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Combined weightbearing CT and MRI assessment of flexible progressive collapsing foot deformity

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ABSTRACT

Background: The objective of this study was to evaluate the correlation between Weightbearing CT (WBCT) markers of pronounced peritalar subluxation (PTS) and MRI findings of soft tissue insufficiency in patients with flexible Progressive Collapsing Foot Deformity (PCFD). We hypothesized that significant correlation would be found.

Methods: Retrospective comparative study with 54 flexible PCFD patients. WBCT and MRI variables deformity severity were evaluated, including markers of pronounced PTS, as well as soft tissue degeneration. A multiple regression analysis and partition prediction models were used to evaluate the relationship between bone alignment and soft tissue injury. P-values of less than .05 were considered significant.

Results: Degeneration of the posterior tibial tendon was significantly associated with sinus tarsi impingement ($p = .04$). Spring ligament degeneration correlated to subtalar joint subluxation ($p = .04$). Talocalcaneal interosseous ligament involvement was the only one to significantly correlate to the presence of subfibular impingement ($p = .02$).

Conclusion: Our results demonstrated that WBCT markers of pronounced deformity and PTS were significantly correlated to MRI involvement of the PTT and other important restraints such as the spring and talocalcaneal interosseus ligaments.

LEVEL OF EVIDENCE: Level III, Retrospective comparative study.

1. Introduction

Adult acquired flatfoot deformity, or as more recently named, [1,2] progressive collapsing foot deformity (PCFD) is a multifactorial disorder characterized by concurrent multiplanar bony deformities, as well as tendinous and ligamentous insufficiencies [1–5]. The exact sequence of involvement of the osseous and soft tissue structures is yet to be fully understood [6–9].

The deformity was initially thought to be primarily resultant from the degeneration and insufficiency of the posterior tibial tendon (PTT) [6–8,10]. However, studies have demonstrated that isolated resection of the tendon does not result in a full-blown deformity [11,12]. The involvement of other soft tissue of the hindfoot and medial longitudinal arch such as the superficial and deep components of the deltoid, as well as spring and interosseous talocalcaneal ligaments, among other structures, has also been shown to play an important role in the pathophysiology and development of PCFD [3,12–15].

Magnetic resonance imaging (MRI) is widely accepted as the gold standard in the evaluation of medial soft tissue structures of the foot and ankle in the setting of PCFD [10,12,16,17]. Deland et al., in a case-control study, have demonstrated the increased frequency and severity of MRI involvement of different medial ligamentous structures in PCFD patients, most importantly both components of the spring (superomedial and inferior fibers) and

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the interosseus talocalcaneal ligaments, and also the anterior aspect of the superficial deltoid, plantar tarsometatarsal and plantar naviculocuneiform ligaments [18]. The involvement of some of the ligaments were as frequent and more pronounced than the degeneration of the PTT itself. The authors, however, emphasized that even though MRI was able to adequately demonstrate the presence and degree of ligamentous pathology, it could not directly assess the actual function of the ligamentous structures and their capacity to maintain bone alignment given the non-weightbearing nature of this test.

On the other hand, weightbearing computed tomography (WBCT) has been recently shown to allow optimized and reliable evaluation of bone alignment in dynamic complex three-dimensional (3D) deformities such as PCFD, with the foot under physiological standing load [12,19–26]. WBCT also provides assessment of important anatomical markers of pronounced hindfoot deformity and peritalar subluxation (PTS) in the coronal plane, such as the amount of subtalar joint (SJ) subluxation, and the presence of sinus tarsi and subfibular impingement [5,21,27–33]. Conventional radiographs do not optimally assess these markers due to the two-dimensional nature of this imaging modality.

To the authors' knowledge, no study to date has investigated symptomatic PCFD patients using both MR images in the assessment of soft tissue pathology and WBCT for evaluation of the bone deformity. Our objective was to investigate the role of this combined imaging assessment in allowing a better understanding of the relationship regarding which soft tissue structures are more frequently and severely affected when specific bone markers of marked PCFD and PTS are present. We hypothesized that significant correlation would be found between WBCT markers of PTS - such as SJ subluxation, sinus tarsi and subfibular impingement – and MRI findings of pronounced degeneration of the medial soft tissue structures.

2. Material and methods

In this institutional review board approved study (HSS/SC 2017/12), compliant with the Declaration of Helsinki and the Health Insurance Portability and Accountability Act (HIPAA), participants have signed a written informed consent.

