Intraoperative Bone Quality Assessment by Orthopaedic Surgeons Compared to Quantitative Measurement by Computed Tomography

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INTRODUCTION:

Bone quality and bone mineral density (BMD) are of particular interest to orthopaedic surgeons who may adjust surgical planning and patient counseling based on a patient's bone characteristics. Low BMD (e.g., osteopenia, osteoporosis) is typically diagnosed by Dual Energy X-ray Absorptiometry (DEXA), but few patients presenting for orthopaedic surgery have a DEXA scan available for review. Recently, computed tomography (CT) data including Hounsfield units (HU) have been used to extrapolate BMD measures suggesting excellent correlation to established gold standards. Surgeons also informally, qualitatively evaluate intraoperative bone quality based on tactile feedback and visual clues. The accuracy of these clinical assessments of bone quality are poorly studied. The purpose of this study is to assess the accuracy of surgeons' intraoperative bone quality assessments compared to quantitative bone density evaluation using incidental CT data.

METHODS:

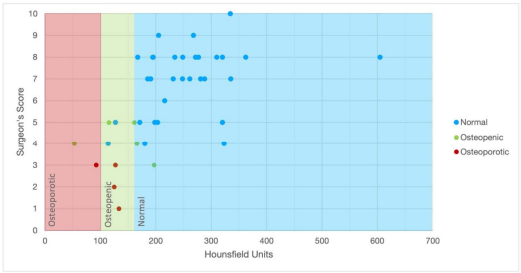
A prospective study of operatively treated orthopaedic patients at an urban Level I trauma center was performed over seven months (November 2023 - May 2024). Eligible patients were skeletally mature adults undergoing surgical treatment who had incidental CT scans of a body location with validated HU assessment within six months of surgery. Surgeons were blinded to objective CT data and were independently asked to assess bone quality intraoperatively. A bone quality score (10-point scale, 10 = best quality) and a classification of "normal," "osteopenic," or "osteoporotic" were recorded by the study team. A fellowship-trained surgeon from the study team performed a blinded review of CT scans data using institutional PACS system for all enrolled patients. For each patient, 3 measurements of HU using a standardized approach based on validated techniques were performed and averaged. Patients were classified based on the standard of HU <100 osteoporotic, 100-160 osteopenic, and >160 normal. Patients' demographic information was collected from the medical record. Statistical analysis consisted of descriptive statistics and linear regression.

RESULTS:

A total of 69 adults were enrolled, with a mean age of 47 years (range 18 to 92 years). 41 (59%) were male. Validated HU units were calculated from CT scans including the following locations: lumbar spine (52), calcaneus (9), femoral neck (3), and glenoid (5). Primary surgical sites included: foot and ankle (20), femur (8), lower leg (9), pelvis and acetabulum (7), humerus (2), and hip (2). Based on CT results, 46 patients had normal bone quality, 12 were osteopenic, 4 were osteoporotic, and 7 were unable to be classified. Subjective surgeon grading of bone quality was correct for 42 (91%) normal patients, 4 (33%) osteopenic patients, and 1 (25%) osteoporotic patient. Of the 12 patients with osteopenia, 5 were incorrectly classified as osteoporotic while 3 were classified as normal. Overall, surgeons demonstrated 91% sensitivity and 81% specificity differentiating normal versus abnormal quality bone. There was a statistically significant positive linear relationship between surgeons' intraoperative bone quality scores and HU on CT (R^2=0.38, $F(1, 67)$=40.57, $p<0.001$). HU significantly predicted surgeon score (β=0.01, $p<0.001$).

DISCUSSION AND CONCLUSION:

This pilot study demonstrates that surgeons' subjective assessment of intraoperative bone quality is both sensitive and specific representing an excellent screening tool for the detection of abnormal bone. This screening test detected reduced bone density with the same or better sensitivity and specificity as DEXA scanning. The ability of surgeons to reliably discern between osteoporotic and osteopenic bone was lower however, which may be due to sample size error. These findings suggest that surgeons can reliably assess bone quality intraoperatively and can consider adjustments or changes to their treatment plan, implant selection, or surgical strategy as a result. Intraoperative bone quality assessment may present a cost-effective and efficient way to identify patients at risk of fragility fracture or in need of bone health referral, minimizing the use of expensive DEXA or CT scans. Further research in larger cohorts is needed to support these findings.


Surgeon's Score
Hounsfield Units
Osteoporotic
Osteopenic
Normal
Normal
Osteopenic
Osteoporotic