Success of Orthotic Interventions in Children with Idiopathic Toe Walking

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Clinical Question: For children with idiopathic toe walking (ITW), which orthotic interventions have the most success in the biomechanical correction of gait?

Background: ITW is defined as the prevalence of a child walking on their toes after 2 years of age with no underlying condition (neurologic, orthopedic, etc.) to explain the habit. It is prevalent in roughly 5% of children.[1] Various treatments have been investigated for this diagnosis including serial casting, surgery, physical therapy, orthotic intervention, and even some vibration-based devices.[2,3] Success varies among these treatment options and clinical decisions can depend on the presence of an equinus contracture of the ankle.[2] When this contracture is not present, the standard treatment protocol at the authors' facility, and many others, has been the use of custom articulated ankle foot orthoses (AFOs) with a plantarflexion stop. This is meant to restrict the patient's plantarflexion range of motion (ROM) to biomechanically train a heel-to-toe gait pattern.[4] Researchers have recently suggested that different orthotic interventions, like foot orthoses (FOs)[4,5] and unique AFO designs[6,7], might better address the biomechanical deficit of toe walking. This CAT examines four articles that look at the success of different orthotic interventions in correcting the gait biomechanics of ITW to help guide clinical decision making.

Search Strategy:
Databases Searched: PubMed, Google Scholar, oandp.org
Search Terms: (children OR pediatric) AND ("idiopathic toe walking" OR "toe walking" OR "tip toe walking" OR "toe walking habit") AND (ortho* OR "carbon footplate") AND (gait OR "range of motion" OR "heel contact" OR "heel strike" OR biomechanics OR "premature heel rise")
Inclusion Criteria: English, peer-reviewed, within last 10 years, original research, orthotic treatment of toe walking, participants 2 years of age or older
Exclusion Criteria: Presence of underlying diagnosis (e.g. Cerebral Palsy, Autism, etc.), systematic reviews, no orthosis studied, abstract only, not original research

Synthesis of Results: Four articles are examined that assess the effectiveness of orthotic interventions on the biomechanics of ITW with a total of 90 participants ages 2-13 years old. Respectively, each study assessed: the efficacy of their original AFO design[6], their original AFO design compared to serial casting[7], AFOs compared to FOs[4], and the efficacy of FOs[5]. Berger, et. al, examines the use of a "circular hinged" AFO that provides contact throughout the dorsum of the foot and ankle in a retrospective chart review. At initial and long-term follow up, they found increased dorsiflexion ROM and decreased prevalence of ITW in their population.[6] Physiotherapy treatment was not controlled in this study, but the varying presence of therapy in this study suggests that a combination of different treatment options may affect the outcome. Hoffman, et. al., investigated their original "Carbon Two Pull AFO" compared to serial casting. They found similar results in gait biomechanics and ROM between the two groups at follow up. The authors suggest that their AFO design may be a less burdensome option than serial casting for some families while achieving similar outcomes.[7] Herrin & Geil examined articulated AFOs with a plantarflexion stop and custom FOs with a carbon fiber footplate. At follow up, they found similar prevalence of ITW between AFO and FO groups with the FO group better sustaining the correction without the orthoses. The authors of this article suggest that AFOs might be most effective in the correction of "purely mechanical equinus" while FOs might have benefits in sensory or perceptual causes of equinus.[4] Michalitis, et. al., studied the use of custom carbon fiber FOs with standardized high-top boots compared to barefoot and shoe walking. They found an increased percentage of heel strikes with FOs compared to both barefoot and shoe walking conditions with no differences in range of motion within the

groups.[6] Similar to Herrin & Geil, these authors suggest that FOs may be useful in the sensory correction of ITW. Overall, the studies did not provide enough evidence to give a definitive advantage to any type of orthosis over another orthosis or the alternative interventions examined in the biomechanical correction of ITW. However, the authors of the studies suggest that orthotic intervention can enhance treatment, especially in combination with other indicated treatment modalities.

Clinical Message: Although the articles examined have limitations in their generalizability given the small sample size and variability in methods, they do demonstrate limited evidence of the success of different orthotic interventions in the treatment of ITW. The articles did not demonstrate a clear overall advantage to any of the orthoses examined in biomechanical outcomes. Each article states, and these authors agree, that the orthotic intervention for each patient should be determined on an individual level based on the child's presentation. It appears possible that each orthosis has its own clinical utility based on the child's presentation and the familiarity and preference of the family and care team. Caution should be taken to ensure no underlying etiology is present to assure the best treatment outcomes.

References:

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7. Hoffman N, Dallum J, Hinshon S, Finch M. Carbon Fiber Two-Pull Solid Ankle-Foot Orthoses versus Serial Casting in the Treatment of Idiopathic Toe Walking with Equinus Contracture. *Journal of Prosthetics and Orthotics.* 2021 April 21. doi: 10.1097/JPO.0000000000000365.