2.1. Study design

In this level III retrospective comparative cohort study, consecutive patients with symptomatic flexible PCFD that underwent clinical assessment at our Institution, between February 2016 and December 2017, were identified from our institution's database. We included adult patients (18 years-old or older) that had available both WBCT images of the affected foot and ankle as well as internal standard quality 1.5 T or 3 T MRI images of the same limb, performed not more than 3 months apart from the WBCT examination, considered an acceptable lag time for a long-term progressive deformity [3]. We excluded patients with inflammatory and rheumatological conditions and the ones that had history of prior realignment or fusion procedures in the hindfoot or first ray of the affected foot and ankle.

2.2. Subjects

Charts of 218 patients with flexible PCFD were initially screened. After applying inclusion and exclusion criteria, a total of 54 patients (55 feet) were included, 17 men and 37 women, 36 left and 19 right, with a mean age of 51.5 (range, 20–76) years. A CONSORT diagram of enrolled, excluded and included patients is presented in Fig. 1.

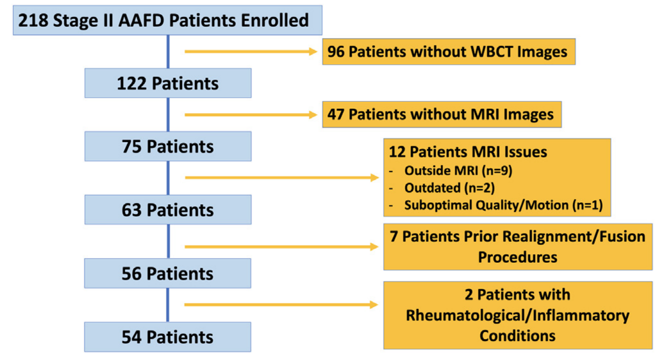

Fig. 1. CONSORT diagram of enrolled, excluded and included patients. Progressive Collapsing Foot Deformity, PCFD; Weightbearing computed tomography, WBCT; Metallic resonance imaging, MRI; Number, n.

2.3. Weightbearing CT and MRI imaging

All patients underwent CT studies at our institution using a cone beam WBCT extremity scanner (PedCAT©, Curvebeam©, Hatfield, Pennsylvania, US). Patients were instructed to weight bear normally, with the feet approximately at shoulder width and distributing the body weight evenly between the two lower limbs. Non-weightbearing 3 T MR images were also performed at our Institution. The standard quality of the images was assessed by two independent musculoskeletal radiologists before patient inclusion. Motion artifacts and metal artifacts were considered.

2.4. WBCT imaging assessment

The raw 3D WBCT data was reconstructed into sagittal, coronal, and axial images using a specific software (CubeView©, CurveBeam©, Hatfield, Pennsylvania, US). Axial images were obtained at 0.3 mm slice thickness. Patient information was removed, and each study was assigned a unique and random identification number. After the conclusion of a training protocol with five flexible PCFD patients, that were not included in the data analysis, two fellowship-trained foot and ankle Orthopaedic Surgeons evaluated markers of PTS in a blinded and independent fashion. To minimize memory bias, one of the observers repeated the measurements after 30 days of the first assessment.

Observers evaluated the degree of PTS assessing the presence or absence of three different specific markers. The first one was the subluxation of the posterior facet of the SJ. To obtain to the appropriate coronal plane image, sagittal WBCT images were used to detect the longest anteroposterior length of the posterior facet. The coronal plane image used for the assessment was positioned at the sagittal midpoint of the articular facet [21,23,30,34]. The amount of lateral uncoverage of the calcaneal articular surface of the posterior facet was measured in millimeters (mm) [28], and the value was divided by the total width of the same articular facet. The resultant percentage was defined as the uncoverage of the posterior facet of the SJ (Fig. 2). Based on prior literature for PTS [35], a value of more than 5% of joint uncoverage was used as a threshold value for defining the presence of subluxation of the posterior facet [19,28,29,35].

The second and third markers evaluated were the presence of findings consistent with sinus tarsi impingement (STI) and subfibular impingement (SFI). Sagittal and coronal plane images were freely assessed looking for respectively direct extra-articular contact between the talus and the calcaneus in the sinus tarsi as well as direct contact between the distal fibula and the calcaneus, respectively. Considering the dynamic nature of the deformity,

