Axial Rotation of the Talus in Progressive Collapsing Foot Deformity: A Weightbearing Computed Tomography Analysis

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INTRODUCTION:

Progressive collapsing foot deformity (PCFD) is often described as a three-dimensional deformity centered around the talus, with eversion of the subtalar joint, lateral translation/dorsiflexion of the navicular, and collapse of the medial longitudinal arch. At the ankle joint, PCFD has been associated with valgus talar tilt in the coronal plane and talar sagging in the sagittal plane, but axial talar motion has not been well described. Given that numerous cadaveric studies have established that the spring ligament complex acts as a buttress to prevent talar head plantarflexion and adduction, it is reasonable to assume that axial rotation of the talus occurs in conjunction with talar sagging.

To date, the primary method of surgical correction of abduction deformity — lateral column lengthening (LCL) — has primarily focused on adduction of the forefoot in order to improve talar head coverage, without considering talar orientation in the axial plane. However, achieving appropriate talonavicular coverage with LCL alone typically necessitates significant lengthening, resulting in subtalar stiffness and possible lateral column overload. Conversely, if abnormal axial rotation of the talus is identified and corrected, the graft size can be reduced, therefore reducing complications of LCL. In addition, this knowledge of talar malrotation in PCFD could help explain the development of medial ankle discomfort, spur formation, and medial ankle arthritis in PCFD, as documented in previous literature.

The purpose of this study was to examine axial plane talar rotation in PCFD. To accomplish our goal, we measured and compared axial talar rotation in PCFD patients and controls using weight-bearing computed tomography (WBCT). Additionally, we compared those with mild to moderate abduction deformity to those with severe abduction deformity to determine whether talar rotation in the axial plane is associated with increased abduction deformity in PCFD. We hypothesized that the talus would exhibit greater internal rotation in PCFD patients than in control patients, and that this rotation would increase with increasing abduction deformity.

METHODS:

Multiplanar reconstructed (MPR) WBCT scans of 79 patients with PCFD were analyzed. Patients were divided into two groups depending on their preoperative talonavicular coverage angle (TNC): moderate abduction (TNC 20-40°, n=57) and severe abduction (TNC >40°, n=22). 39 WBCT scans from healthy control patients without PCFD or hindfoot deformity were included as controls. Using the MPR WBCT images, the axis of talus (TM [transmalleolar]-Tal), calcaneus (TM-Calc), and 2nd metatarsal (TM-2MT) were measured in reference to the transmalleolar axis (**Figure 1**). The difference between TM-Tal and TM-Calc was calculated to assess talocalcaneal subluxation. The prevalence of medial tibiotalar joint space narrowing which was assessed with medial to dorsal tibiotalar joint space ratio (M/D ratio <0.5 was defined as 'narrowing') and medial ankle spur was assessed. Statistical analysis compared differences between three groups.

RESULTS:

Overall, TM-Tal was significantly smaller (more internally rotated talus) in PCFD patients compared to controls (**Figure 2**). This difference was accentuated in PCFD with severe abduction, who had significantly smaller TM-Tal (more internally rotated talus) than the moderate abduction group. TM-Calc did not differ between groups, indicating that PCFD and the controls did not differ in axial calcaneal orientation. The TM-2MT revealed a significant difference between groups, reflecting the clinical observation of foot abduction in PCFD and its severe deformity. Diff Tal-Calc values were greater in PCFD patients compared to controls, indicating that the PCFD patients have more talocalcaneal subluxation in the axial plane. The severe abduction group had a higher Diff Tal-Calc value than the moderate abduction group. PCFD patients had significantly higher prevalence of medial ankle joint space narrowing (43/79, 54.5%) than control patients (3/39, 7.7%); The severe abduction group (16/22, 72.7%) had a higher prevalence of medial joint space narrowing than the moderate abduction group (27/57, 47.4%), but this difference did not reach statistical significance. Medial ankle spur grade yielded similar results, with PCFD patients (45/79, 57%) having more medial spur formation than controls (5/39, 12.8%) but no significant differences between the severe and moderate abduction groups.

DISCUSSION AND CONCLUSION:

This study found that internal malrotation of the talus is a key component of PCFD and is accentuated in more severe abduction deformities. These findings suggest that talar malrotation in the axial plane should be considered an underlying feature of abduction deformity and that this deformity should be corrected at the time of reconstructive surgery, especially in cases of severe abduction deformity. In addition, these findings support the relatively common finding of medial joint narrowing and medial spur formation in PCFD patients, which may later lead to ankle arthritis and pain. Further research is warranted to identify optimal strategies for correction of talar rotation and how to reproducibly assess this intraoperatively.

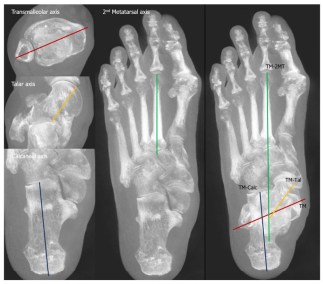

Figure 1. Determination of axes of bones of interest in weightbearing computed tomography. The angle of rotation for each axis was assessed in relation to the transmalleolar (TM) axis. TM, transmalleolar.

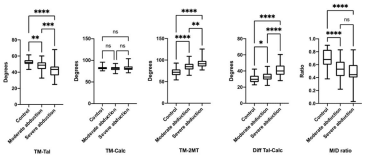

Figure 2. Comparison of rotational profiles of the three bones of interest and medial joint space narrowing between three groups on weightbearing computed tomography. TM, transmalleolar; M/D, medial to dorsal.