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# Analysis of mortality and fixation failure in geriatric fractures using quantitative computed tomography

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ABSTRACT

*Objectives:* While osteoporosis has been shown to be a contributing factor in low energy fractures in the elderly, limited data exists regarding the correlation of bone mineral density (BMD) and T-Scores to mortality and failure of fracture fixation. This study seeks to determine the relationship between femoral neck BMD in elderly patients with typical geriatric fractures and mortality and fracture fixation failure using Quantitative Computed Tomography (QCT).

*Materials and methods:* Patients over the age of 65 who sustained fractures of the proximal humerus, distal radius, pelvic ring, acetabulum, hip, proximal tibia, and ankle who also underwent a CT scan that included an uninjured femoral neck were retrospectively reviewed. QCT was used to assess bone mineral density and T scores. Mortality and fixation failure were recorded. Standard descriptive statistics, as well as logistic regression were used to correlate BMD and mortality, and BMD and fixation failure.

*Results:* Of the 173 patients initially screened, 150 met inclusion criteria. Patients who remained alive at the end of the study (LP) had significantly ($P = .019$) higher adjusted mean femoral neck BMD (0.502 g/cm$^2$) than non-polytrauma patients who died (MNPT) (0.439 g/cm$^2$) when controlling for age, time to mortality, follow up, CCI, and ASA.

Patients who had fixation failure events (FE) had significantly ($P = .002$) lower adjusted mean femoral neck BMD (0.342 g/cm$^2$) than patients without failure events (NE) (0.525 g/cm$^2$) when controlling for age and time to radiographic follow-up.

*Conclusions:* Our study illustrates that QCT is a reliable method for the determination of femoral neck BMD in elderly patients with geriatric fractures. Furthermore, lower BMD/T-Scores are associated with increased mortality and fixation failures in this patient population.



## Introduction

Osteoporosis contributes to thousands of fractures in the elderly each year [1–3]. In 2005 it was estimated that there were greater than 2 million osteoporosis related fractures in the United States, at an estimated healthcare cost of $17 billion [1]. These injuries are not only economically costly but are also often sentinel events regarding patient health. Current literature quotes the one year mortality of hip fracture patients as high as 30% [[1–3],4]. While osteoporosis has been shown to be a contributing factor in low energy fractures in the elderly, limited data exists regarding the correlation of bone mineral density (BMD) and T-Scores to mortality and failure of fracture fixation [[1–3],[1–3]].

Significant effort has been given to developing tools to predict which patients are at risk for sustaining low energy fractures, most of which rely heavily on the early diagnosis of osteoporosis [5–8]. Additionally, given the poor quality of bone associated with osteoporotic fractures, several studies have looked into how best to optimize fixation in osteoporotic patients sustaining low energy fractures [9–11]. However, limited data exists demonstrating that decreased bone mineral density is associated with increased failure of fracture fixation. Furthermore, while there is a great deal of literature documenting the increased fracture risk of osteoporotic patients, there is little data to support low bone mineral density as an independent marker of frailty and predictor of mortality in geriatric fracture patients [5–8].

Treating osteoporosis is key to improving outcomes; however, obtaining DEXA scans to document osteoporosis and its severity can often be difficult to acquire in the inpatient setting following a fracture and is often overlooked during follow up [12]. Quantitative Computed Tomography (QCT) software has been developed to

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allow for the derivation of femoral neck BMD from conventional CT scans, allowing for rapid determination of T-Scores without the need of formal DEXA scans [13–15]. Previous studies have demonstrated the accuracy of QCT when compared to conventional DEXA scanning with regards to determining bone density [13–15]. This is particularly useful in patients who have obtained CT scans of the pelvis as part of a trauma workup as those images could theoretically be used for analysis without further radiation exposure. This technique has been used in a laboratory setting to obtain bone mineral density, however, its use in a clinical setting has been limited [13].

The goals of our study are to determine: 1) if using QCT is a feasible method for obtaining BMD for inpatients, 2) if a correlation exists between low BMD and mortality of elderly patients sustaining typical fractures, and 3) if low BMD is a risk factor for fixation failure in operatively treated geriatric fractures. We hypothesize that using QCT software will allow for reliable determination of bone mineral density and that low BMD will be associated with increased mortality and failure of fixation. This study was approved by our Institutional Review Board (IRB).