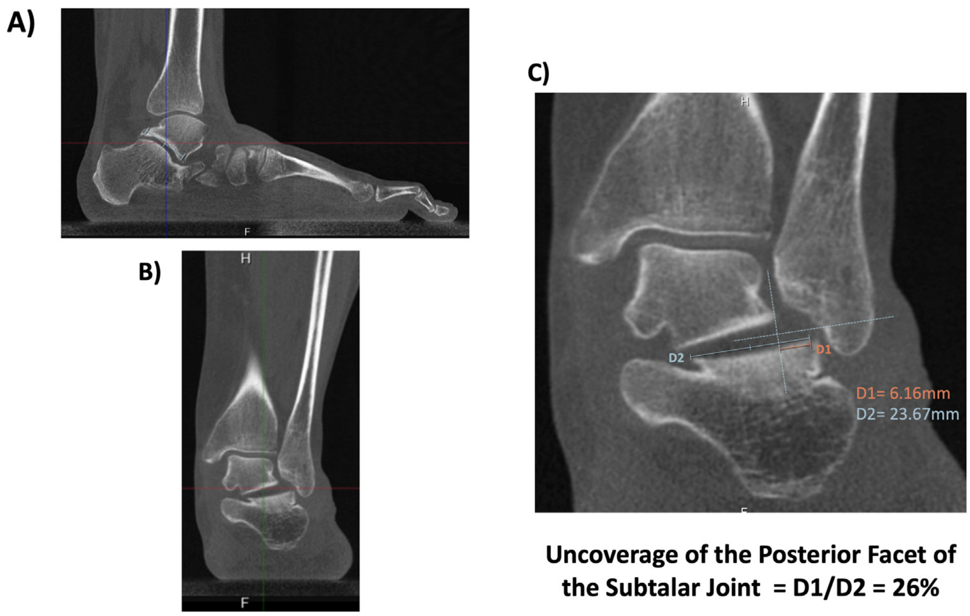

Fig. 2. Example of weightbearing CT measurement of the uncoverage of the posterior facet of the subtalar joint. First the midpoint of the longest anteroposterior length of the posterior facet is marked in the sagittal plane. The multiplanar reconstruction (MPR) cross-section tool is brought to the midpoint of the posterior facet (A). The resultant coronal plane image is identified (B). Calculation is performed by dividing the amount of lateral uncoverage (D1) by the total width (D2) of the calcaneal articular surface of the posterior facet.

indirect signs of impingement were also considered to grade the presence or absence of it. These indirect signs considered were focal sclerosis, osteophyte and/or cystic formation (Fig. 3), as previously utilized and reported in the literature [5].

2.5. MR imaging assessment

MR images of the ankle were obtained with either a 1.5 Tesla or a 3.0 Tesla unit (General Electric Medical Systems, Chicago, IL). All images were obtained with either a quadrature or dedicated phased array foot and ankle coil. All ankles were positioned in neutral ankle dorsiflexion, with the Achilles tendon parallel to the long axis of the magnetic field. Acquired images included: Sagittal inversion recovery (STIR) repetition time (TR) 4000 ms/echo time (TE) 13–15 ms, inversion time 150 ms, slice thickness (SL) 3–3.5 mm, echo train length (ETL) 10, field of view (FOV) 180 mm, matrix 256 × 192, number of excitations (NEX) 2; sagittal proton density (PD) TR 4500/TE 25, SL 3 mm, ETL 12, FOV 150 mm, matrix 512 × 384, NEX 2; coronal PD TR 5000/TE 25, SL 4 mm, ETL 12, FOV 110 mm, matrix 512 × 384, NEX 2; axial PD TR 5000/TE 24, SL 3.3 mm, ETL 12, FOV 130 mm, matrix 512 × 256, NEX 2.

All images were reviewed on a PACS (Picture Archiving and Communication System) system (SECTRA, Linkoping, Sweden). Patient identifiers were removed, and studies were assigned unique and random numbers. After similar training protocol, two independent musculoskeletal radiologists graded the severity of degeneration of different medial soft tissue structures, using the exact same protocol and grading systems described by Deland et al.

