

Three-Dimensional Distance Mapping Comparisons between Asymptomatic and Symptomatic Progressive Collapsing Foot Deformity

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INTRODUCTION:

Flattening of the longitudinal arch of the foot (flatfoot) can represent a normal spectrum of foot morphology. The issue comes when the foot is collapsing progressively, what is now termed Progressive Collapsing Foot Deformity (PCFD). Interestingly, while patients may appear subjectively or radiographically similar, the clinical presentation of the deformity ranges from severe pain requiring treatment to entirely asymptomatic. Literature on this asymptomatic cohort, thought to represent a key step in the development of this progressive disease, has been scarce since asymptomatic patients do not seek medical attention. Alignment differences between asymptomatic flatfoot and PCFD have not been established and may represent a key step in understanding predictors of PCFD. Specifically, the subtalar joint has been analyzed in PCFD using distance mapping as a measure of subfibular impingement (Figure 1). As a possible source of pain and a well-understood marker of disease progression, peritalar subluxation (PTS) is of particular interest when investigating potential predictors of PCFD development, especially within the asymptomatic population. Therefore, the objective of this study was to use a three-dimensional distance mapping algorithm of the subtalar joint in 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 patients (n=20, 8 male 12 female). Using a commercially available software package, 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 out of 13 articular surfaces and 3 out of 4 sinus tarsi regions. Asymptomatic distances were also significantly greater than control measures in 11 out of 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 3.21 mm) were greater than both control (mean 2.73 mm, 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 AND CONCLUSION:

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 of painful flatfoot.

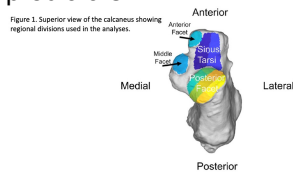


Table 1. Subtalar joint facet distance (mm) ANOVA, means and 95% confidence intervals

Location	Groups	ANOVA		95% CI		P
		P	Means (mm)	Lower	Upper	
Anterior Facet	Asymp vs Control		2.83 vs 1.98	1.36	1.34	0.01
	Asymp vs Symp	<0.01	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		2.05 vs 1.38	1.11	0.27	<0.001
	Asymp vs Symp	<0.001	2.05 vs 1.77	0.70	0.14	0.25
	Control vs Symp		1.38 vs 1.77	0.01	0.83	0.06
Posterior Facet	Asymp vs Control		2.43 vs 1.74	1.04	0.34	<0.0001
	Asymp vs Symp	<0.001	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		3.21 vs 2.73	0.87	0.09	0.01
	Asymp vs Symp	<0.01	3.21 vs 2.63	0.97	0.19	0.002
	Control vs Symp		2.73 vs 2.63	0.46	0.26	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	Medial		2.64 vs 2.12	0.88	0.51	0.07
	Asymp vs Symp	0.02	2.64 vs 2.12	0.98	0.28	0.04
	Control vs Symp		2.12 vs 2.11	0.26	0.19	0.82
Middle	Asymp vs Control		2.67 vs 2.03	1.07	0.17	0.002
	Asymp vs Symp	<0.01	2.67 vs 2.03	0.88	0.04	0.01
	Control vs Symp		2.03 vs 2.02	0.22	0.46	0.41
Lateral	Asymp vs Control		2.14 vs 1.62	0.93	0.20	<0.0001
	Asymp vs Symp	<0.001	2.14 vs 1.62	0.93	0.20	0.07
	Control vs Symp		1.62 vs 1.61	0.10	0.34	0.31
Posterior	Medial		2.19 vs 1.72	1.11	0.13	0.002
	Asymp vs Symp	<0.001	2.19 vs 1.72	1.06	0.18	0.04
	Control vs Symp		1.72 vs 1.73	0.39	0.49	0.31
Middle	Asymp vs Control		2.61 vs 2.03	1.04	0.14	0.001
	Asymp vs Symp	<0.001	2.61 vs 2.03	0.91	0.11	0.01
	Control vs Symp		2.03 vs 2.04	0.27	0.31	0.75
Lateral	Asymp vs Control		2.13 vs 1.78	0.95	0.11	0.008
	Asymp vs Symp	<0.001	2.13 vs 1.78	0.78	0.20	0.01
	Control vs Symp		1.78 vs 1.78	0.20	0.27	0.41
Posterior	Medial		2.18 vs 1.73	1.06	0.18	<0.0001
	Asymp vs Symp	<0.001	2.18 vs 1.73	1.02	0.17	0.001
	Control vs Symp		1.73 vs 1.73	0.47	0.21	0.42
Middle	Asymp vs Control		2.61 vs 1.73	1.11	0.11	<0.001
	Asymp vs Symp	<0.001	2.61 vs 1.73	1.11	0.11	<0.001
	Control vs Symp		1.73 vs 1.62	0.30	0.30	0.87
Lateral	Asymp vs Control		2.13 vs 1.62	1.06	0.20	<0.0001
	Asymp vs Symp	<0.0001	2.13 vs 1.62	1.21	0.11	0.002
	Control vs Symp		1.62 vs 1.61	0.11	0.26	0.11

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

Location	Groups	ANOVA		95% CI		P
		P	Means (mm)	Lower	Upper	
Anterior	Medial		3.76 vs 3.52	2.84	1.00	0.001
	Asymp vs Symp	<0.01	3.76 vs 3.52	2.88	0.40	0.008
	Control vs Symp		3.52 vs 3.51	1.60	0.17	0.21
Middle	Asymp vs Control		3.06 vs 2.78	1.40	2.38	0.42
	Asymp vs Symp	<0.01	3.06 vs 2.78	1.20	0.20	0.30
	Control vs Symp		2.78 vs 2.74	0.52	0.94	0.04
Posterior	Medial		3.76 vs 3.19	0.42	1.23	0.47
	Asymp vs Symp	<0.0001	3.76 vs 3.19	1.98	1.17	<0.0001
	Control vs Symp		3.19 vs 2.98	2.08	1.32	<0.0001
Lateral	Asymp vs Control		2.41 vs 2.61	0.69	1.70	0.26
	Asymp vs Symp	<0.01	2.41 vs 2.61	2.84	0.10	0.01
	Control vs Symp		2.61 vs 2.63	1.22	0.68	0.001