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Effect of Custom-Made Foot Orthosis for Scoliosis with Pelvic Malalignment in a Patient with Myelomeningocele of Partial Neurological Deficit: A Case Report

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

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Patient: Female, 5
Final Diagnosis: Myelomeningocele
Symptoms: Poor posture during static and dynamic position
Medication: —
Clinical Procedure: —
Specialty: Podiatry

Objective: Unusual setting of medical care
Background: The treatment of patients with spinal deformities, such as developmental scoliosis in children with myelomeningocele, poses a formidable challenge. We observed the effects of a custom-made foot orthosis in a case of mild scoliosis with pelvic malalignment, in a patient with myelomeningocele.
Case Report: The patient was a 5-year-old female who was diagnosed with myelomeningocele and who had a partial neurological deficit. At the time of the first visit, the patient showed moderate pelvic rotation to the clockwise side during gait and severe left anterior pelvic tilting during the drooping upper body. Radiographic images revealed mild lumbar scoliosis and severe pelvic asymmetry. After applying a custom-made foot orthosis for 8 months, the patient showed moderate improvement of pelvic rotation and tilting. Clinical biomechanical changes were well correlated with radiographic images.
Conclusions: These results highlight that custom-made foot orthosis controlling 3 motion planes of the pelvis had a corrective effect on mild lumbar scoliosis in a patient with myelomeningocele.

MeSH Keywords: Bone Malalignment • Foot Orthoses • Meningomyelocele • Scoliosis

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Background

Myelomeningocele is a saclike structure containing cerebrospinal fluid and neural tissue caused by a failure of the neural tube to close during the fourth week of gestation [1]. Multiple studies have documented the incidence of the various types of spine problems in children with myelomeningocele at different ages [2–5]. There is a high incidence of spinal deformity in patients with myelomeningoceles. Scoliosis, in particular, can be one of the most debilitating issues this patient population faces. Previous studies have reported that scoliosis is a progressive condition and the fastest progression is seen during the early teenage years [6,7]. However, only serial radiographic follow-up is recommended in children with scoliosis $<20^\circ$ [2,6–8], because it has been suggested that bracing does not prevent progression of the deformity. For this reason, using rigid criteria, Trivedi et al. suggested that the definition of scoliosis in children with myelomeningocele should be reserved for Cobb's angle of $>20^\circ$.

A custom-made foot orthosis (shoe insert) has recently been used to manage idiopathic scoliosis. Lee et al. showed the positive effect of the custom-made foot orthosis to correct malalignment of the pelvis and lower limbs in an adolescent with mild scoliosis [9]. Kim et al. reported improvement of lumbar scoliosis associated with pelvic obliquity after the application of the shoe lift [10]. However, to our knowledge, no studies have assessed the application of custom-made foot orthosis in a patient with myelomeningocele.

In this current study, we report the effect of custom-made foot orthosis in mild scoliosis associated with pelvic malalignment in a patient with myelomeningocele.

Case Report

A 5-year-old female presented with concerns of poor posture during static and dynamic position. She was diagnosed with myelomeningocele in the lumbosacral region at birth and underwent closure surgery. She had some urologic problems with incontinence and underwent surgery. Since then, anticholinergic medication and clean intermittent catheterization were performed once a day. The patient had no problems walking and running, but dynamic balance had been somewhat reduced while walking and running. On neurologic examination, she had mildly delayed milestones with manual muscle test (MMT, 0–5 grade) where 0=no activity, 1=some activity, 2=motion possible but not able to act against gravity, 3=able to act against gravity, 4=able to withstand some resistance, and 5=normal function [11]. MMT was remarkable for grade 4+ strength in the left lower extremities with the exception of the left ankle dorsiflexion and ankle plantarflexion, which were grade 4. Otherwise, she had no history suggestive of spasticity of the lower extremity, hydrocephalus, or gastrointestinal problems. Radiographic evaluation revealed left-sided lumbar scoliosis with Cobb's angle 11.10° associated with severe pelvic asymmetry (Figure 1). We performed biomechanical assessments

Figure 1. Pre-management radiographic images of a patient with myelomeningocele showing left-sided lumbar scoliosis with a Cobb's angle of 11.10° and severe pelvis asymmetry.

Figure 2. Custom-made foot orthosis with superior view (A). Calcaneus cuboid joint posting (B) and midfoot valgus posting (C).

of the patient's pelvis using an angulometer (Biomechanics, Goyang, Korea), a type of gravity goniometer, in the following manner. The patient stood in a relaxed bipedal stance with her feet apart as wide as her shoulder width. First, both arms of the angulometer were placed on her iliac crest and the degree of pelvic level angle was determined. Second, the pelvic elevation angle of both sides was measured during Trendelenburg position. Third, we measured the pelvic rotation based on whether the pelvic movement during stationary walking was symmetrical or not. Fourth, the examiner's thumb was placed on the posterior superior iliac spine (PSIS) when the patient stood upright. If one PSIS was more elevated than the other after bending the patient's trunk forward, the anterior tilting side was formed [9]. The biomechanical assessments of the patient's pelvis revealed pelvic malalignment, showed moderate pelvic rotation to the clockwise side during stationary walking and severe left anterior pelvic tilting during bending her trunk forward. A cast of both feet was produced for the patient, from which a pair of custom-made foot orthosis was manufactured (Biomechanics, Goyang, Korea). The custom-made foot orthosis was produced from a positive cast of each foot, which captured the foot position with the subtalar joint in a neutral position. A calcaneus cuboid joint posting was added at both insoles to correct pelvic rotation, and a midfoot valgus posting was added at the right insole to correct the left anterior pelvic tilting (Figure 2). We recommended that the patient wear the orthoses more than 8 hours per day and walk with heel strike at initial contact and reciprocal arm swing to normalize the gait pattern. The patient follow-up at the Foot Clinic 8 months later included a biomechanical assessment

of the pelvis that showed improvement of pelvic malalignment compared to pre-management. It was shown that symmetrical pelvic rotation during stationary walking and slight left anterior pelvic tilting during forward bending of the trunk remained. Follow-up radiographic evaluation demonstrated marked improvement of pelvic asymmetry. Left-sided lumbar scoliosis was also improved with Cobb's angle 5.06° (Figure 3).

