Local Bone Density on Preoperative CT Predicts Failure in Well-Reduced Geriatric Intertrochanteric Hip Fractures

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INTRODUCTION:

Intertrochanteric (IT) fractures continue to be the most common hip fracture with a growing incidence and evolving patient demographic as life expectancy increases. Early fracture fixation failure remains a complication that contributes to the high one-year morbidity and mortality associated with hip fractures. Surgical factors such as tip-to-apex distance (TAD), calcar-referenced TAD (CalTAD), and high-quality fracture reduction are associated with reduced rates of failure following fixation of IT fractures. However, even when these are optimized, failures still occur, and our understanding of contributing factors to these unexpected failures remains cloudy. Hounsfield units (HU) derived from computed tomography (CT) scans are correlated with local bone density, and literature demonstrates that lower HU measurements are predictive of various long bone fractures and fracture fixation failure. To date, there has been limited investigation into the effect of local bone density on outcomes following satisfactory operative fixation of IT fractures. We aimed to characterize the association between local bone density using preoperative CT HU and radiographic outcomes following IT fracture fixation. We hypothesized that decreased local bone density is associated with increased rates of fixation failure in well-reduced geriatric IT fractures.

METHODS:

We retrospectively reviewed low energy IT fractures repaired with a long or short cephalomedullary nail (CMN) among patients aged > 60 years old between January 2017 and March 2024 at a single center. Exclusion criteria were pathologic fractures, periprosthetic fractures, follow up < 6 weeks, and lack of preoperative CT scan. Radiographic variables including anteroposterior (AP) and lateral reduction quality measured as neck-shaft angles, TAD, and CalTAD were collected for each fracture immediately postoperatively and at the latest follow-up between 6 and 24 weeks postoperatively. Fracture shortening (mm) was measured as the difference in percentage of the head screw medial to the CMN between immediate postoperative and follow up AP hip radiographs, multiplied by the length of the head screw, as previously described. Local bone density was measured as average femoral head HU using a spherical region of interest (ROI) at the superior head-neck junction on preoperative CT scan of the affected hip, as previously described. Fixation failure was defined as non-physiologic shortening > 8mm or varus angulation > 10º between radiographs. A simple linear regression of shortening on local bone density was completed. Two-sample t-tests and the Mann-Whitney U test were used to compare average local bone density between patients who experienced failure and those who did not. Various cutoff points to predict shortening between low and high local bone density groups were analyzed using two sample t-tests.

RESULTS: 107 patients (75F, 32M) aged 79.3 ± 9.7 years with a BMI of 26.3 ± 6.6 kg/m^2 with AO/OTA 31A IT fractures were included for analysis. The average length of follow up between analyzed radiographic measures was 94.5 ± 36.0 days. All fractures were well-reduced with a neck-shaft angle of 125-140° and TAD or CalTAD < 25mm on immediate postoperative radiographs. 34 patients experienced non-physiologic shortening, and 10 patients experienced varus collapse. The average local bone density among 107 fractures was 191.8 ± 63.2 HU. Average local bone density was significantly lower among patients who experienced fixation failure than those who did not (163.7 HU vs. 207.3 HU, $p<0.01$). A simple linear regression revealed a significant negative relationship between local bone density and shortening ($R^2 = 0.080$, $p<0.01$) (Figure 1). When using different theoretical HU cutoff points to compare shortening in low and high local bone density groups, HU of 150 predicted shortening between the two groups (Table 1).

DISCUSSION AND CONCLUSION: There remains a subset of patients that experience hardware failure and/or loss of reduction despite optimization of modifiable surgical variables. Our data demonstrates a clear relationship between local bone density and fixation failure following surgical repair of well-reduced geriatric IT fractures. Further, we demonstrate a potential cutoff of 150 HU measured on routine preoperative hip CT as a significant predictor of shortening within 24 weeks of surgery. Our data allow the clinician to more accurately assess surgical risk and identify patients that may benefit from supplemental fracture fixation.

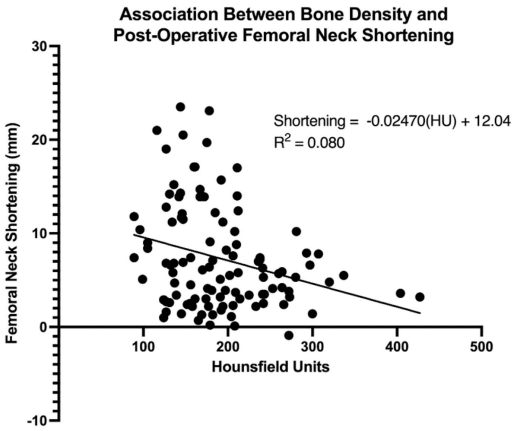

Figure 1: A simple linear regression reveals a significant negative relationship between preoperative local bone density and amount of postoperative shortening.

Table 1: Comparison of average shortening between high and low local bone density groups with different theoretical Hounsfield Unit (HU) cutoff points to define each group

HU Cutoff Point	Number of Patients in High HU Group	Number of Patients in Low HU Group	Difference in Mean Shortening (mm) (high HU - low HU group)	p-value
130	93	14	-1.45	0.36
140	84	23	-1.25	0.34
150	75	32	-3.24	<0.01
160	70	37	-2.28	0.04
170	63	44	-2.77	0.01
180	53	54	-3.24	<0.01
190	49	58	-3.08	<0.01
200	41	66	-2.96	<0.01