

Three-Dimensional Distance Map Comparisons between Asymptomatic and Symptomatic Progressive Collapsing Foot Deformity (PCFD)

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INTRODUCTION: Progressive collapsing foot deformity (PCFD) is a complex three-dimensional foot deformity that is characterized, in part, by peritalar subluxation (PTS). The subtalar joint has been analyzed in PCFD using distance mapping as a measure of subfibular impingement (Figure 1). However, the progression of PCFD from healthy to asymptomatic to symptomatic and painful, specifically within the subtalar joint, is largely unknown. Therefore, investigating asymptomatic PCFD may offer clinical insight into both the pathology of PCFD within the subtalar joint and how the disease progresses. The objective of this study was to use a three-dimensional distance mapping algorithm of the subtalar joint for asymptomatic PCFD patients to describe and compare this stage of the deformity with a previously described cohort of symptomatic PCFD patients and healthy controls.

METHODS: In this prospective comparative study, patients with asymptomatic flatfeet were recruited to undergo a weight-bearing CT (WBCT) scan. This cohort (20 feet, 8 male, 12 female) was compared to a previously described cohort of both control (n=10, 4 male, 6 female) and symptomatic PCFD (n=20, 8 male, 12 female). Using a commercially available software package (Disior Bonologic), models of the talus and calcaneus were created and analyzed. Distance mapping was then used to measure the distance along the normal direction of vectors projected from the calcaneal subchondral surface to the opposing talar surface. In this manner, the subtalar joint was objectively measured across the entire peritalar surface, including articular and nonarticular regions (Figure 1). Mean distances over the described articulations of the subtalar joint were compared using an analysis of variance (ANOVA) test to compare each parameter between the three groups.

RESULTS: Regarding mean distance values, the asymptomatic group was significantly higher than symptomatic measures in 10/13 articular surfaces and 3/4 sinus tarsi regions. Asymptomatic distances were also significantly greater than control measures in 11/13 articular surfaces (Table 1, Table 2) but were smaller and without significance in the sinus tarsi region. (Table 3). When looking at the sinus tarsi as a whole, asymptomatic distances (mean 3.21mm) were greater than both control (mean 2.73mm, p=0.01,) and symptomatic distances (mean 2.63, p=0.002) (Table 1). More specifically, asymptomatic distances were different than both symptomatic and control distances in the anteromedial, posteromedial and posterolateral regions of the sinus tarsi (Table 3).

DISCUSSION: To our knowledge, this is the first study to examine the asymptomatic flatfoot within the subtalar joint. Asymptomatic distances were found to be largely greater than both symptomatic and control distances. This suggests that the bones are unstable and moving in patients who have flatfeet but no symptoms. When PTS, in an unstable asymptomatic foot, produces sinus tarsi impingement, that may be the trigger to further collapse and subsequent pain. Our data supports the idea that asymptomatic flatfoot should be considered a risk for progression to PCFD and represents a step toward finding predictors for development painful flatfoot.

SIGNIFICANCE/CLINICAL RELEVANCE: This study's novel exploration of asymptomatic flatfoot reveals substantial subtalar joint instability and impingement, highlighting its potential role as a predictor for the progression to painful progressive collapsing foot deformity (PCFD). The findings underscore the importance of identifying asymptomatic flatfoot as a risk factor, enabling early intervention strategies to prevent the development of symptomatic PCFD and associated foot pain.

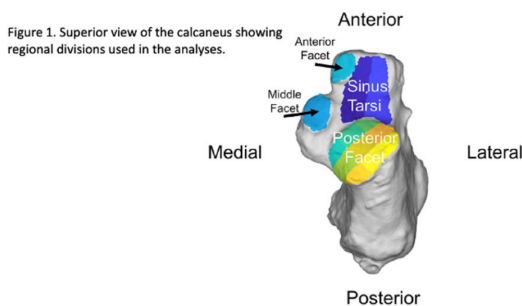


Table 1. Subtalar joint facet distance (mm) ANOVA, means and 95% confidence intervals

Location	Groups	ANOVA		95% CI		P
		P	Means (mm)	Lower	Upper	
Anterior Facet	Asymp vs Control	<0.01	2.83 vs 1.98	-1.36	-0.34	0.01
	Asymp vs Symp		2.83 vs 2.66	-0.68	0.34	0.70
	Control vs Symp		1.98 vs 2.66	0.17	1.19	0.04
Middle Facet	Asymp vs Control	<0.001	2.05 vs 1.36	-1.11	-0.27	<0.001
	Asymp vs Symp		2.05 vs 1.77	-0.70	0.14	0.25
	Control vs Symp		1.36 vs 1.77	-0.01	0.83	0.06
Posterior Facet	Asymp vs Control	<0.001	2.43 vs 1.74	-1.04	-0.34	<0.0001
	Asymp vs Symp		2.43 vs 1.90	-0.88	-0.18	0.002
	Control vs Symp		1.74 vs 1.90	-0.19	0.51	0.52
Sinus Tarsi	Asymp vs Control	<0.01	3.21 vs 2.73	-0.87	-0.09	0.01
	Asymp vs Symp		3.21 vs 2.63	-0.97	-0.19	0.002
	Control vs Symp		2.73 vs 2.63	-0.49	0.29	0.81

