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Issue **Article**

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EARLY DETECTION OF FOOT ASYMMETRY IN SUSPECTED CEREBRAL PALSY USING 3D SCANNING TECHNOLOGY: A CLINICAL CASE

Abstract: *This case report describes a 1.5-year-old child with suspected cerebral palsy who underwent three-dimensional foot scanning using the UPOD Full Foot Scan system. Despite normal psychomotor development, the scan revealed significant asymmetries in foot structure and ankle positioning, including low arches, hallux valgus, and opposing heel orientations. Additionally, cross-sectional analysis showed differing lower leg volumes. These findings suggest early compensatory or pathological changes that may precede overt neurological symptoms. The case highlights the potential role of 3D scanning in supporting early clinical decision-making in children with subtle motor abnormalities.*

Key words: *Cerebral palsy; 3D foot scanning; asymmetry; motor development; foot morphology.*

Language: *English*

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Introduction

Cerebral palsy (CP) is a group of permanent disorders affecting movement and posture, attributed to non-progressive disturbances occurring in the developing fetal or infant brain. Although typically diagnosed in early childhood, establishing the diagnosis in toddlers remains complex due to the variability of early motor development and the subtlety of symptoms, especially in mild cases [1].

Timely identification of CP is crucial to initiate appropriate therapeutic interventions. Recent clinical guidelines emphasize the importance of early diagnostic tools, including standardized neurological assessments and motor evaluation scales [2]. However, in borderline or atypical presentations, traditional methods may lack the sensitivity needed for early detection.

Three-dimensional (3D) foot scanning technology has emerged as a promising tool for objective assessment of foot morphology, structural asymmetries, and plantar pressure distribution. It has been increasingly utilized in pediatric populations for orthopedic analysis and the customization of foot orthoses [3]. Despite its widespread application in biomechanics and prosthetics, its role in supporting early neurological diagnoses remains underexplored.

This case report presents a toddler with suspected cerebral palsy in whom 3D foot scanning revealed marked bilateral asymmetry. The findings demonstrate the potential utility of this method to support early clinical decision-making through precise morphological documentation.

Case Presentation: A female toddler, aged 1 year and 6 months at the time of evaluation, presented with no prior history of perinatal complications or developmental delays. According to the parents, the child achieved major motor and cognitive milestones within normal timeframes, including crawling, standing, and walking independently. Speech and social interactions were age-appropriate.

During a routine pediatric wellness check-up, the examining physician observed increased muscle tone

in the lower limbs, raising concerns for potential neuromotor dysfunction. Although the child had not exhibited obvious gait abnormalities or regression of motor skills, a referral was made to a neurologist with a preliminary concern for cerebral palsy (CP).

At the time of reporting, a definitive neurological diagnosis had not yet been established. No magnetic resonance imaging (MRI) or neurophysiological testing had been performed. However, to objectively evaluate structural features of the lower extremities, a three-dimensional foot scan was performed using the UPOD Full Foot Scan system (China).

The 3D scan revealed pronounced asymmetry in multiple foot and ankle parameters (Fig. 1).

Notably:

1. Arch Index (Индекс продольного свода стопы):

- Left: 0.37
- Right: 0.36
- Interpretation: Both feet show a low longitudinal arch (Low (+++)), which may indicate flatfoot (pes planus) or decreased arch height. This condition is commonly seen in children with muscle tone abnormalities, including hypertonia or hypotonia.

2. Hallux Angle (Угол большого пальца стопы):

- Left: 10.3° → Normal
- Right: 20.4° → Mild deformity
- Interpretation: The right foot shows early signs of hallux valgus (a lateral deviation of the big toe), which may develop further over time.

3. Heel Angle (Угол пятки):

- Left: 11° (Severe eversion)
- Right: 35° (Severe inversion)
- Interpretation: There is a severe asymmetry in heel positioning.
- The left heel is excessively turned outward (valgus).
- The right heel is excessively turned inward (varus).

This could suggest muscle imbalance or abnormal tone, potentially associated with conditions like cerebral palsy (CP).

4. Malleolar Valgus Index (Вальгусный индекс лодыжки):

- Left: 6.22 (Rectus, within normal limits)
- Right: -50.00 (Extreme value, possibly erroneous or severely abnormal)
- Interpretation: Suggests significant ankle misalignment or possible pathology, especially on the right side. The value should be reviewed for measurement error, but if correct, it indicates severe displacement.

5. Foot Length & Shape:

- Left Foot: 127.2 mm
- Right Foot: 125.0 mm
- Length is almost equal, but differences in angles and pressure suggest asymmetry in load distribution, typical for mild hemiparesis or diplegia in CP.

Conclusion:

The scan shows pronounced asymmetry in foot structure and alignment, especially on the right side. Key concerns include:

- Flatfoot (bilateral, more pronounced)
- Possible early hallux valgus (right foot)
- Significant asymmetry in heel and ankle positioning
- Suspected muscle tone disorder
- Findings may support a diagnosis of mild cerebral palsy (e.g., hemiparetic form) or another central motor control disorder.

