



Can osteoporosis or osteopenia be confidently suggested by femoral neck hounsfield units on computed tomography?

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OBJECTIVE:

The objective of this study is to determine if Hounsfield units (HU) of the femoral necks, a standardized computed tomography attenuation coefficient, correlate with T-score values obtained by DEXA scan.

INTRODUCTION:

Osteoporosis is a systemic skeletal disease that is characterized by low bone densities and architectural osseous deterioration with a subsequent fragility. There are more than 100 million people affected by osteoporosis worldwide². Half of all postmenopausal women will have an osteoporosis-related fracture during their lives, including 15% who will suffer a hip fracture². Hip fractures are associated with high mortality rates and loss of independence.

The gold standard exam for bone mineral density quantification is Dual-energy X-ray absorptiometry (DEXA). This has become a routine screening exam in modern medical practice.

Recent studies have raised the possibility to estimate bone mineral density using diagnostic computed tomography (CT) images¹². This study investigates whether there is a correlation between the T-scores of DEXA scans and the HU values obtained from CT. Based on this work, we may be able to use CT evaluations to screen patients with bone mineral disease, and possibly evaluate their risk of hip fracture.

METHODS AND MATERIALS:

Patients

This is a retrospective study reviewing seventy-three female patients that were older than forty-years of age, with both a CT scan of the pelvis and a DEXA scan. These studies were performed within a minimum of 2-years from each other. Patients who underwent prior spinal or hip surgeries or had invalid DEXA results due to spinal degeneration, fracture, or deformity were excluded from the study. Of the seventy-three female patients, thirty-eight had abnormal DEXA scans. Twenty-five females were classified as osteopenia and thirteen as osteoporosis.

Imaging

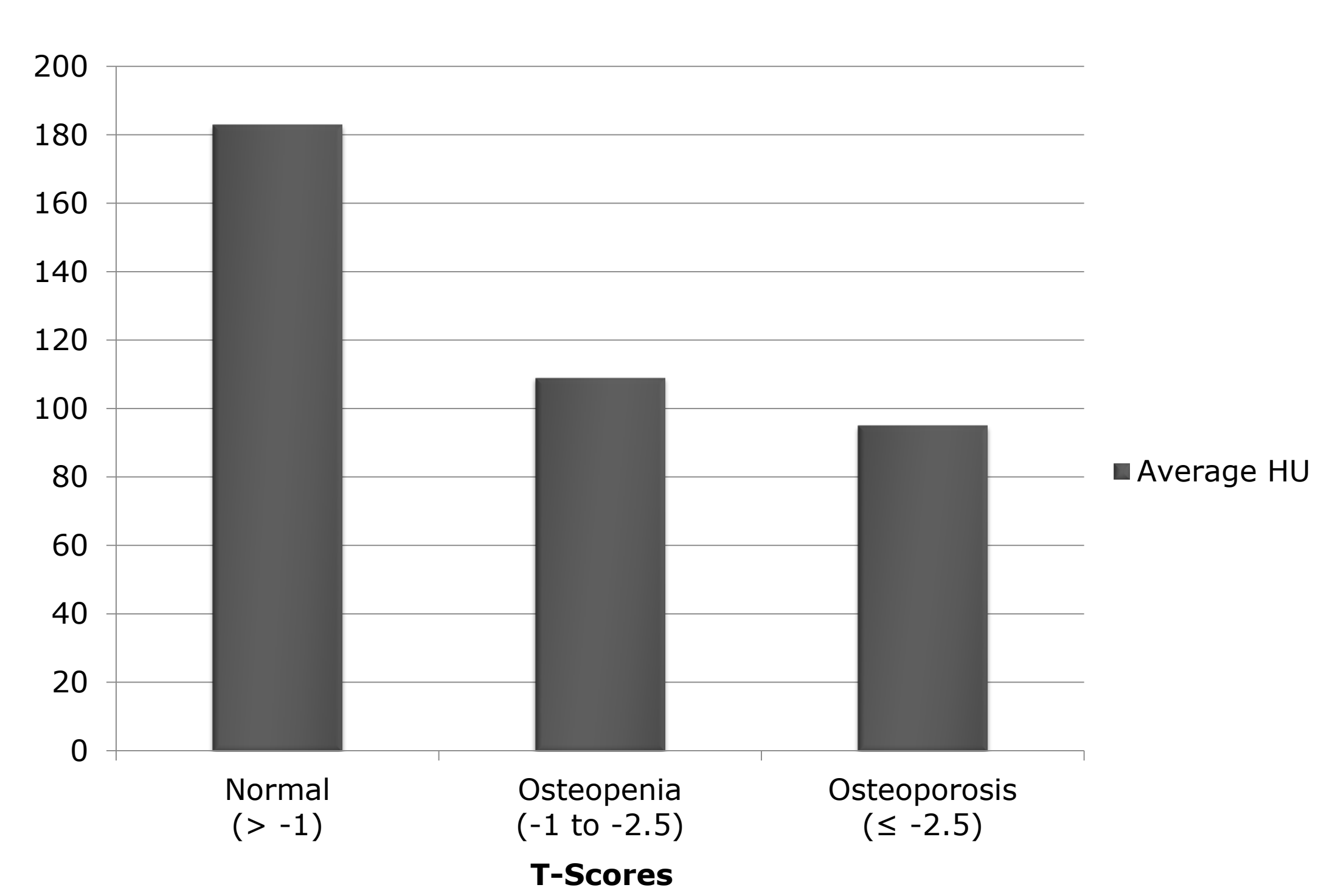
DEXA T-scores were obtained from the bilateral femoral necks and averaged; giving each patient an overall T-score value.