Table 2. Posterior facet distance (mm) ANOVA, means and 95% confidence intervals

Location	Groups	ANOVA		95% CI		P	
		P	Means (mm)	Lower	Upper		
Anterior	Asymp vs Control	0.01	2.83 vs 2.22	-0.45	0.03	0.07	
	Asymp vs Symp		2.83 vs 2.11	-0.96	-0.08	0.02	
	Control vs Symp		2.22 vs 2.11	-0.55	0.19	0.82	
	Asymp vs Control		<0.01	2.87 vs 2.01	-1.10	-0.17	0.002
	Asymp vs Symp			2.87 vs 2.23	-0.88	-0.04	0.05
	Control vs Symp			2.01 vs 2.23	-0.22	0.66	0.45
Lateral	Asymp vs Control	<0.001	2.44 vs 1.62	-1.29	-0.35	<0.001	
	Asymp vs Symp		2.44 vs 1.99	-0.92	0.02	0.07	
	Control vs Symp		1.62 vs 1.99	-0.10	0.84	0.15	
	Asymp vs Control		<0.001	2.89 vs 1.72	-1.11	-0.23	0.002
	Asymp vs Symp			2.89 vs 1.77	-1.06	-0.18	0.004
	Control vs Symp			1.72 vs 1.77	-0.39	0.49	0.96
Posterior	Asymp vs Control	<0.001	2.65 vs 2.01	-1.04	-0.24	0.001	
	Asymp vs Symp		2.65 vs 2.14	-0.91	-0.11	0.01	
	Control vs Symp		2.01 vs 2.14	-0.27	0.51	0.72	
	Asymp vs Control		<0.001	2.81 vs 1.62	-1.10	-0.28	<0.001
	Asymp vs Symp			2.81 vs 1.78	-0.93	-0.12	0.008
	Control vs Symp			1.62 vs 1.78	-0.25	0.57	0.43
Middle	Asymp vs Control	<0.001	2.83 vs 1.31	-1.06	-0.38	<0.0001	
	Asymp vs Symp		2.83 vs 1.18	-1.19	-0.51	<0.0001	
	Control vs Symp		1.31 vs 1.18	-0.47	0.21	0.16	
	Asymp vs Control		<0.001	2.83 vs 1.72	-1.11	-0.31	<0.001
	Asymp vs Symp			2.83 vs 1.62	-1.12	-0.41	<0.0001
	Control vs Symp			1.72 vs 1.62	-0.50	0.30	0.82
Lateral	Asymp vs Control	<0.001	2.82 vs 1.43	-1.18	-0.60	<0.0001	
	Asymp vs Symp		2.82 vs 1.80	-1.21	-0.23	0.002	
	Control vs Symp		1.43 vs 1.80	-0.12	0.86	0.18	

Table 3. Sinus tarsi distance (mm) ANOVA, means and 95% confidence intervals

Location	Groups	ANOVA		95% CI		P	
		P	Means (mm)	Lower	Upper		
Anterior	Asymp vs Control	<0.01	5.75, 5.52	-1.47	1.01	0.90	
	Asymp vs Symp		5.75, 4.11	-2.88	-0.40	0.006	
	Control vs Symp		5.52, 4.11	-2.65	-0.17	0.22	
Lateral	Asymp vs Control	<0.01	7.96, 7.78	-7.40	2.38	0.42	
	Asymp vs Symp		6.96, 5.60	-2.92	0.20	0.10	
	Control vs Symp		7.78, 5.60	-3.74	-0.62	0.004	
Sinus Tarsi	Anterior	Asymp vs Control	<0.0001	5.78, 5.19	-0.42	1.23	0.47
		Asymp vs Symp		5.78, 4.04	-2.98	-1.32	<0.0001
		Control vs Symp		6.19, 4.04	-2.98	-1.32	<0.0001
	Posterior	Asymp vs Control	<0.01	7.43, 7.81	-0.99	1.75	0.78
		Asymp vs Symp		7.43, 5.96	-2.84	-0.10	0.03
		Control vs Symp		7.81, 5.96	-3.22	-0.48	0.005