**Table 1**
Demographic data, and data regarding various fractures in the study.

| | |
|---|---|
| Demographics | |
| Number | 150 |
| Age (Mean and SD) | 82.13 (8.97) |
| Gender (M:F) | 54:96 |
| BMD (mean g/cm2 and SD) | 0.490 (0.010) |
| T Score (mean and SD) | −2.747 (1.124) |
| | |
| Fractures | |
| Proximal Humerus | 2 |
| Distal Radius | 14 |
| | |
| Pelvic Ring | |
| LCI | 45 |
| LCII | 4 |
| LCIII | 1 |
| Acetabulum | 16 |
| | |
| Hip | |
| Valgus impacted femoral neck | 3 |
| Displaced femoral neck | 24 |
| Intertrochanteric | 35 |
| Subtrochanteric | 4 |
| Greater Trochanter | 6 |
| Proximal Tibia | 4 |
| | |
| Ankle | |
| Medial Malleolus | 1 |
| Lateral Malleolus | 1 |
| Bimalleolar | 7 |
| Trimalleolar | 4 |
| Distal Tibia/Plafond | 2 |

Note: some patients had more than one fracture included.

## Methods

### *Data collection*

Following IRB approval, a retrospective review of our institution's trauma registry was conducted to identify patients ≥65 years of age who sustained common fractures afflicting geriatric patients including fractures of the proximal humerus, distal radius, pelvic ring, acetabulum, proximal femur, proximal tibia, and ankle. All patients who met these criteria and underwent a CT scan within 30 days of injury featuring an intact femoral neck for analysis were included. Plain radiographs and CT scans of all study patients were individually reviewed to confirm diagnoses and presence of a complete scan.

Exclusion criteria included poor quality CT scans, patients without fractures listed in inclusion criteria, and any barriers to accurate QCT analysis such as femoral neck bone tumors, Paget's disease, bilateral femoral neck fractures or hardware. Age, gender, injury, associated injuries, surgical intervention (if applicable), maximum follow up, surgical failures, mortality, time from injury to death (if applicable), Charlson Comorbidity Index (CCI), and American Society of Anesthesiologists (ASA) score were all recorded. Most patient demographic and historical data was gleaned from the institution's electronic medical record which has been in place since the start date of the study (Table 1).

For the mortality analysis, patient mortality status was confirmed by reviewing publically available obituary data. Each patient was individually queried using demographic information such as name, birthdate, location of residence, etc. All patients had at minimum 90 days from injury date to mortality review ensuring 30-day and 90-day mortality data for all patients. Patients in this analysis were considered to have "polytrauma" if in addition to their study fracture they sustained any of the following: Multiple fractures (>1) requiring fixation, major arterial injury, thoracic trauma, intra-abdominal trauma, intra-cranial trauma, and cervical spine injuries. Since polytrauma is a well-described risk factor for mortality and a substantial confounder, all patients in the mortality group who sustained polytrauma were excluded from final analysis [16]. Polytrauma patients in the living group were not excluded from final analysis as polytrauma would not be considered to improve survival.

For the fixation failure analysis, follow up radiographs were obtained from electronic medical records and reviewed for all patients who underwent operative fixation of their fractures. Fixation failures were defined as substantial loss of reduction, implant cut out, implant breakage (excluding auto-dynamization of interlocking screws), nonunion, malunion, or need for revision fixation. Only patients with at least four weeks of radiographic follow up were included in the analysis.

In order to obtain BMD data on all study patients, the institution's CT scanners were calibrated to QCT software utilizing a phantom of known density (Model 4 CT Calibration Phantom, Mindways, Austin, TX). The CT scans of each patient were reviewed for completeness to ensure axial cuts through the pelvis with at least one intact femoral neck were available for analysis. The CT scan DICOM files were then converted to a format that is readable by the QCT software using an included conversion tool (QCT Pro Version 6.1, Mindways, Austin, TX). Each scan was then individually analyzed to reveal femoral neck BMD in g/cm$^2$ and T-Score (Fig. 1).

### *Statistics*

ANCOVA with Tukey's Honest Significance Test and Dunnett's Two-Sided Test was used to examine the relationship of femoral neck BMD and, separately, T-Score to mortality and fixation failure, respectively. Logistic regression analysis was then used to confirm results (XLSTAT, Addinsoft, New York, NY). For mortality analysis, age, time to mortality follow up, CCI, and ASA score were controlled for as potential confounders. In the fixation failure analysis, age and time to radiographic follow up were controlled for as potential confounders. Statistical significance was set to $p < .05$ *a priori*. Post-hoc power analysis was performed for both the mortality and fixation failure ANCOVA investigations.

## Results

### *Demographics*

Of the 171 patients initially screened for the study, ten could not be analyzed due to hardware or fractures obscuring the femoral