

Measurements and Protocols Used for Weight-Bearing Cone-Beam CT Scans for  
Evaluating the Alignment of the Foot and Ankle: A Systematic Literature Review

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**Abstract:**

**Background:** Weight-bearing CT (WBCT) has been used by orthopedic surgeons to obtain detailed 3D information of the foot and ankle. However, there is a lack of validated tools to effectively utilize this imaging modality in clinical practice. Although new parameters exist using traditional axes, angular concepts, and 3D reconstructed bones, small sample size, obscure inclusion/exclusion criteria, and skewed validation methods make it difficult to expand the use of WBCT in a standardized manner.

**Methods:** The literature search was conducted in two databases: PubMed (MEDLINE) and EMBASE (Elsevier). The main search terms and logics were: ((foot) OR (ankle) OR (hindfoot) OR (midfoot) OR (forefoot)) AND ((WBCT) OR (Weightbearing CT) OR (Cone beam CT scan) OR (PedCAT)). A longer string of key words, expanded using the MeSH and Emtree features of PubMed and EMBASE, respectively, was utilized to narrow the results to WBCT imaging associated with foot and ankle pathologies. All articles were reviewed by two independent senior foot and ankle surgeons based on pre-designed exclusion criteria.

**Results:** A total of 216 articles were selected for retrieval and further organized by measurement techniques. Seven groups were set by the type of the methodology used. Among them, 123 studies utilized traditional 2D measurement parameters (eg, hindfoot moment arm, Meary's angle, talonavicular uncoverage, hallux valgus angle, etc.), 8 introduced new parameters but based on 2D axial/angular concepts (eg, middle

face subluxation percentage and angle), 22 used semi-automated 3D measurement techniques (3D segmentation + 2D axial and angular methods), 19 using semi-3D measurement techniques (Foot and Ankle Offset), 29 measured real 3D parameters (volume evaluation in the syndesmosis and Lisfranc joints, distance mapping), 3 morphological studies used 3D segmentation and sphere fitting. Advantages and disadvantages of each type of measurement were carefully examined and listed out.

**Conclusion:** WBCT imaging appears to be highly variegated. Axial and angular measurements do not apply well to irregular bones and there is a low reproducibility in 3D scenarios. Also, inter- and intraobserver reproducibility scores were reported inconsistently. We observed a high correlation between parameters, like 2D and 3D hindfoot angles, in many articles, but validity is still lacking. Variations in analytical methods warrant a more uniformly defined coordinate and image-gathering system. Therefore, continued investigation is needed to develop more standardized WBCT measurement methodologies for foot and ankle pathologies.