CT parameters included a slice thickness of 5 mm with a helical 64-slice General Electric LightSpeed VCT scanner. Regions of interest were measured at the inferior, middle, and superior axial sections through the femoral neck. To prevent volume averaging with measurements, the largest possible circular region of interest was drawn without involving the cortical margins. These three values were averaged to a mean HU value for each femoral neck. Subsequently, the two femoral necks were averaged to a mean HU for each patient, which we use to represent their overall femoral neck density. During the measuring, the observer was blinded to the patients accompanying DEXA scores.

Statistical analysis

The correlations of HU value with both age group and DEXA T-score results was determined and tabulated.

RESULTS:



The results are charted in the corresponding tables, which show a significant difference between the hounsfield units of patients with an abnormal DEXA versus a normal DEXA scan. There is less specificity between the patients with osteopenia and osteoporosis.

DEXA scan T-score with corresponding average femoral neck HU in ROI (± stdv)

T-Score classifications			
Age	Normal (> -1)	Osteopenia (-1 to 2.5)	Osteoporosis (≤ -2.5)
40-49	221 ± 23 HU	152 ± 52 HU	None in age range
50-59	184 ± 15 HU	133 ± 31 HU	102 ± 6 HU
60-69	177 ± 18 HU	108 ± 18 HU	94 ± 22 HU
70-79	154 ± 62 HU	97 ± 10 HU	98 ± 16 HU
> 80	149 ± 45 HU	78 ± 14 HU	75 ± 13 HU



Osteoporosis bone density scan
48-year-old female
CT bilateral femoral neck HU average 72.4



Osteopenia bone density scan
51-year-old female
CT bilateral femoral neck HU average 102.8

