A Multicenter Study of Correction Accuracy in Coronal Plane Alignment Modifying Osteotomies using Patient-Specific Instrumentation

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INTRODUCTION: High tibial osteotomy (HTO) and distal femoral osteotomy (DFO) are powerful tools for correcting coronal malalignment of the lower extremity, and are effective, joint-preserving treatment strategies for addressing early tibiofemoral compartment osteoarthritis in young patients. Historically, these procedures have been performed freehand using intraoperative fluoroscopy, after extensive presurgical planning based on preoperative imaging. More recently, the advent of 3D CT-based patient-specific instrumentation (PSI) has been associated with decreased intraoperative fluoroscopy, improved safety and possibly improved accuracy in a cadaveric model. The purpose of this study was to assess correction accuracy of coronal plane modifying osteotomies using PSI in a consecutive series of patients.

METHODS: All patients who underwent single-level coronal plane correction osteotomy (HTO or DFO) with PSI (Bodycad, Quebec City, Canada) at 2 tertiary referral centers between October 2020 and September 2024 were eligible for study inclusion. Patients who underwent sagittal plane correction osteotomies, dual level osteotomies, or had intraoperative hinge fractures were excluded. All included patients underwent preoperative and postoperative long-standing alignment radiographs at a minimum of 3 months postoperatively. Preoperative and postoperative 3D CT-based measurements of medial tibial width ratio (MTWR) and joint line congruency angle (JLCA) were obtained from the PSI preoperative plan. Preoperative and postoperative radiographic measurements of MTWR and JLCA were performed by two independent raters. Means +/- standard deviations and medians with ranges were used as descriptive statistics for normally and non-normally distributed variables, respectively. Intraclass correlation coefficients (ICCs) were used to assess both interrater and intermethod reliability for MTWR and JLCA. Wilcoxon signed-rank tests were used to compare the MTWR between 3D CT data and radiographic measurements. Cutoffs of +/-2.5%, +/-5% and +/-10% relative to the planned postoperative 3D CT MTWR were used to assess correction accuracy (**Fig 1**).

RESULTS: 160 patients met study inclusion criteria. Patient characteristic data are found in **Table 1.** Median age was 39 years (range: 16-63) and 51% of patients were female. One hundred and twelve patients (70%) underwent HTO and 48 patients (30%) underwent DFO. The ICC score for interrater reliability on preoperative radiographs was 0.99 (95% CI: 0.99-0.98) for MTWR and 0.92 (95% CI: 0.87-0.95) for JLCA. The ICC score between preoperative 3D CT data and measured values on preoperative radiographs was 0.99 (95% CI: 0.98-0.99) for MTWR and 0.57 (95% CI: 0.45-0.71) for JLCA. There was no significant difference in preoperative MTWR measured on 3D CT compared to preoperative radiographs (difference in means = 0.4% (95% CI: -0.9%, 0.1%), p=0.12). Similarly, there was no significant difference in postoperative MTWR planned on 3D CT compared to postoperative radiographic measurement (difference in means = 1.4% (95%CI: -0.18%, 3.0%, p=0.08). When comparing final MTWR measured on postoperative radiographs with the planned 3D CT MTWR, 23.7%, 46.6% and 81.3% of patients had a measured MTWR on postoperative radiographs within 2.5%, 5%, 10% of the planned 3D CT MTWR, respectively (**Fig 3A)**. Subgroup analysis of osteotomy type demonstrated similar results, with 23.1%, 44.9% and 79.5% of medial opening wedge HTO patients (**Fig** 3B) and 26.7%, 46.7% and 86.7% of lateral opening wedge DFO patients meeting the 2.5%, 5% and 10% accuracy cutoffs, respectively (**Fig 3C**).

DISCUSSION AND CONCLUSION:

MTWR demonstrated a high degree of intermethod reliability between radiographic measurements and 3D CT data, whereas JLCA demonstrated much lower intermethod reliability. Thus, the MTWR appears to be a highly reliable method for communicating coronal plane correction, as this value is normalized to each patient's tibia and avoids measurement limitations associated with abnormalities in the anatomic axis of the femur and/or tibia. Additionally, the planned degree of correction was highly reliable between the radiographic and CT data. The PSI method for coronal plane osteotomy was highly accurate in achieving the desired correction in coronal plane alignment, with 23.7%, 46.6% and 81.3% of patients' final radiographic coronal alignment falling within 2.5%, 5% and 10% of the preoperative 3D CT plan. Overall, this study demonstrates 1) a high degree of concordance between preoperative radiographic measurements of MTWR and 3D CT data and 2) a high degree of accuracy in obtaining the desired coronal correction and final MTWR using PSI for coronal plane osteotomies.

Table 1. Patient characteristics.

Characteristic	N = 160
Sex, n (%)	
Male	78 (49%)
Female	82 (51%)
Age, median (range)	39 years (16 – 63)
Laterality, n (%)	
Left	77 (48%)
Right	83 (52%)
Osteotomy Type, n (%)	
DFO	48 (30%)
LOW	39 (24%)
MCW	8 (5.0%)
LCW	1 (0.6%)
HTO	112 (70%)
MOW	102 (64%)
MCW	10 (6.3%)

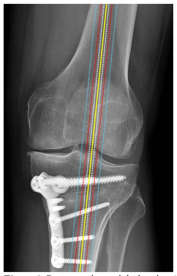

Figure 1. Postoperative weight-bearing AP knee radiograph demonstrating 3D CT planned postoperative MTWR (yellow line), with +/- 2.5% (white dashed line), +/- 5% (red dashed line) and +/- 10% (blue dashed line) accuracy cutoffs.

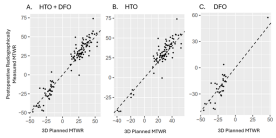

Figure 2. Distribution of preoperative to postoperative change in radiographic measurement of MTWR compared to planned preoperative to postoperative change on 3D CT software for **A)** all patients, **B)** HTO patients only, and **C)** DFO patients only. Dashed line shows perfect agreement (x=y).

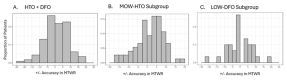

Figure 3: **A)** Histogram demonstrating the proportion of patients within each accuracy category for **A)** all patients, **B)** Medial Opening Wedge HTO patients only, and **C)** Lateral Opening Wedge DFO patients only