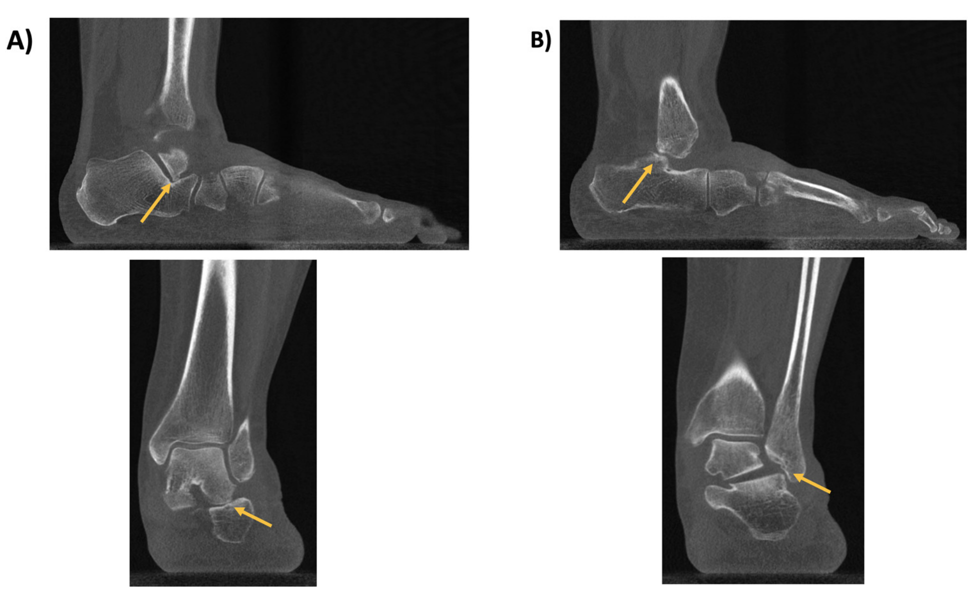

Fig. 3. Examples of sagittal and coronal plane weightbearing CT images of sinus tarsi impingement (A) and subfibular impingement (B).

[18]. One of the observers repeated the evaluation after 30 days of the first assessment.

A total of seven structures were assessed, consistent with prior literature that demonstrated the most commonly and significantly degenerated soft tissue in PCFD patients when compared to controls [18]; PTT; superomedial and inferior components of the spring ligament; interosseus talocalcaneal ligament; anterior fibers of the superficial deltoid ligament; plantar naviculo-medial cuneiform ligament; and the plantar medial cuneiform-first metatarsal ligament.

The pathology of the soft tissue structures were graded on a five-part scale: grade 0, an intact ligament with uniformly hypointense signal intensity; grade I, degeneration, with increased signal intensity involving less than 50% of the cross-sectional area of the ligament/tendon on axial images; grade II, degeneration of more than 50%; grade III, a partial tear with discontinuity of less than 50% of the fibers, with increased signal intensity and abnormal morphology; and grade IV, same features, but with a tear of more than 50% of the cross-sectional area [18]. Examples of MRI readings are shown in Fig. 4.

2.6. Statistical analysis

Continuous variables were assessed for normality by the Shapiro-Wilk test. Mean, median, interquartile range (IQR), and 95% confidence interval (CI) values for each measurement were reported. Ordinal and nominal data were reported using descriptive statistics including percentages and probabilities.

The influence of MRI soft tissue degeneration on the diagnosis of SJ subluxation, sinus tarsi and subfibular impingement was assessed using multivariate nominal/ordinal logistic regression. Receiver Operating Curves (ROC) curves, Area Under the Curve (AUC) and partition prediction models were also used to reveal the specific soft tissue affected and the grading of deterioration that could be used as thresholds for assessing the diagnosis of markers of pronounced bone deformity (SJ subluxation, STI and SFI) [36,37].

Intra and Interobserver reliabilities for WBCT measurements and MRI assessment was performed using either Intraclass Correlation Coefficient or Spearman's correlation. P values of <.05 were considered significant.

3. Results

Intra and interobserver agreement for WBCT and MRI assessment are reported in Tables 1 and 2. The mean and median values of the percentage of posterior facet uncoverage were respectively 15.3% (95% CI, 13.2–17.4%), 17% (IQR, 20.2%).

The number and percentages of patients with and without SJ subluxation, STI and SFI are presented in Fig. 5. Similarly, the distributions of MRI soft tissue involvement are depicted in Fig. 6.

When assessing the influence of MRI soft tissue involvement on the presence of markers of pronounced WBCT deformity, the multivariate logistic regression demonstrated the following findings. The only MRI variable involvement to correlate with STI was PTT degeneration (p = .04), with an R^2 value of 0.15 and an AUC of 0.73. The partition prediction model showed that patients with grades III or higher degeneration of the PTT had increased prevalence of STI (89.5%), than patients with grade II or lower involvement (63.9%). The probability of STI in patients with PTT degeneration was 64.1% when grading was equal or lower than stage II, and 88.6% when staging was equal or higher to III.

The presence of SJ subluxation was influenced by the involvement of both superomedial (p = .04) and inferior components of the spring ligament (p = .01), with an R^2 value of 0.26 and an AUC of 0.79. The partition prediction model demonstrated that the degeneration of the inferior component of the spring ligament was the best predictor for SJ subluxation, with an important threshold value when the grade of degeneration was equal or higher than grade II. All those patients (100%) had WBCT signs of SJ subluxation when compared to 62.2% of patients with grade 0 or I. Patients with grade 0 or I degeneration had a probability of 62.4% of having SJ subluxation, while the patients with grade II or higher had 97.2% chances of demonstrating same findings.