Discussion

In this case report, we observed improvement of radiographic pelvic asymmetry and scoliosis as well as clinical pelvic malalignment in a patient with myelomeningocele after wearing custom-made foot orthosis.

Myelomeningocele, a congenital birth defect that affects sensory and motor function, often results in muscle paresis proportional to ascending spinal lesion level [12,13]. Frequently seen in young children, developmental scoliosis primarily results from paralysis and typically is a long, sweeping, C-shaped curve with or without pelvic obliquity. Many factors are correlated with the occurrence of developmental scoliosis. It appears that the motor level, ambulatory status, and last intact laminar arch are the most important factors in predicting the development of scoliosis [2,8]. Trivedi et al. found that the prevalence of scoliosis was 93%, 72%, 43%, and <1% respectively in patients with thoracic, upper lumbar, lower lumbar, and sacral motor levels. They also found the prevalence of scoliosis to be 89%, 44%, 12%, and 0% in thoracic, upper lumbar,

Figure 3. Post-management radiographic images of a patient with myelomeningocele. Pelvic asymmetry and the spinal curve were improved with Cobb's angle 5.06° after administration of custom-made foot orthosis for 8 months.

lower lumbar, and sacral last intact laminar arches in patients with myelomeningocele [2]. In our case report, the patient could gait independently, showed lower lumbar motor level, and had lower lumbar last intact laminar arch. Radiographic evaluation showed mild scoliosis with Cobb's angle of 11.10° . Many studies recommend radiographs every 4 to 6 months in children with scoliosis $<20^\circ$, because the curve between 10° and 20° often fluctuates, resolves, or even reverses direction [2,8]. However, because scoliosis in myelomeningocele is a progression condition, especially in younger children, we suggest that early detection and taking an active action, could delay curve progression of scoliosis in myelomeningocele. Moreover, unlike previous studies that only measured and focused on Cobb's angle in cases of scoliosis, we observed severe pelvic asymmetry as well as mild scoliosis in a patient of myelomeningocele. We suggest that in our patient case, pelvic malalignment was due to the imbalance of the muscle groups' functions and their respective strengths. Gutierrez et al. evaluated 30 self-ambulatory children with mid-lumbar to low-sacral myelomeningocele using a 3-dimensional gait analysis according to the MMT grades. Kinematic alterations were observed even when there was some paresis of the ankle dorsiflexors and plantar-flexors (Group 1). Group 1 showed greater anterior pelvic tilt and more flexed positions at the knees and hips during the gait cycle [14]. We also observed moderated pelvic rotation to the clockwise side during gait, and we observed left anterior pelvic tilt during drooping upper body in biomechanical assessments of the pelvis.

Walker and Dickson [15] recommended that pelvic tilt scoliosis must be identified and excluded to detect idiopathic scoliosis in the thoracolumbar or lumbar region. In other words, pelvic

assessment has to be performed whether or not pelvic malalignment is concurrent in case of scoliosis [15]. In this study, we observed radiographs of the entire spine in the anteroposterior and lateral plane in the standing position. As measuring the pelvic rotation and anteroposterior tilting is difficult in a radiographic view, we also performed biomechanical assessments of the patient's pelvis. The biomechanical assessments of the pelvis in this case report was the 3-dimensional method that measured asymmetry of the lower extremity and pelvis movement commonly used in podiatric medicine [16]. The parameters measured in the pelvis were pelvic level, pelvic elevation angle in Trendelenburg position, pelvic rotation during stationary walking, and pelvic tilting during bending trunk [9]. It is well known that certain articular asymmetry has an influence on adjacent joints and muscles.

Recently, custom-made foot orthosis has been used to control 3 motion planes of the pelvis. D'Amico demonstrated that after use of an under-foot wedge, leg asymmetry was corrected, and spine deformities were reduced assessing the 3D optoelectronic measurement approach [17]. Zabjek et al. showed that after pertinent shoe lift, Cobb's angle was significantly decreased. There was also shown a significant increase in the vertical height of S1 and T1 and a decrease in the difference of pelvic bone version [18]. We also manufactured custom-made foot orthosis according to the biomechanical assessment in the pelvis. Calcaneus cuboid joint posting was added at both insoles to correct pelvic rotation, and the midfoot valgus posting was added at the right insole to correct the left anterior pelvic tilting. After application of custom-made foot orthosis for 8 months, the patient showed moderate improvement of pelvic rotation and tilting, and these clinically biomechanical changes

well correlated with radiographic images. The follow-up radiograph revealed a marked improvement of pelvic asymmetry as well as lumbar scoliosis.

Conclusions

The current study showed significant improvement of mild scoliosis with pelvic malalignment by custom-made foot orthosis in a patient with myelomeningocele. To the best of our knowledge, there has been no other study about clinical

and radiological changes using custom-made foot orthosis in patients with scoliosis in myelomeningocele. However, in our study there was short-term follow-up, and it remains to be seen whether this custom-made foot orthosis might prevent progression of the deformity during the patient's teenage years. Long-term follow-up is needed. Moreover, as the patient's scoliosis is a mild form, it is unclear whether this custom-made foot orthosis could play a major role in more severe scoliosis in myelomeningocele. Further complementary studies involving larger case numbers and long-term follow-up are warranted to corroborate these findings.

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