A Multicenter Study of Correction Accuracy in Anterior Closing Wedge High Tibial Osteotomies using Patient-Specific Instrumentation

Katherine Esser, Tyler J Uppstrom, Joseph Featherall, Jillian S R Neufeld, Joanna Roder, Alexa N Dietrich, Matthew T Provencher, Michael J Alaia, Armando Felipe Vidal

INTRODUCTION:

Posterior tibial slope (PTS) is a critical predictive factor for increased risk of anterior cruciate ligament (ACL) injury and re-rupture following ACL reconstruction. Prior studies suggest PTS > 12 degrees in the setting of revision ACL reconstruction is associated with increased risk of re-rupture and poor outcomes. Either performed in a staged fashion or concomitantly with revision ACL reconstruction, the most common strategy for correcting PTS is via a sagittal plane anterior closing wedge tibial osteotomy. This is a technically demanding procedure, which has historically been performed via freehand technique using intraoperative fluoroscopy after extensive presurgical planning based on preoperative imaging. More recently, the advent of patient-specific instrumentation (PSI) and 3D-printed osteotomy guides based on preoperative 3D CT data has been associated with improved accuracy in a small series of patients. The purpose of this study was to assess correction accuracy of sagittal plane modifying osteotomies using patient-specific instrumentation in a consecutive series of patients with increased posterior tibial slope and ACL insufficiency.

METHODS: All patients who underwent single-level sagittal plane correction anterior closing wedge high tibial osteotomy (ACW HTO) with patient specific instrumentation (Bodycad, Quebec City, Canada) performed at two tertiary orthopaedic centers between September 2021 and September 2024 were eligible for study inclusion. Patients who underwent coronal plane correction osteotomies or dual level osteotomies were excluded. All included patients underwent preoperative and postoperative weight-bearing lateral knee radiographs at a minimum of 3 months postoperatively. Patients without complete preoperative and postoperative imaging were excluded. Preoperative and postoperative CT-based measurements of medial posterior tibial slope (mPTS) were obtained from the PSI preoperative plan. Preoperative and postoperative radiograph measurements of mPTS were performed by two independent reviewers. mPTS was measured on short leg lateral knee radiographs using a line tangent to the medial tibial plateau and the tibial proximal anatomical axis, defined as a line passing through the center of two circles 5 cm and 10 cm distal to the joint line which are aligned with the anterior and posterior tibial cortices. Means with 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 mPTS. Paired samples t-tests were used to compare means of mPTS between 3D CT data and radiographic measurements. Cutoffs of +/- 1 degree, +/- 2 degrees, +/- 3 degrees and +/- 5 degrees relative to the planned postoperative 3D CT mPTS were used to assess correction accuracy

RESULTS:

A total of 36 patients were included in this study. Patient characteristic data is found in **Table 1.** Median age was 31 years (range: 18 - 51) and 58% of patients (n = 21) were female. The mean preoperative mPTS measured on 3D CT data was 14.9 degrees and the mean preoperative mPTS measured on radiographs was 12.9 (difference of means = 2.1, 95% CI: 1.1-3.1), $p < 0.001$). ICC score for interrater reliability of preoperative mPTS measurements on radiographs was 0.93 (95%CI: 0.87-0.96). The mean postoperative mPTS planned on 3D CT data was 8.1 and the mean postoperative mPTS measured on radiographs was 6.7 degrees (difference of means = 1.0, 95%CI: 0.04–2.1), $p = 0.04$). When comparing postoperative mPTS measured on radiographs with the planned postoperative mPTS on 3D CT data, 34%, 62%, 71% and 88% of patients had a final measured mPTS on postoperative radiographs within 1 degree, 2 degrees, 3 degrees and 5 degrees of the planned 3D CT mPTS, respectively (**Figure 1; Table 2)**.

DISCUSSION AND CONCLUSION:

The results demonstrate a high degree of accuracy of anterior closing wedge high tibial osteotomies using PSI for addressing increased posterior tibial slope in the setting of ACL insufficiency, with > 60% of patients corrected to within 2 degrees and >70% of patients corrected to within 3 degrees of the planned 3D CT mPTS. When comparing the preoperative mPTS measured on 3D CT data versus short leg lateral radiographs, the 3D CT data demonstrated consistently higher mPTS measurements. This discrepancy is likely related to the use of full length tibia measurements in the 3D CT data compared to the short leg lateral radiographs often used clinically for measurement of mPTS preoperatively. Surgeons performing sagittal plane correction osteotomies should be aware of this discrepancy and further research is required to compare mPTS on 3D CT data versus full length lateral tibia radiographs, as this may provide a more consistent intermethod measurement between the two modalities.

Table 1: Patient characteristics.

Characteristic	N = 36
Sex, n (%)	
Male	15 (42%)
Female	21 (58%)
Age, median (range)	31 years (18 – 51)
Laterality, n (%)	
Left	19 (53%)
Right	17 (47%)

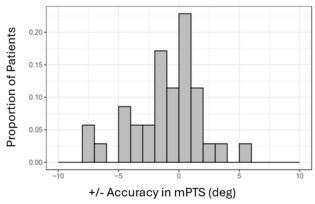

Figure 1. Histogram demonstrating the proportion of patients within each accuracy category.

Table 2: Percentage of patients meeting accuracy cutoffs.

Accuracy Range	N (total = 36 patients)	% patients within accuracy range
+/- 1 deg	12	34%
+/- 2 deg	22	62%
+/- 3 deg	25	71%
+/- 5 deg	32	88%