Finally, the occurrence of SFI was only influenced by the involvement of the talocalcaneal interosseus ligament (p = .02), with an R^2 value of 0.28 and an AUC of 0.84. The partition model found that patients with grades III or higher degeneration of the interosseus ligament demonstrated increased risks of subfibular impingement, with no patients with interosseus ligament involvement grade II or lower presenting with SFI, while 20% of patients with grade III or IV had signs of impingement. The

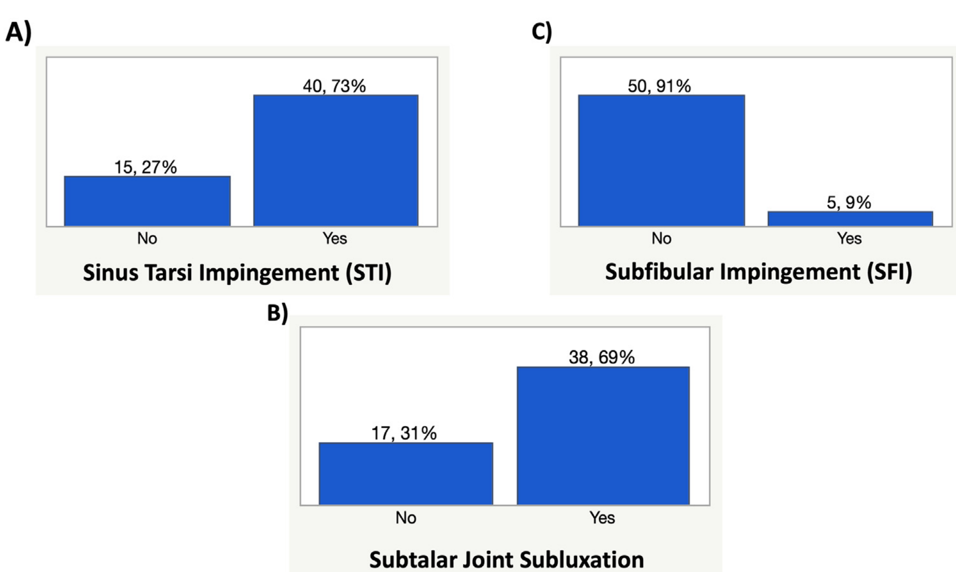

Fig. 4. Examples of MR imaging for soft tissue involvement (coronal plane proton density weighted images). Spring Ligament Superomedial Fibers (A); Grade I (Top) and Grade IV (Bottom). Posterior tibial tendon (B); Grade I (Top) and Grade IV (Bottom). Interosseus Ligament (C); Grade I (Top) and Grade IV (Bottom).

Table 1
Intra- and Interobserver Agreement for Weightbearing CT Assessment. Abbreviations: CT, Computed Tomography; ICC, Intraclass Correlation Coefficient.

	Intraobserver Agreement Correlation Coefficient 95% Confidence Interval P-value	Interobserver Agreement Correlation Coefficient 95% Confidence Interval P-value
Sinus Tarsi Impingement (Yes/No)	**Spearman ρ** 0.83 0.72 – 0.83 <.0001	**Spearman ρ** 0.64 0.45 – 0.64 <.0001
Subfibular Impingement (Yes/No)	**Spearman ρ** 0.83 0.72 – 0.90 <.0001	**Spearman ρ** 0.77 0.63 – 0.86 <.0001
Subtalar Joint Subluxation (Yes/No)	**Spearman ρ** 0.87 0.79 – 0.92 <.0001	**Spearman ρ** 0.69 0.53 – 0.81 <.0001
Subtalar Joint Subluxation Percentage (%)	**ICC** 0.94 0.84 – 0.97 <.0001	**ICC** 0.88 0.76 – 0.94 <.0001

Table 2
Intra- and Interobserver Agreement for MRI Soft Tissue Degeneration. MRI, Magnetic Resonance Imaging; ICC, Intraclass Correlation Coefficient.

