

Predicting Proximal Humerus Fracture Mechanical Complications: Are Computed Tomography Hounsfield Units the Answer?

Nina Douglas Fisher¹, Andrew Sheng Bi², Steven Rivero, Nirmal C Tejwani³, Joseph D Zuckerman⁴, Kenneth A Egol⁴
¹NYU, ²NYU Langone Health, Department of Orthopedic Surge, ³NYU LANGONE HEALTH, ⁴NYU Langone Medical Center

INTRODUCTION:

Tissue density can be approximated using a region of interest (ROI) on modern computed tomography (CT) scans, quantifying the standardized linear attenuation coefficient of tissue using Hounsfield units (HU). HU are defined on a normalized scale from -1000 (defined for air), to 0 (defined for water at standard pressure and temperature), with metal typically measuring greater than 5000 HU. Common in preoperative planning for spine surgery, the purpose of this study was to determine if CT HU can predict postoperative complications following operative treatment of proximal humerus fractures.

METHODS:

A total of 149 patients with proximal humerus fractures who underwent operative fixation at single institution between July 2013 and January 2023 were identified. Of this cohort, 66 (44.3%) had CT scans available. Demographic, injury, and operative information was collected from chart review. Radiographic measurements included the deltoid tuberosity index (DTI) on preoperative antero-posterior (AP) shoulder radiographs, and the HU value from the operative proximal humerus was determined by measuring the humeral head at the mid-axial, mid-coronal, and mid-sagittal CT image of widest diameter using a circle-type region of interest (ROI; $\geq 35 \text{ mm}^2$). Measurements were performed by two independent authors, twice in each proximal humerus, and the average value of the two tests was calculated. Postoperative complications recorded were hardware failure (including plate pull-out and screw penetration/cutout), development of avascular necrosis, nonunion, and acute periprosthetic fracture. Patients with and without complications were statistically compared, and binary logistic regression was performed to determine if preoperative proximal humerus CT HU were predictive of complications.

RESULTS:

The 66 included patients had an average age of 63.8 \pm 12.7 years, with 47 (71.2%) females. Eight (12.1%) patients developed 11 overall complications, with 3 patients experiencing multiple complications each; complications included avascular necrosis (4), hardware failure (5), nonunion (1), and acute periprosthetic fracture (1). All-cause reoperation rate was 12.1% (3 revision ORIF, 5 conversion arthroplasty). There was no difference in age, sex, CCI, BMI, smoking status, Neer classification, AO/OTA classification, number of screws in the head, or use of calcium phosphate between those with and without complications (**Table 1**). With respect to radiographic parameters, patients with complications had significantly lower DTI and overall HU as well as HU in the coronal and sagittal planes (**Table 1**).

DISCUSSION AND CONCLUSION:

CT HU can identify patients with poorer bone quality and thus help predict proximal humerus postoperative complications. This information may help determine if certain patients are better served by treatment with an initial shoulder arthroplasty as opposed to attempts at operative fixation.

Table 1.

	Total (N = 66)	No Complications (N = 58)	Complications (N = 8)	Sig.
Age (years)	63.83 \pm 12.7	62.88 \pm 12.7	70.75 \pm 10.8	0.099
Female Gender	71.2% (47)	74.1% (43)	50.0% (4)	0.159
Age-Adjusted CCI	2.47 \pm 1.8	2.33 \pm 1.7	3.50 \pm 2.3	0.083
BMI	27.43 \pm 5.7	27.35 \pm 6.0	28.0 \pm 3.8	0.124
Current Smoker	7.5% (5)	8.9% (5)	0.0% (0)	0.543
DTI Average	1.45 \pm 0.1	1.46 \pm 0.1	1.35 \pm 0.1	0.024
HU Axial	105.16 \pm 48.1	108.97 \pm 47.4	78.01 \pm 50.6	0.091
HU Coronal	109.48 \pm 51.9	115.85 \pm 51.8	64.08 \pm 29.4	0.004
HU Sagittal	103.44 \pm 51.8	108.49 \pm 51.4	67.49 \pm 45.7	0.018
HU Total Average	106.03 \pm 48.6	111.11 \pm 48.3	69.86 \pm 39.9	0.012
Neer	2-part: 25.8% (17) 3-part: 45.5% (30) 4-part: 28.8% (19)	2-part: 27.6% (16) 3-part: 46.6% (27) 4-part: 25.9% (15)	2-part: 12.5% (1) 3-part: 37.5% (3) 4-part: 50.0% (4)	0.338
AO/OTA	11A: 24.2% (16) 11B: 42.4% (28) 11C: 33.3% (22)	11A: 25.9% (15) 11B: 43.1% (25) 11C: 31.0% (18)	11A: 12.5% (1) 11B: 37.5% (3) 11C: 50.0% (4)	0.515
# of Screws in Head	6.00 \pm 0.674	6.00 \pm 0.7	6.00 \pm 0.5	1.000
Calcium Phosphate	53.0% (35)	51.7% (30)	62.5% (5)	0.426

Abbreviations: CCI = Charlson Comorbidity Index, BMI = body mass index, DTI = deltoid-tuberosity index, HU = Hounsfield units