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Sensitivity of bone mineral density measurements to axial rotations and scan analysis in dual energy x-ray absorptiometry of the lateral distal femur

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Sensitivity of Bone Mineral Density Measurements to Axial Rotations and Scan Analysis in Dual Energy X-Ray Absorptiometry of the Lateral Distal Femur

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INTRODUCTION

- Dual energy x-ray absorptiometry (DXA) is the current standard for measuring bone mineral density (BMD) as it offers quick scan times with low radiation dose
- When scanning the hip or spine of non- or minimally-ambulatory patients, surgical implants or severe contractures can limit the ability to produce accurate and repeatable measures for tracking BMD over time
- The lateral distal femur is being studied as an alternative scanning location, particularly in pediatric patients, to avoid these problems[1] (Fig. 1)

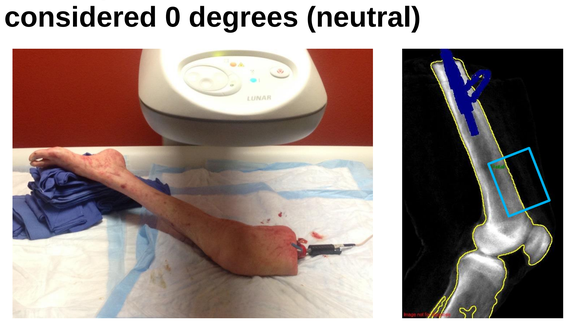
Figure 1: Current method of positioning pediatric patients for lateral bone mineral density scanning of the distal femur.

PURPOSE

- To determine the sensitivity of BMD measurements using DXA in a cadaveric study: i) due to the effect of axial rotations of the femur that occur when positioning the patient; and ii) due to the effect of selecting the region of interest (ROI) when analyzing the DXA scan

METHODS

- Eight fresh frozen cadaver legs from mid-femur to foot were used in this study
- The femoral canal was fitted with a 9-axis orientation sensor to measure axial alignment (Fig. 2A)
- The femur is positioned lateral side down on the DXA table, considered 0 degrees (neutral)



A B

Figure 2: A. Cadaver set-up for achieving axial rotations of the distal femur. B. Region scanned by DXA with a region of interest selected to encompass the anterior portion of the lateral distal femur.

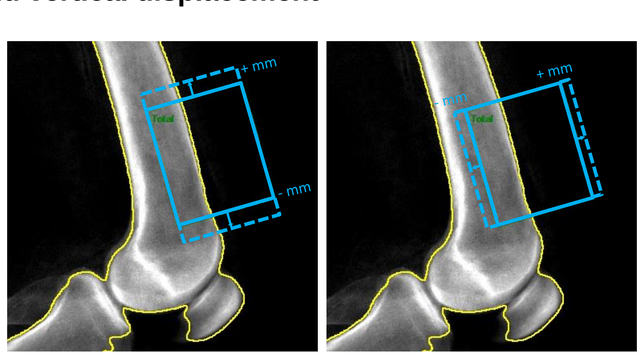
METHODS

To determine the effects of axial rotation:

- Specimens were then scanned at 0, 1, 2, 5, and 10 degrees of internal and external rotation using a GE Healthcare Lunar iDXA System
- The DXA scan was analyzed using a region selected following the protocol by Henderson et al [2] (Fig. 2B)
- A paired t-test with significant level of 0.05 was used to determine a difference between the neutral position and each axial rotation (+/- 1, 2, 5, 10)

To determine the effects of ROI selection:

- The ROI was translated in a vertical direction by +/- 1, 2, 3, 4, and 6 mm from the initial position (Fig. 3A)
- The ROI was translated in a horizontal direction by +/- 1, 2, 3, and 4 mm from the initial position (Fig. 3B)
- A paired t-test was used to determine a difference between the initial ROI position and each horizontal and vertical displacement

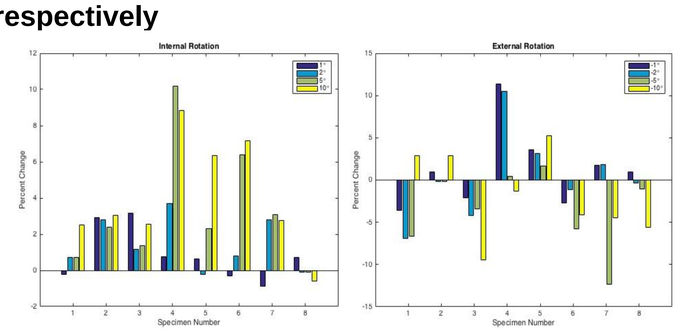


A B

Figure 3: One-directional translation (dashed lines) of the region of interest from the initial position (solid line) in the A. vertical, and B. horizontal directions.

RESULTS

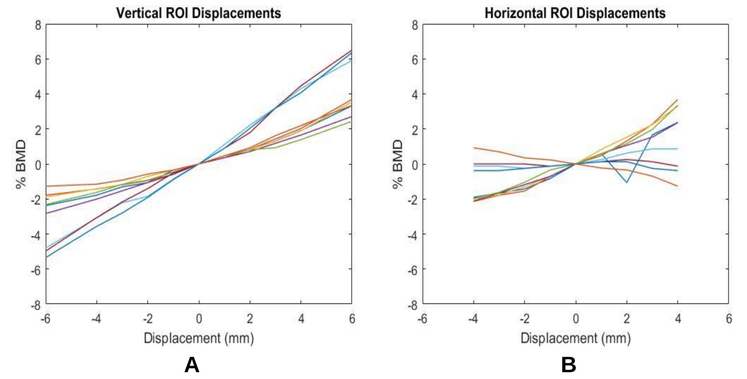
- A significant difference in percent change in BMD was found between the neutral position and 2, 5 and 10 degrees of internal rotation (p=0.04, p=0.05, p=0.01, respectively)
- No significant difference in BMD was found between the neutral position and any of the external rotations
- Mean percent change in BMD was 2.4+/-0.89% and 0.88+/-0.22% for internal and external rotation, respectively



A B

Figure 4: Percent change of BMD for each specimen at each degree of A. internal rotation, and B. external rotation.

RESULTS



A B

Figure 5: Percent change in BMD for each specimen for translations of the region of interest in the A. vertical, and B. horizontal direction.

- A significant difference in BMD was found between the initial ROI position and each of the vertical ROI displacements (all displacements p<0.001)
- No significant difference in BMD was found between the initial ROI position and each of the horizontal ROI displacements
- Mean percent change in BMD was 1.9+/-1.4% and 1.1+/-0.86% for vertical and horizontal displacements, respectively

CONCLUSIONS

- Bone mineral density measurements are affected by the apparent change in projected cross-sectional area caused by axial rotations of the femur and by the positioning of the ROI during scan analysis

CLINICAL RELEVANCE

- Variability in patient positioning and ROI selection by the DXA technician may affect the BMD measures in longitudinal studies of pediatric patients
- This may affect course of treatment defined by the physician
- This study supports the need for a bracing system that can assist with repeatability in patient positioning for longitudinal scans

REFERENCES

- [1] Harcke HT, Taylor A, et al. Pediatr Radiol. 1998;28(4):241-246.
- [2] Henderson RC, Henderson BA,, et al. J Clin Densitom. 2015; 18(1):102-108.

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