	Intraobserver Agreement Correlation Coefficient 95% Confidence Interval P-value	Interobserver Agreement Correlation Coefficient 95% Confidence Interval P-value
Posterior Tibial Tendon	**Spearman ρ** 0.98 0.95 – 0.98 <.0001	**Spearman ρ** 0.87 0.82 – 0.94 <.0001
Superomedial Spring Ligament	**Spearman ρ** 0.94 0.90 – 0.97 <.0001	**Spearman ρ** 0.70 0.52 – 0.81 <.0001
Inferior Spring Ligament	**Spearman ρ** 0.95 0.92 – 0.97 <.0001	**Spearman ρ** 0.54 0.32 – 0.71 <.0001
Talocalcaneal Interosseus Ligament	**Spearman ρ** 0.92 0.86 – 0.95 <.0001	**Spearman ρ** 0.53 0.33 – 0.71 <.0001
Anterior Deltoid Ligament	**Spearman ρ** 0.93 0.89 – 0.96 <.0001	**Spearman ρ** 0.52 0.33 – 0.71 <.0001
Plantar Naviculo-Cuneiform Ligament	**Spearman ρ** 0.92 0.83 – 0.94 <.0001	**Spearman ρ** 0.33 0.07 – 0.55 = .01
Plantar Medial Cuneiform – First Metatarsal Ligament	**Spearman ρ** 0.97 0.96 – 0.98 <.0001	**Spearman ρ** 0.58 0.39– 0.74 <.0001

probabilities of SFI in patients with talocalcaneal interosseus ligament involvement were less than 1% when grading was equal or lower than stage II and 19.6% when degeneration equal or higher than stage III.

4. Discussion

To the authors' knowledge, this is the first study to demonstrate strong correlations between WBCT markers of PTS and MRI incidence and severity of soft tissue degeneration. Presence of STI correlated with more advanced involvement of the PTT, SJ subluxation correlated with more severe degenerative findings of the spring ligament, and SFI correlated with degeneration of the talocalcaneal interosseous ligament.

Our study cohort demonstrated a high prevalence of established WBCT markers of PTS [5,19,21,27–29,35,38], with STI and SJ subluxation present in 73% and 69% of the patients, respectively. SFI was less prevalent and identified in only 9% of patients. Even though no temporal relationship can be determined in our study regarding the sequence in which these three deformities occur, our results corroborate previous findings in the literature in which STI is a more frequent and possibly earlier finding of PTS than SFI [5,39].

Malicky and colleagues were the first to report the prevalence of STI and SFI in PCFD using simulated WBCT [5]. In their cohort of 19 patients, STI and SFI were present in 92% and 66% of patients, respectively. Most importantly, all patients with SFI demonstrated signs of STI, but not vice versa. This led the authors to infer that STI may be an earlier finding, whereas SFI may represent more advanced PTS. More recently, Jeng and colleagues also conveyed on the prevalence of these WBCT markers in PCFD patients, reporting that STI (38%) was only slightly more prevalent than SFI (35%). The fact that those authors also included patients with more severe stages of PCFD could potentially explain their higher prevalence of SFI when compared to our results (9% SFI, including only flexible deformity) [39].

The amount and frequency of SJ subluxation found in our study is also consistent with the reported literature [19,28,29]. In a study of 30 "severe" PCFD patients, Ferri and colleagues observed that only four (13%) had SJ subluxation of the posterior facet on simulated WBCT (50% body weight). This difference observed may be due to differences in weightbearing protocol and patient inclusion criteria [40]. de Cesar Netto and colleagues reported in a cohort of 30 patients with flexible PCFD a significant amount (average, 45.3%) of subluxation at the middle facet, that was present in all 30 patients. [35]. Although the efficacy of using the middle versus the posterior facet in assessing PTS severity is unknown, the authors postulated the middle facet possibly represents an earlier and more pronounced marker of PTS. [35]. This may account for the difference in prevalence and severity of subluxation observed here. Future comparative studies evaluating the diagnostic accuracy of using the posterior and middle facets in assessing PTS severity are needed.

The prevalence and severity of medial soft tissue involvement is also consistent with previous findings [18]. We found that 43% of patients had mild or no (grade I or zero) PTT degeneration, while only 26%, 25%, and 24% demonstrated mild or no degenerative findings of the superomedial component of the spring, talocalcaneal interosseus, and superficial deltoid ligaments, respectively. This is consistent with previous literature in which the PTT is usually less frequently and severely involved than these other structures [11,13,18,41,42]. We chose to evaluate seven specific structures previously identified by Deland and colleagues to have significant involvement in PCFD [18]. The authors reported the superomedial component of the spring ligament (grade III or IV degeneration in 74% of patients) and talocalcaneal interosseus ligament (grade III or IV degeneration in 42% of patients) were among the most commonly involved ligaments,14 which is consistent with our findings [18].

