3D-Printed Versus Prefabricated Foot Orthoses in Functional Pes Planus: A Critically Appraised Topic

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Clinical Question: In adults with functional pes planus, do custom 3D-printed foot orthoses compared to standard prefabricated EVA insoles or no orthoses improve biomechanical outcomes and user comfort during walking?

Background: Functional pes planus is a common condition characterized by the collapse of the medial longitudinal arch during weight-bearing, often leading to altered gait mechanics, discomfort, and increased risk of musculoskeletal issues. Traditional orthoses have been used to support the arch and improve function, but recent advances in 3D printing offer customizable, patient-specific solutions that may enhance outcomes[1,2]. Thermoplastic polyurethane (TPU) materials used in 3D printing vary in mechanical properties, which can influence orthotic performance and durability[3]. The purpose of this analysis was to understand the clinical efficacy and mechanical reliability of these innovations which are essential for evidence-based implementation.

Search Strategy: Research studies that pertain to the field of orthotics that focuses on 3D printed Foot Orthotics.

Databases Searched: PubMed (NIH), MDPI, JPO

Search Terms: (3D-Print OR 3D-Printing OR TPU) AND (Foot Orthotic OR Foot Orthosis OR Foot Orthoses OR Insole) AND (Ples Planus OR Flatfoot OR Flat Feet)

Inclusion/Exclusion Criteria: Adults aged 18–65 with flexible flatfoot who can walk independently, and complete gait or comfort assessments were included. Individuals with rigid flatfoot, neurological or musculoskeletal gait impairments, recent foot surgery, or material sensitivities were excluded. One study did not involve human participants and therefore does not contribute to inclusion/exclusion criteria.

Synthesis of Results: Hsu et al[1] conducted a small clinical study involving adults with functional pes planus and found that all three types of 3D-printed insoles tested improved navicular height and ankle dorsiflexion angles while also increasing subjective comfort ratings[1]. Among the designs, the medial wedge provided the greatest arch support, although changes at the knee joint were minimal[1]. The study was limited by its short testing duration and small sample size, which restrict the strength of its conclusions[1].

In contrast, Iacob et al[2] emphasized the material science perspective by evaluating the flexural fatigue performance of thermoplastic polyurethane (TPU) insoles through laboratory testing rather than human trials[2]. Their results demonstrated that TPU 95A had superior fatigue resistance and flexibility, whereas TPU 64D was stiffer and more prone to brittle failure[2]. These findings are valuable for guiding material selection in orthotic design, though the absence of clinical validation leaves uncertainty regarding real-world patient outcomes[2].

Özgün et al[3] contributed a single-subject case report that highlighted the potential clinical benefit of custom 3D-printed insoles in an obese adult with pes planus[3]. Compared with prefabricated ethylene-vinyl acetate insoles, custom devices reduced heel pressure, redistributed plantar loading, and improved comfort[3]. Although the report provides early support for personalized additive manufacturing in orthotic care, its generalizability is limited by the case-based design and restricted sensor coverage during gait assessment[3].

Clinical Message: Custom 3D-printed foot orthoses, particularly those using TPU 95A and medial wedge designs, show promise in improving arch support, gait mechanics, and user comfort in adults with functional pes planus[1,2,3]. While early evidence supports their biomechanical and subjective benefits, clinicians should be cautious due to limited long-term data and small sample sizes. Implementation should prioritize an individual assessment and consider material properties to optimize orthotic performance.