Evidence Table

	Herrin & Geil, 2016[4]	*Michalitsis, et. al., 2019*[5]	*Berger, et. al., 2021*[6]	*Hoffman, et. al., 2021*[7]
Population	18 children ages 2-8 years with a diagnosis of ITW, candidate for orthotic intervention, no orthotic history	15 children, ages 4-9 years diagnosed with ITW and 15 degrees of ankle range of motion	22 children ages 2-13 years, 6 months of toe walking present before treatment	35 children ages 4-9 years with bilateral idiopathic toe walking, -5 to +5 dorsiflexion/plantarflexion range of motion
Exclusion Criteria	Neurologic conditions, history of Achilles treatment (botox or tenotomy), & plantarflexion contracture	Other condition causing toe waking, history of Achilles lengthening, serial casting, botox injections, or orthotic intervention within last 12 months	Congenital or other neurologic conditions causing ITW; less than 24 months of follow up	Non-idiopathic origins of toe walking
Study Design	Parallel prospective randomized control trial	Within subjects randomized control trial	Retrospective cohort study	Randomized prospective cohort trial
Intervention	Custom FOs with carbon fiber footplates or custom articulated AFOs with a plantarflexion stop	Full length custom carbon fiber FOs in standardized high-top boots	Circular Hinged AFOs with dorsal contact	Carbon Fiber Two-Pull Solid Ankle AFOs in 1 degree of dorsiflexion tuned in standardized shoe to 10 degrees SVA (Carbon AFO over Copolymer inner AFO with full anterior/dorsal shell)
Comparison	Baseline assessment and follow up without orthosis in participant's own athletic shoes	Participant preferred shoe wear and barefoot	N/A	Serial Casting
Methodology	• Assessment consisting of ankle range of motion, 3D gait analysis (5 trials), parental satisfaction survey, and L-test of Functional Mobility • 6 weeks of orthosis wear • Repeat follow up assessment with and without orthosis with addition of a subset of the Orthotic and Prosthetic User Survey (OPUS)	GaitRite mat at self-selected walking speed for each condition. Two trials for each condition (barefoot, shoe, orthosis)	6 weeks of full-time wear, 4 weeks weaning out of daytime wear, 6 weeks of nighttime wear, as needed per patient afterwards.	Each group proceeded with treatment until they met discharge criteria of range of motion and foot flat initial contact 75% of the time during 6-minute walk test. Both groups transitioned to polypropylene solid AFO with copolymer inner boot.

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	Herrin & Geil, 2016[4]	*Michalitsis, et. al., 2019*[5]	*Berger, et. al., 2021*[6]	*Hoffman, et. al., 2021*[7]
Key Outcomes	• Heel rise time • Walking speed • Cadence • Step length • Parental satisfaction • OPUS • L-Test	• Heel strike • Ankle range of motion • Gait velocity • Stride length • Stride time • Percentage of time in swing, stance and double limb support	• Recurrence of toe walking gait • Dorsiflexion range of motion • Parent perception of gait	• Dorsiflexion range • Percentage of heel-to-toe gait pattern according to parents and in 6-minute walk test • Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) • Pediatric Reach Test (PRT) • Observational Gait Scale (OGS)

Key Findings	• Both groups had significant correction of heel rise time in device, but FO group was only one to sustain correction without orthosis.
	• AFO group was significantly faster than FO group when orthoses were worn (1.36 m/s vs 1.22 m/s).
	• No difference in cadence or step length between groups or conditions at follow-up
	• No difference between FO and AFO in parent reported toe walking time or parental satisfaction with gait or effectiveness.
	• OPUS found easier donning in FO versus AFO
	• No difference in L-test between groups or conditions at follow up
		• Percentage of Heel Strikes:
		  • Barefoot: 64%
		  • Shoe: 68%
		  • Orthosis: 89%
		• No change in ankle range of motion from baseline
		• Increased gait velocity in shoe compared to barefoot
		• Increased stride length and time in orthosis and shoe compared to barefoot
		• Decreased cadence in orthosis compared to barefoot
		• Decreased percentage of swing phase, increased percentage of stance phase and double limb support in orthosis compared to barefoot
			• At 12 months, the % of time spent toe walking was:
			  • 0-15% in 64% of patients
			  • 16-35 in 9% of patients
			  • 36-65% in 9% of patients
			  • 5% of patients had recurrence of toe walking
			• At 24 months, the % of time spent toe walking was:
			  • 0-15% in 64% of patients
			  • 16-35% in 4% of patients
			  • 32% of patients had recurrence in toe walking
			• Dorsiflexion range:
			  • Baseline: 3 degrees
			  • 12 months: 16 degrees
			  • 24 months: 14 degrees
				• No significant differences between CTP-AFO and serial casting for all but passive dorsiflexion range of motion knee extended R2 right lower limb
				• Both groups had improvement in dorsiflexion range of motion, hamstring range of motion dorsiflexion strength
				• No significant differences between groups for parent-reported percentage of time in heel-toe gait pattern and popliteal angle range of motion
				• BOT-2
				  • CTP-AFO had steady increases in all measures over time
				  • Significant differences within group for balance and body coordination
				• PRT
				  • Both groups showed improvement over time

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	Herrin & Geil, 2016[4]	*Michalitsis, et. al., 2019*[5]	*Berger, et. al., 2021*[6]	*Hoffman, et. al., 2021*[7]
				• OGS • Significant improvement within groups • Serial casting had a dip in all measures at the posttreatment time period
Study Limitations	• Small sample size • No blinding • No standardized shoes • Limitations of outcome measures • Short term follow-up/treatment time • Suitability of orthotic intervention for patient	• Small sample size • No blinding • No long-term follow-up • All subjects had at least 15 degrees of dorsiflexion range	• Small sample size • No blinding • Continued nighttime wear from some users • Lack of control or comparison group	• Small sample size • No blinding • Limited generalizability due to other styles of AFOs • Dorsiflexion range was controlled for but reported as an outcome