The strengths of our study should be emphasized. They include the novel combined assessment of WBCT and MRI in a homogeneous cohort of flexible PCFD by a total of four independent and blinded readers, with overall good to excellent reliability. The most meaningful aspect of our findings is the potential for clinical applicability and for laying the groundwork for future

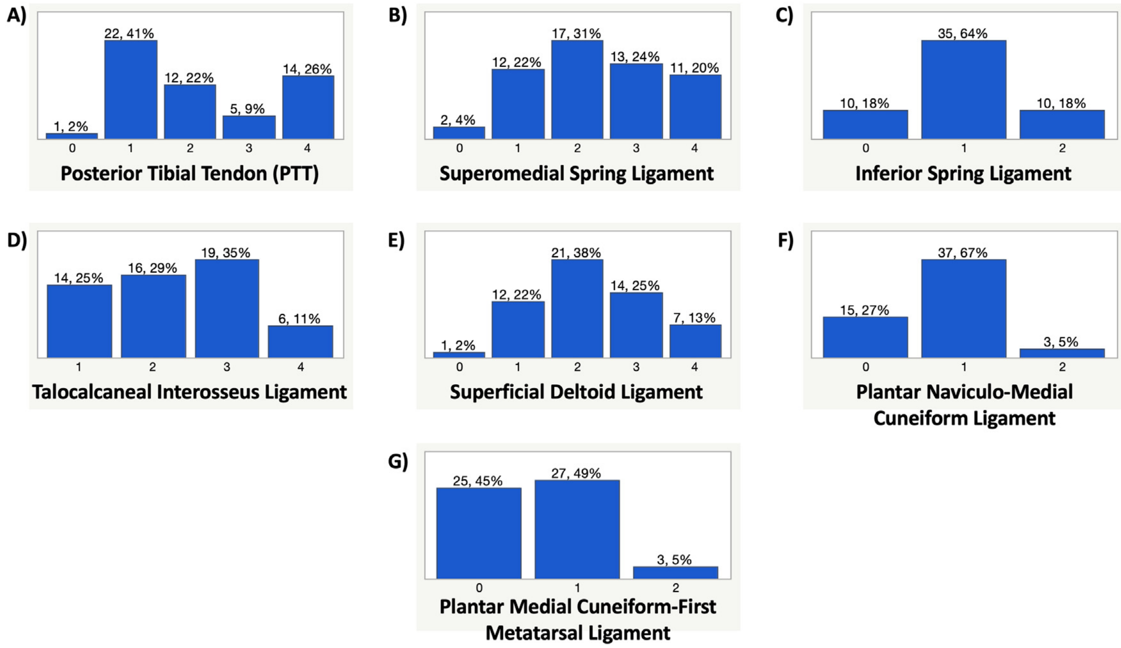

Fig. 5. Distribution of Progressive Collapsing Foot Deformity (PCFD) patients (number, percentage) with Weightbearing CT findings of Sinus Tarsi Impingement (A), Subtalar Joint Subluxation (B) and Subfibular Impingement (C).

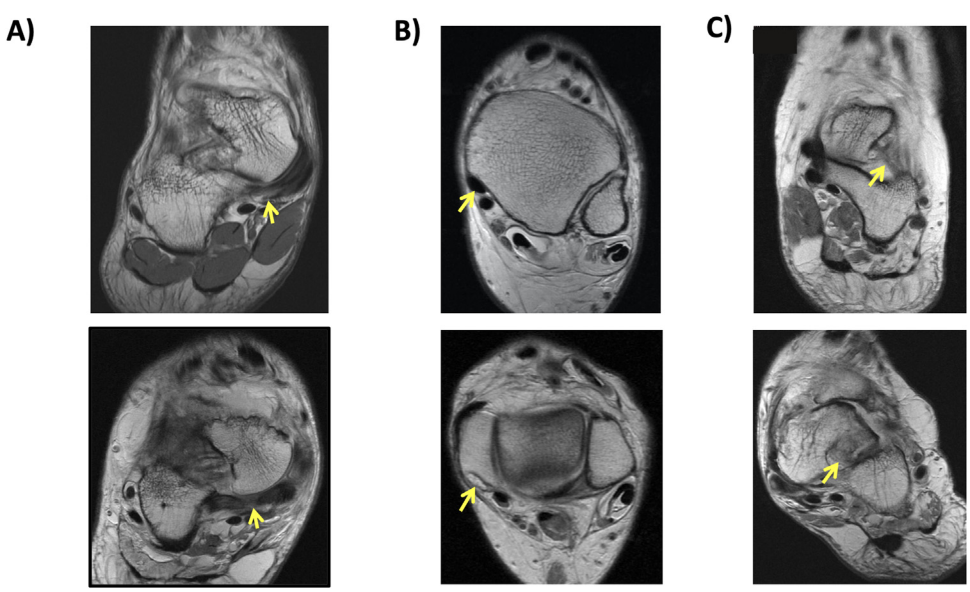

Fig. 6. Distribution of Progressive Collapsing Foot Deformity (PCFD) patients (number, percentage) with MRI soft tissue involvement of the Posterior Tibial Tendon (A), Superomedial Fibers of the Spring Ligament (B), Inferior Fibers of the Spring Ligament (C), Talocalcaneal Interosseus Ligament (D), Anterior Fibers of the Superficial Deltoid Ligament (E), Plantar Naviculo-Medial Cuneiform Ligament (F), and Plantar Medial Cuneiform-First Metatarsal Ligament (G).

