Pes Cavovarus in Charcot-Marie-Tooth Disease vs Idiopathic: A Comparison using Known and Novel Measurements

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INTRODUCTION:

Pes cavovarus (PC) is clinically identified as an elevated longitudinal arch. This often presents as a severe deformity in the setting of Charcot-Marie-Tooth (CMT) disease. Interestingly, PC may also present idiopathically. At least one previous study has attempted to quantify the differences between these two patient cohorts utilizing both two- and three-dimensional radiographic measurements, including measurements of the medial longitudinal arch. However, this is not the only arch of the foot. The transverse arch (TA) has been demonstrated to play a critical role in foot stiffness and has been studied in flatfeet, clinically referred to as progressive collapsing foot deformity (PCFD). In the PCFD cohort, the TA was directly measured using the recently described transverse arch plantar (TAP) angle. The TAP angle was shown to significantly differ between PCFD patients and healthy controls. An investigation into the TA has never been applied to the PC population.

Therefore, the objectives of this study were to evaluate morphological differences between a large CMT PC and idiopathic PC population utilizing the recently described measure of the TA, as well as fourteen other previously described and validated measurements. We hypothesize that CMT PC will demonstrate a more pronounced TA, signifying a greater degree of severity.

METHODS:

Weightbearing CT images were retrospectively evaluated in 40 CMT feet with pes cavus (CMT-PC) and 40 idiopathic pes cavus (I-PC) feet. Eleven two-dimensional (2D) measurements and four three-dimensional (3D) measurements were evaluated. Of these, the transverse arch plantar (TAP) angle was used to directly assess TA morphology in both PC cohorts. (Figure 2). To assess where along the TA there is the greatest deformity, a line was drawn connecting the medial cuneiform and fifth metatarsal at the level of the most inferior aspect of the medial cuneiform in the coronal plane. The distance between each metatarsal and that line was collected.

Other measurements performed in the sagittal plane were calcaneal pitch, talus-first metatarsal angle, cuneiform-to-floor distance, cuneiform-to-skin distance, navicular-to-skin distance, and navicular-to-floor distance.

Axial measurements collected were talus first-metatarsal angle (Kite's angle), and forefoot arch angle. Finally, 3D measurements consisted of foot and ankle offset (FAO), calcaneal offset, and hindfoot alignment angle.

RESULTS:

Overall, the CMT-PC cohort demonstrated greater deformity for fourteen of fifteen measures. Specifically, the CMT-PC cohort showed a significantly greater Kite's angle ($p=0.002$) (Figure 2), as well as strong differences in Sagittal Talus-first metatarsal angle ($p=0.104$), cuneiform-to-floor distance ($p=0.053$), and forefoot arch angle ($p=0.128$), when compared to I-PC (Table 1).

Assessment of the TA demonstrated that the TAP angle is significantly more acute in CMT-PC than in I-PC with a mean angle of 94.24° (SD 13.39) compared to 100.49° (SD 9.39) respectively ($p=0.018$) (Table 2) (Figure 2). Patients with CMT-PC also showed a significantly greater distance at all locations measured along the TA (Figure 2). This includes a greater distance between the plantar first cuneiform and the plantar second metatarsal ($p<0.001$), the first cuneiform and third metatarsal ($p=0.001$) and the first cuneiform and the fourth metatarsal ($p=0.002$) (Table 1).

DISCUSSION AND CONCLUSION:

To the best of the author's knowledge, this is the first study to investigate the TA in the PC population. The TA as a whole as measured by the TAP angle, as well as each component of the TA, were significantly more affected in CMT-PC than in I-PC. Further, fourteen of fifteen measures demonstrated greater cavus severity in CMT-PC than in I-PC including a significantly greater Kite's angle. Taken together, this suggests that the morphologies of these two pathologies differ. Further, the TA may be implicated in the pathogenesis of PC and the role of the TA in the clinical presentation and treatment of PC should be investigated further.

2D Measurements	CMT PC N=40	Idiopathic PC N=40	*p*-value
Calcaneal Pitch (°)			
Mean	33.22	33.47	0.917
Standard Deviation	10.11	11.33	
Sagittal Talus-first metatarsal angle (°)			
Mean	14.33	10.38	0.104
Standard Deviation	14.99	9.44	
Cuneiform-to-floor distance (mm)			
Mean	35.14	31.22	0.053
Standard Deviation	10.61	7.99	
Cuneiform-to-skin distance (mm)			
Mean	27.53	24.95	0.164
Standard Deviation	10.44	6.24	
Navicular-to-skin distance (mm)			
Mean	38.13	36.92	0.668
Standard Deviation	15.70	10.77	
Navicular-to-floor distance (mm)			
Mean	46.14	42.93	0.190
Standard Deviation	12.76	8.56	
Axial Talus-first metatarsal angle (Kite's angle) (°)			
Mean	24.59	13.47	**0.002**
Standard Deviation	17.62	12.07	
Forefoot arch angle (°)			
Mean	27.94	23.16	0.128
Standard Deviation	17.02	9.64	
C2/M2 Distance (mm)			
Mean	15.41	11.98	**<0.001**
Standard Deviation	3.48	2.55	
C2/M3 Distance (mm)			
Mean	9.56	7.50	**0.001**
Standard Deviation	2.64	2.54	
M4 Distance (mm)			
Mean	3.84	2.56	**0.002**
Standard Deviation	2.07	1.50	

Table 1. Mean and SD for all 2D measurements.

3D Measurements	CMT PC N=40	Idiopathic PC N=40	*p*-value
Schmidt Angle (°)			
Mean	94.24	100.49	**0.018**
Standard Deviation	13.39	9.39	
FAO (%)			
Mean	-5.83	-3.93	0.4032
Standard Deviation	11.37	8.67	
Calcaneal offset (mm)			
Mean	-9.73	-6.23	0.3989
Standard Deviation	19.68	16.97	
Hindfoot alignment angle (°)			
Mean	-15.79	-12.43	0.588
Standard Deviation	30.44	24.48	

Table 2. Mean and SD for all 3D measurements.

Figure 1. Tables including mean and SD for all 2D and 3D measurements as well as p-values comparing CMT PC and Idiopathic PC.

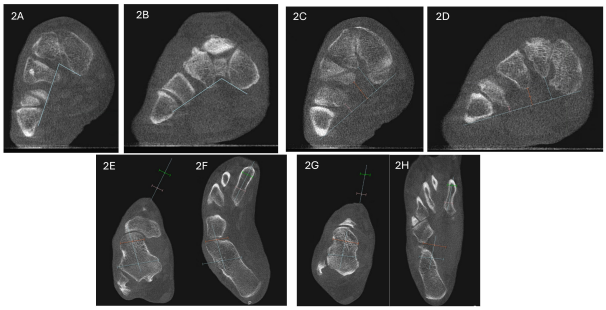

Figure 2. WBCT images of CMT PC (left) and Idiopathic PC (right) for: TAP Angle (A-B), TA Distance Measures (C-D), and Kite's Angles (E-F vs G-H).