

# 3D Automated Analysis of Charcot-Marie-Tooth Cavovarus Reconstruction using Preoperative and Postoperative Weightbearing Computed Tomography

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**INTRODUCTION:** Charcot-Marie-Tooth (CMT) disease is the most common cause of cavus foot. The complex deformities in cavovarus feet of CMT disease are difficult to evaluate. The bone axes of CMT may be difficult to calculate by conventional weightbearing computed tomography (WBCT). For this reason, 3D automated measurements have been used to assess complex anatomy. The aim of this study was to quantitatively assess deformity correction following CMT cavovarus reconstruction using pre- and postoperative WBCT. This is the first study investigating perioperative WBCT findings in CMT feet using automated 3D measurements.

**METHODS:** The study was approved by our institutional review board and informed consent was obtained from all patients. CMT reconstruction surgery was performed with multiple soft tissue releases and bony procedures. Among the 201 cases from January 2020 to March 2023, twenty-eight CMT patients who had both pre- and post-operative WBCTs were retrospectively analyzed. 3D measurements of WBCT were performed using semi-automated software (Bonelogic, Disior) to investigate changes in sagittal, axial, and coronal parameters. Pre- and postoperative data was compared in the cases along with normative data using a t-test. Correlation among these sagittal, axial, and coronal parameters were also analyzed using Pearson's correlation coefficient test.

**RESULTS SECTION:** The sagittal, axial, and coronal malalignment of the hindfoot, and the sagittal and axial malalignment of forefoot was significantly improved after corrective surgery ( $p < 0.05$ ). Sagittal Meary's angle, talonavicular coverage angle (TNCA), and coronal hindfoot alignment showed significant changes postoperatively ( $p < 0.05$ ). Though significantly improved from the preoperative state, the hindfoot parameters remained significantly different than normative values. Forefoot parameters were no longer significantly different. Correlation coefficient evaluation demonstrated that sagittal, axial, and coronal deformity and the amount of correction were closely related. Regarding preoperative measurements and amount of correction, TNCA was the most strongly related to improvement in sagittal Meary's angle ( $p < 0.01$ ) and coronal hindfoot alignment ( $p < 0.01$ ).

**DISCUSSION:** There are several key findings in our study. The most important finding has to do with the TNCA. Correction of the TNCA is strongly correlated with hindfoot and forefoot measures in multiple planes. Not only the preoperative sagittal, axial, and coronal parameters showed significant relationships, but also the amount of correction in the parameters exhibited significant relationships each other. The strength of the study is that we used the 3D anatomic modeling of WBCT images allowed for precise, automated 3D axis calculation of CMT feet which was previously validated in the foot and ankle literature. Another major strength of this study is that relatively large number of CMT patients were included, and all operations were performed by the same orthopedic surgeon with extensive clinical experience in treating CMT deformity, thereby limiting the number of variables that may affect patient outcomes. However, additional investigation correlating radiographic measurements with clinical outcomes using patient reported outcomes measurement information system (PROMIS) score is necessary to refine operative goals and direct operative intervention for CMT feet deformities.

In summary, the quantitative analysis revealed that reconstructive surgery with soft tissue releases and bony procedures significantly corrected abnormal sagittal, axial, and coronal deformity of the CMT feet. Reduction of talonavicular joint is the key to the reduction of the other deformed joints.

**SIGNIFICANCE/CLINICAL RELEVANCE:** To date, the effect of CMT reconstruction procedures on the 3D anatomy of foot and ankle have not been analyzed. This CMT research using automated 3D measurements of WBCT might give insights to surgeons understanding the effect of CMT reconstruction surgery on multiplane foot deformity.

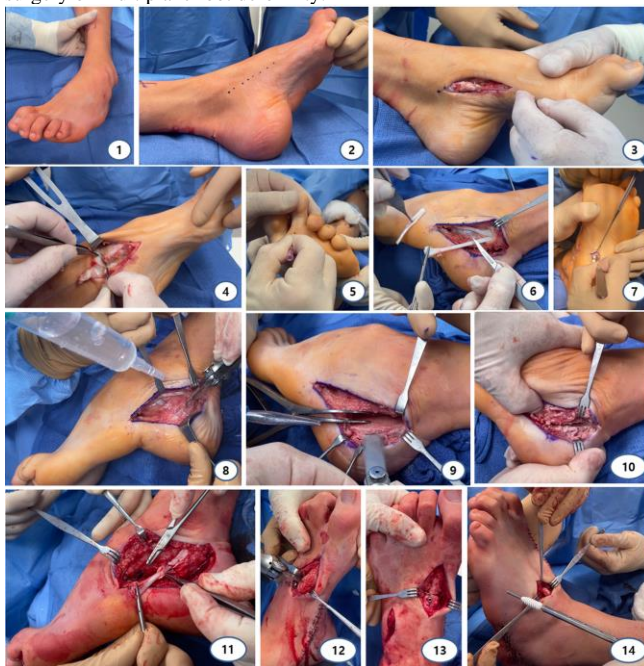


Figure 1. CMT surgery with soft tissue releases and bony procedures.

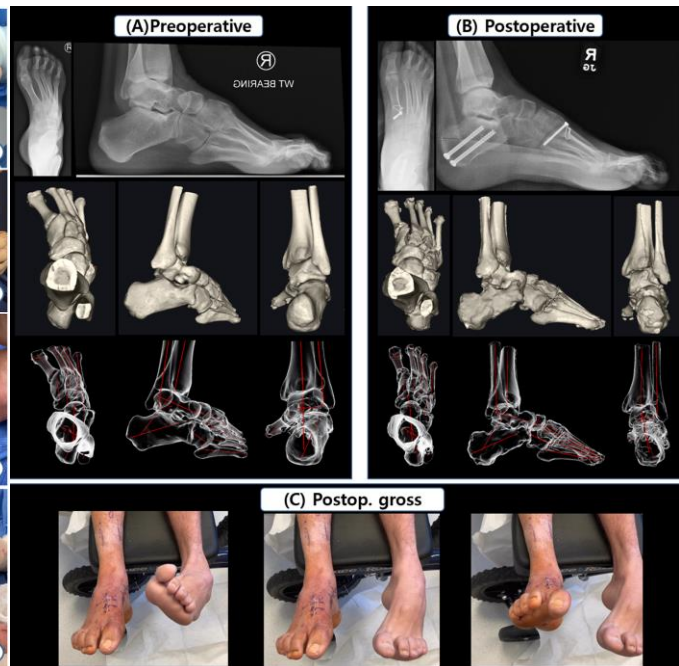


Figure 2. Pre- and postoperative radiographic results, and gross photos of the operated right foot of a 17-year-old male patient.