investigations. While both WBCT and MRI provide important information regarding a patient's condition and therefore assist with treatment planning, the reality is that both studies are not available as standard of care. The correlations we have identified between WBCT markers of PTS and MRI findings of soft tissue degeneration have important implications in allowing surgeons and researchers to estimate the amount of PTS when assessing MR images, and conversely, the degree of MRI soft tissue involvement when assessing WBCT in PCFD patients.

Specifically, presence of STI was significantly associated with degree of PTT degeneration with an 89% probability of STI when degeneration was grade III or higher. This finding is consistent with Donovan and Rosenberg, in which a study of 75 PCFD patients using only MRI demonstrated that 57% of patients with grade III degeneration of the PTT had talocalcaneal–subfibular impingement [43]. STI may represent a relatively earlier and more prevalent finding of PTS, making for a more easily appreciated WBCT marker than subluxation of the posterior facet. The presence of STI, even if not symptomatic, should alert surgeons of the likely progressive nature of the deformity and highlights the importance of assessing PTT condition both preoperatively and intraoperatively.

Presence of SJ subluxation was significantly associated with involvement of both components of the spring ligament, with a

97% probability of subluxation when degeneration of the superior component of the spring ligament was grade II or higher. This corroborates with the function of the spring ligament in maintaining stability and congruency of the subtalar and talonavicular joints [44–49]. The presence of SJ subluxation would entail significant degeneration of the spring ligament and concomitant peritalar instability. Presence of both SJ subluxation and STI should raise strong concerns for progressive collapse, instability, and PTS. This demands close clinical follow-up and consideration for surgical treatment in order to avoid further progression of the deformity and less functional results. Surgical treatment options in the presence of SJ subluxation should include spring ligament assessment, repair or reconstruction, and even a SJ fusion.

Finally, SFI was significantly associated with involvement of the talocalcaneal interosseus ligament with a 20% probability of SFI when degeneration of the interosseus ligament was grade III or higher. As highlighted in previous studies [5,39], SFI is likely a later marker of advanced PTS, where the calcaneus rotates and displaces enough to impinge on the medial and/or distal aspect of the fibula. This is likely associated with degeneration of the interosseus ligament, an important stabilizer of the SJ [50–55]. In the presence of SFI, reconstruction of the interosseus ligament or SJ fusion should be considered. Prospective, controlled studies with assessment of postoperative deformity correction and clinical outcomes are encouraged to further support these interpretations.

Our study has important limitations. The retrospective and non-controlled design may have added intrinsic biases that may be better mitigated in a prospective controlled study. No sample size calculation was performed, and therefore our study may be underpowered in demonstrating additional significant correlations. Another important limitation is that beyond simple association, no formal causation between WBCT markers of PTS and MRI involvement of soft tissues can be assured. Finally, we did not assess clinical or patient-reported outcomes, which may decrease the clinical applicability of our findings. As previously mentioned, this study sets the groundwork for a future longitudinal investigation across multiple stages of PCFD, correlating radiographic assessment with clinical and surgical outcomes.

In conclusion, our study assessed the prevalence and interplay of WBCT and MRI findings in patients with flexible PCFD. We found that WBCT markers of pronounced PTS such as STI and SJ subluxation are highly prevalent in these patients, and more common than SFI. The PTT, spring and interosseus ligaments were the most severely degenerated medial soft tissue structures on MRI. Significant correlations were observed, with STI, SJ subluxation and SFI being influenced by degeneration of the PTT, spring ligament, and interosseus ligament, respectively. These relationships should be considered when treating PCFD patients.

Reported disclosures for the study "Combined weightbearing CT and MRI assessment of flexible adult acquired flatfoot deformity":

- **Dr. de Cesar Netto** reports grants, personal fees and other from CuerveBeam, personal fees from Ossio, grants and personal fees from Paragon 28, outside the submitted work; and Treasurer International Weightbearing CT Society, Foot & Ankle International Media Board Member, AOFAS Young Physician Committee Member.
- Dr. Ellis reports other from Wright Medical, other from Paragon 28, outside the submitted work.
- Dr. Greditzer has nothing to disclose.
- Dr. Roney has nothing to disclose.
- Dr. Saito reports personal fees from Wright Medical, outside the submitted work.
- Dr. Day has nothing to disclose.
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