

Intraoperative Fluoroscopic Distortion in Tibial Shaft Fractures: Does it Matter?

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Introduction: Intraoperative fluoroscopy is regularly used by orthopaedics surgeons in trauma cases to enhance surgical decision making. Though most orthopaedic trauma surgeries involve the use of intraoperative fluoroscopy, studies have shown that these images suffer from distortion. Distortion is an occurrence that alters the patient's true anatomy in image-intensified radiography; therefore, leading to potential complications, such as undersized or oversized orthopaedic implant placement. The primary purpose of this study is to quantify the amount of error caused by distortion in intraoperative fluoroscopic images of patients who underwent tibial intramedullary nail (IMN) insertion between multiple operating rooms (ORs) at a single Level 1 Trauma Center. Secondary aims included evaluation of associations between total distortion and patient demographics, OR number, weekday of operation, and fracture characteristics. We hypothesize that there will be a significant difference in angle measurements between intraoperative fluoroscopic and postoperative flat plate radiographs.

Methods: The study is a retrospective cohort chart review using Level I Trauma Center Registry data from January 2021 through May 2022 at a single institution. The Trauma Registry database was queried for patients sustaining tibial shaft fractures resulting in 137 patients. Inclusion criteria included patients who are greater than 18 years old, skeletally mature and underwent tibial IMN insertion. Exclusion criteria included patients who had tibial shaft fractures that extended into the ankle joint, inadequate radiographs, or previous ankle surgery on the ipsilateral side of the tibial shaft fracture. Intraoperative fluoroscopic images as well as postoperative radiographs, specifically of the anterior posterior (AP) ankle, were used to calculate measurements. The intraoperative fluoroscopic image and postoperative radiograph represented the distorted and non-distorted image, respectively. Lateral distal tibial angle (LDTA) was calculated from the AP ankle of the two radiographs and were compared. LDTA angles were evaluated by three independent readers, who are current orthopaedic surgery resident physicians that have completed medical school and at least three years of residency training. T tests were calculated utilizing Microsoft Excel. This study was approved by the University Medical Center (UMC) Institutional Review Board (IRB).

Results: A total of 137 tibial shaft fractures (135 patients) were included for initial review. The three independent readers collectively decided that 18 of the patients had an inadequate radiograph; therefore, these patients were excluded. Six patients didn't have a postoperative radiograph and were also excluded. Thus, 113 tibial shaft fractures (111 patients) were available for review. The average age of patients included in the study was 39.8 (19-83) years old. In regards to sex, there were 78 (69.0%) males compared to 35 (31.0%) females included in the study. There was a statistically significant difference in the Distorted and Non-Distorted LDTA between all readers as well as average of the readers measurements ($p < 0.05$). The Net LDTA, the Non-Distorted LDTA subtracted from the Distorted LDTA, represented the amount of distortion. Reader 1's average Net LDTA between the tibial shaft fractures was measured as 2.33° with a range of 0° - 8.6° . Reader 2's and 3's average Net LDTA was 2.95° (0° - 11.1°) and 2.98° (0.1° - 10.9°), respectively. Averaging the three readers average Net LDTA demonstrated an overall average Net LDTA as 2.75° . 17 tibial shaft fractures average Net LDTA between the three readers exceeded 5° . The mean Net LDTA for each operating room was statistically significant ($p < 0.05$). Since a majority of the cases were completed in OR 17, the orthopaedic trauma OR, this was utilized as the reference OR. There was no statistically significant difference in mean Net LDTA for OR 17 compared to the other ORs ($p = 0.85$). Laterality, left compared to right tibial shaft fracture, had a statistically significant difference in average Net LDTA ($p < 0.05$). There was no statistically significant difference in average Net LDTA in relation to day of the week ($p = 0.15$), open fracture ($p = 0.55$), mechanism of injury ($p = 0.77$), and fracture location ($p = 0.95$).

Discussion: Although distortion of intraoperative fluoroscopy is a documented error in the literature, there remains limited studies quantifying this error. This study identified differences in angles, specifically LDTA, measured between the distorted and non-distorted images. This study confirmed our hypothesis as there was a statistically significant difference in Distorted and Non-Distorted LDTA. Average degree measurements have been outlined to quantify the level of distortion. There has been one study in the orthopaedic literature that quantifies distortion in arthroplasty. Carlson et al. describes how the combined vertical distortion during direct anterior total hip arthroplasty was measured to be 10.0 (range 2-20) mm.¹ Our study describes similar findings by quantifying distortion in the trauma setting. Orthopaedic surgeons performing surgeries that require fluoroscopy will have insight into how distorted their intraoperative images are. The knowledge of quantified distortion can help prevent these surgeons from complications described in the introduction, such as undersized and oversized orthopaedic implant placement. Though quantifying distortion is helpful for future surgeries, there is a need for technological advancements that eliminate distortion with intraoperative images. Future studies can assess the accuracy of these technological advancements.

Significance/Clinical Relevance: This study will provide orthopaedic surgeons with the knowledge of how distorted intraoperative images from C-arm fluoroscopy truly are, allowing them to make adjustments as necessary. Additionally, it calls for technological advancements to be made for improved accuracy and trust of intraoperative images.

References:

1. Carlson VR, Elliott IS, DeKeyser GJ, Pelt CE, Anderson LA, Gililland JM. Are We Being Fooled by Fluoroscopy? Distortion May Affect Limb-Length Measurements in Direct Anterior Total Hip Arthroplasty. *J Arthroplasty*. 2021 May;36(5):1799-1803. doi: 10.1016/j.arth.2020.11.021. Epub 2020 Nov 21. PMID: 33303328.