25% of cases): Although the ROM of the subtalar joint is free, the shortened Achilles tendon can often result in several foot problems. 3. Rigid flatfoot, which is less seen clinically. The ROM of the subtalar joint is limited, and foot pain is frequently complained.

On standing, in a biomechanical viewpoint, the flatfoot indicates not only deficiency or insufficiency of the longitudinal arch but those including medial midfoot collapse, bulging medial foot margin, and hindfoot valgus. Dynamically, these foot abnormalities can wreck the normal gait patterns. During the late stance phase, for example, the "collapsed" foot will fail to function as a rigid lever arm for "push-off" because structurally the foot is unable to align in a locked position. Other investigators also discovered excessive stress in the foot and ankle joints, compressive shearing in medial and lateral knee joint, and compensatory internal rotation of the hip joint. Clinically, foot pain and soreness are frequently complained. Tibialis posterior and Achilles tendonitis, plantar fasciitis, and metatarsalgia, etc, were also common.

Leung et al. reported objective proofs on the immediate effect of UCBL by using 2-dimensional gait analysis in patients with flexible flatfoot [2]. These immediate effects include reduced degree and duration of abnormal pronation during the stance phase, thus tends to decrease strain in the plantar ligaments and reduce abnormal tibial rotation.

* Corresponding author at: Department of Physical Medicine and Rehabilitation, Chang Gung Memorial Hospital, 5 Fu-Hsing St. Kwei-Shan, Tao-Yuan 333, Taiwan. Tel.: 001-886-3-3281200 ext 3846; fax: 001-886-3-3277566.
E-mail address: albert.ckchen@gmail.com (C.-K. Chen).

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Table 1
Clinical parameters: the Flatfoot group and control group

	Flat foot group	Control group	p
Sex (men/women)	7/3	9/6	0.691
Age (years)	24.8±8.8	25.1±4.6	0.921
Body height (cm)	163.9±6.5	165.4±8.2	0.640
Body weight (kg)	62.6±9.1	59.7±9.4	0.447

Our previous study revealed that an average 5 degree forefoot varus was presented in patients with flexible flatfoot [3]. We postulated that forefoot medial posting was needed when providing a total contact insole. Therefore, the purpose of this study is to verify that rearfoot valgus will be decreased by wearing total contact insole with forefoot medial posting.

2. Methods

2.1. Subjects

Ten persons (20 feet) with symptomatic (foot or leg pain) flexible flatfoot were recruited in this study. The average age is 24.8±8.8 (15–45) years. There's no other known foot disease or trauma. Fifteen (30 feet) age-matched normal subjects were also enrolled as control group (Table 1). The flexible flatfoot was assessed by the measurement of arch index which was described by Cavanagh and Rodgers [4]. Footprints data were analyzed from both feet by traditional ink footprint device. Then the footprint images were scanned into the computer using Sigmascan Pro 5 software to analyze Arch Index (AI). AI is defined as the ratio of the middle third to the whole foot toeless footprint area. An arch index of less than 0.21 has been said to be indicative of a cavus foot, while an arch index greater than 0.26 is indicative of a Flat foot. Arch index is 0.32±0.03 for flat foot patients, and 0.22±0.05 for normal subjects.

2.2. Design and fabrication of the total contact insole with forefoot medial posting (TCIFMP)

The design of the foot orhtosis contained four characteristic features. 1. Custom-made for each patient. 2. Total foot contact with extended heel guard to keep subtalar joints in neutral position (STN) [5,6]. 3. Forefoot medial posting. 4. Double-layer composition with superficial PPT and semi rigid plastozote base (Figure 1). For fabrication, the foot is first placed manually by the orthotist at subtalar joint neutral position and compressed into the foam-box for negative impression. Liquid cast was then poured into the negative mold to form the positive mold. Then, we applied the double-layer material to the positive mold and fabricate the total contact insole via vacuum suction. Finally, the fabrication process was complete through fine trimming by the emery wheels; adjustments were made if any discomfort was felt.

2.3. Gait analysis

A motion analysis system (Vicon 370; Oxford Metrics Ltd., UK) has six infrared cameras that acquire kinematic trajectories of reflective markers attached to a subject's lower limbs at a rate of 60 Hz. Rearfoot and lower leg of a subject were modeled as two rigid segments. Movement of the rearfoot and leg segments was defined by two in a triangular alignment plastic of three markers, one was attached to the posterior counter of the shoe, and another was attached on the posterior shank to avoid artifacts introduced by skin movement (Figure 2). Two AMTI force plates (Advanced Mechanical Technology, Watertown, MA, USA) embedded in the floor was used to determine initial contact and toe off phases of stance was collected.

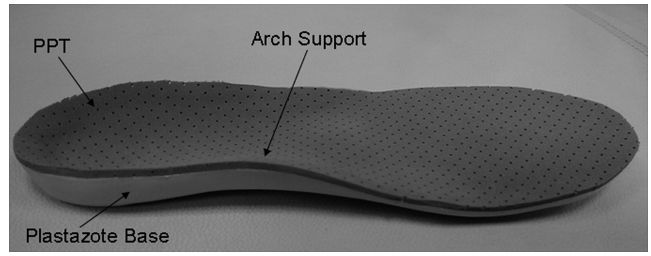

Fig. 1. The total contact insole (TCI) with forefoot medial posting.

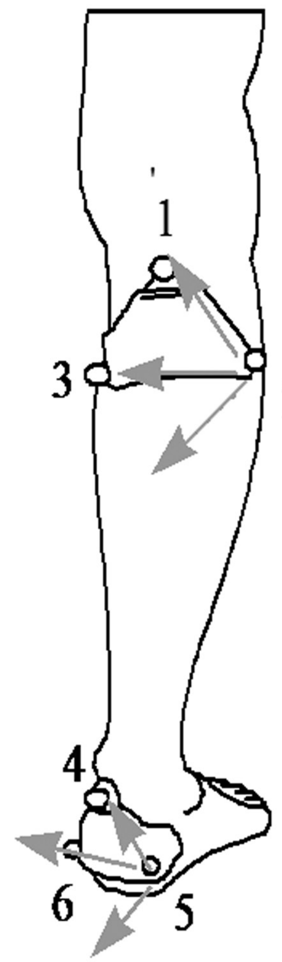

Fig. 2. Each segment was defined by markers set in a triangular alignment.

The plantar pressure was collected using a Pedar in-shoe pressure measurement system (Novel GmbH, Munich, Germany). The system consisted of the A/D conversion electronics housed in a small unit, attached to the waist of each participant. Each 99-sensor insole was 6 connected to the A/D conversion electronics linked to a computer with a sampling rate of 50 Hz. The pressure-measuring insole had a linear response to applied loads ranging from 0 to 50 N/cm^2.

Each subject was then measured walking at a self-selected, comfortable speed in three test conditions (walk with barefoot, walk with sports shoes, and walk with TCIFMP and sports shoes). The order of the three conditions was randomized. A minimum of three walking trials were collected for each condition.