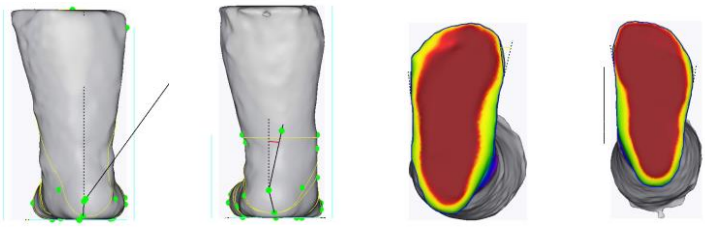

Fig. 1. 3D scanning of the lower limbs (shins and feet)

Additionally, transverse cross-sectional views from the 3D scan demonstrated a visible difference in lower leg volume between the left and right sides. This may reflect early asymmetry in muscle tone or use-dependent hypertrophy/atrophy, often seen in unilateral or asymmetric presentations of cerebral palsy (Fig. 2).

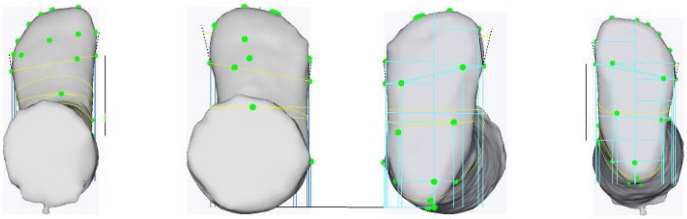

Fig. 2. 3D cross-sectional scan showing asymmetry in lower leg thickness

Discussion: Diagnosing cerebral palsy (CP) in the early years of life remains a clinical challenge, especially in children who appear to have normal or near-normal developmental trajectories. While most children with CP are diagnosed within the first two years of life, milder forms—particularly hemiparetic or diplegic subtypes—can go unrecognized due to compensatory motor strategies and subtle early signs [2].

In the case presented, the child had no prior developmental concerns until increased lower limb tone was noted during a routine check-up. This scenario reflects a well-documented diagnostic gray zone, where children exhibit isolated motor findings in the absence of overt functional limitations or neuroimaging evidence [4].

The use of a 3D foot scanning system (UPOD Full Foot Scan) provided an objective and non-invasive assessment of lower limb morphology. The scan revealed clear bilateral structural abnormalities, including severe heel angle asymmetry and low arches. These findings may reflect altered muscle tone distribution or compensatory loading mechanisms—a pattern previously associated with early CP presentations.

Of particular note is the significant inversion of the right heel (35°) contrasted with eversion of the left (11°), which may indicate early unilateral spasticity or imbalance in muscular activation. This aligns with studies showing that foot alignment and plantar pressure patterns can serve as indirect markers of neurological involvement in toddlers and preschool-aged children [5].

Furthermore, although flatfoot (pes planus) is common in young children and not necessarily pathological, the combination of flatfoot with asymmetry, toe deformities, and abnormal heel orientation raises concern for early neuromotor dysfunction. In such cases, 3D analysis adds diagnostic value by providing reproducible metrics that may support clinical suspicions, even in the absence of definitive neurological imaging.

The findings in this case suggest that 3D scanning technology may serve as a supplementary tool in early neuromotor assessment, particularly in borderline or undiagnosed cases. It allows clinicians to document morphological anomalies, monitor changes over time, and guide decisions on referral or early rehabilitation [6-9].

Conclusion: This case highlights the potential role of three-dimensional foot scanning in the early identification of lower limb asymmetry in children with suspected cerebral palsy. Although the child had no overt functional limitations or confirmed neurological diagnosis at the time of evaluation, the 3D scan revealed significant structural deviations suggestive of early neuromotor imbalance.

Given the subtle clinical presentation and the diagnostic uncertainty, we recommend the following steps:

1. Comprehensive neurological evaluation, including brain MRI and standardized motor function assessment tools such as the Hammersmith Infant Neurological Examination (HINE) or General Movements Assessment (GMA), where applicable.
2. Follow-up by a pediatric neurologist and orthopedic specialist, to monitor the progression of any asymmetries or emerging motor impairments.
3. Early referral to pediatric physical therapy, focused on motor pattern correction, postural training, and prevention of secondary deformities.
4. Repeat 3D foot scanning at regular intervals, to objectively document morphological changes and support clinical decision-making over time.
5. Consideration of customized orthotics, if structural foot deviations persist or contribute to functional limitations [10].

The use of 3D scanning technologies such as the UPOD Full Foot Scan system may offer an accessible, non-invasive adjunct to traditional neurological evaluations, especially in ambiguous or early-stage cases. Further research is warranted to validate its utility in larger pediatric populations and to integrate it into multidisciplinary early intervention protocols.

Ethical Standards and Protection of Personal Data: All images and data presented in this article were collected and published in full compliance with ethical standards. No identifiable personal information is included, and every effort has been made to protect the privacy and dignity of the children involved.

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