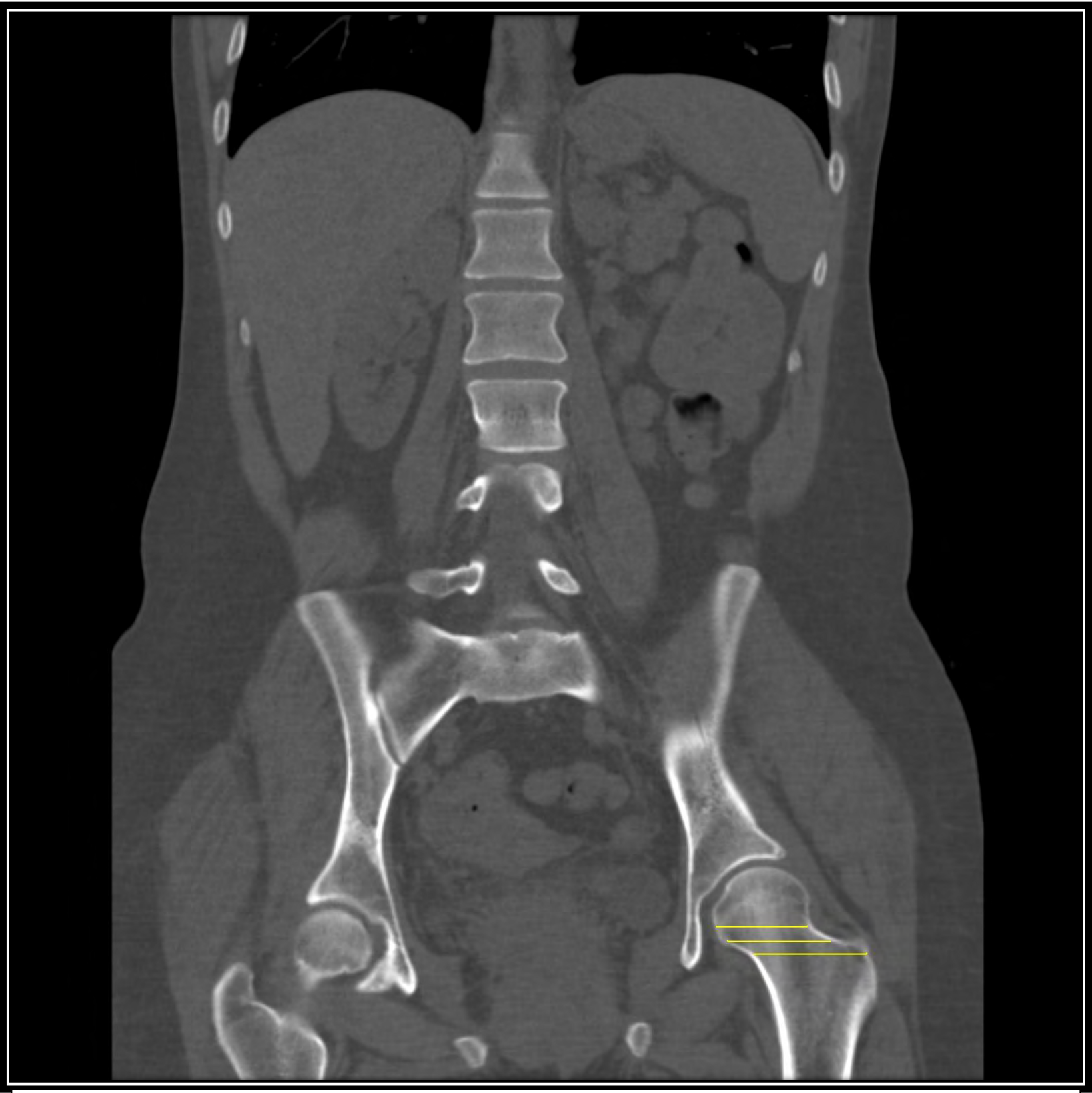
DISCUSSION:

This study suggests that the bone mineral density measurement provided by DEXA has a linear relationship with the HU value obtained by CT. On this basis, and in all appropriately calibrated and utilized CT scanners, specific portions of the CT image can be assigned a HU value with validity and reproducibility. Prior research has shown that increased HU values correlate linearly with an increase in material density. This study shows that HU values follow this trend, but also appear to decrease with patient age and are linked with T-score values.

To establish a diagnosis of osteoporosis physicians use DEXA-based T-scores that are defined by the number of standard deviations below the mean peak bone mass (average mass of young healthy adults). HU values were found to be associated with T-scores in this study. Thus, a patient's HU value may provide a physician with a likely diagnosis of osteoporosis or osteopenia in their patients. This could encourage physicians to undertake further studies, including DEXA, as well as properly tailoring their treatments. This could decrease risk for future hip or vertebral body fracture with the appropriate treatments.

CT Scans are one of the most popular diagnostic tools in modern medical practice. A remarkable amount of CT abdomen/pelvis studies are being performed at institutions nationwide. Also, multiple other protocols have the potential to cover the femoral necks, including CT pelvis, lumbar spine, and hips. Thus, CT provides much more data for use in the evaluation of bone mineral density due to its common use in practice for other indications. Patients often could be evaluated without any additive costs. According to this study, a patient with an average femoral neck HU value less than 120 has a high probability of osteopenia or osteoporosis.

This study has several limitations. First, the data obtained was only for female patients aged over 40 years. This will bias the information so it cannot be accurately extrapolated to other population groups. Secondly, the maximum two-year interval between the CT and DEXA may have influenced the results while the patients were on treatment for osseous demineralization or suffering from an endocrine disorder that affects bone mineral density. Thirdly, cancellous bone is very heterogeneous and the three axial sections obtained may not accurately summarize the bone quality.



Normal bone density scan of a 44-year-old female
CT bilateral femoral neck HU average 211
Axial sequences below with reference lines on the coronal reformat



CONCLUSION:

There is strong supporting evidence that CT imaging can be used to infer the diagnosis of osteoporosis or osteopenia, which would secondarily lower overall patient radiation exposure and/or cost. This could help identify patients with osseous demineralization who may not otherwise have a DEXA scan; and prevent future fracture or other comorbidities by allowing early treatment and further workup.

Further research with larger subject populations are needed. With a statistically significant dataset, CT hounsfield unit criteria could be implemented to formally diagnose osteoporosis or osteopenia.

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