Association Between Vitamin D Deficiency and Regional Cortical Thickness in the Distal Radius

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INTRODUCTION: Serum vitamin D is a well-established regulatory hormone in the dynamic remodeling of bone[1], and its deficiency is associated with an increased risk of falls and fractures[2]. Cortical bone thickness (CBT) measured on radiographs is closely correlated with local bone mineral density. This study evaluates the hypothesis that distal radius CBT differs between vitamin D sufficient and deficient patients.

METHODS: A retrospective cohort study was performed on operatively treated distal radius fractures (DRFs) at two tertiary care hospitals between 2013 and 2023. Patient demographics, serum 25-hydroxyvitamin D assay results, fracture mechanisms, and posteroanterior wrist radiographs were collected. Fractures resulting from high- energy mechanisms were excluded. Vitamin D deficiency was defined as a 25-hydroxyvitamin D <20 ng/mL[3]. Radiographs were analyzed using ImageJ software. Capitate length was fixed at 21.65 mm to account for variable image magnification, based on existing literature[4]. CBT was measured at 20, 30, 50, and 60 mm proximal from the most radial aspect of the distal radioulnar joint by subtracting the medullary canal diameter from the total transverse diameter of the radius at each level. Radiographs were excluded if all measurements could not be obtained or if fracture morphology significantly obstructed measurement landmarks. Average CBT (CBTavg) was calculated for the metadiaphyseal transition zone (20 and 30 mm) and the diaphyseal (50 and 60 mm) regions. Second metacarpal percentage (2MCP) was also measured using wrist radiographs. Independent t-tests were used to compare metadiaphyseal transition zone and diaphyseal CBTavg values, and 2MCP, between vitamin D deficient and sufficient patients. Multivariable linear regression models evaluated the relationship between vitamin D deficiency and both CBTavg at each region and 2MCP, adjusting for age and sex. Inter- and intra-observer reliability was evaluated using intraclass correlation coefficients.

RESULTS SECTION: A total of 164 patients met inclusion criteria (mean age 59, 86% female, 45 with vitamin D deficiency). Vitamin D deficient patients had significantly lower metadiaphyseal CBTavg (3.24 ± 0.57 mm vs. 3.46 ± 0.74 mm, p = 0.04), but diaphyseal CBTavg did not differ between the two groups (5.24 ± 0.90 mm vs. 5.26 ± 1.00 mm, p = 0.87). There was no significant difference in 2MCP between the two groups (55.01 ± 10.18% vs 53.56 ± 10.69%, p = 0.40). In multivariable models adjusting for age and sex, vitamin D deficiency was a significant predictor of reduced metadiaphyseal CBTavg (β = -0.27 mm, p = 0.03) while age and sex were not. In contrast, age and sex predicted diaphyseal CBTavg and 2MCP. Inter- and intra-observer reliability was excellent (ICC = 0.98 and 0.99, respectively).

DISCUSSION: Regions of the distal radius with higher cellular turnover, such as the metadiaphyseal transition zone, are more vulnerable to cortical thinning in the setting of vitamin D deficiency. In contrast, the preservation of CBT in the diaphyseal region and second metacarpal isthmus suggests a differential role of vitamin D in the cortical stability of long bone shafts.

SIGNIFICANCE/CLINICAL RELEVANCE: Vitamin D deficiency preferentially compromises metabolically active regions of the bone most susceptible to fragility fractures like DRFs. Metadiaphyseal CBT radiographic measurements may be useful screening and surveillance tool in bone health. Moreover, routine assessment of 25-hydroxyvitamin D and appropriate supplementation can be employed as a fracture prevention strategy.

IMAGES AND TABLES:

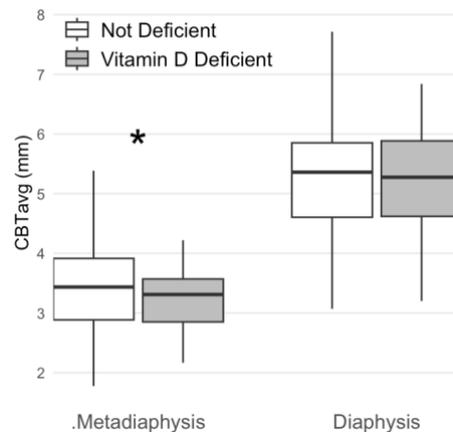**Figure 1.** Measurement technique for CBT. (e.g., at 20 mm; CBT = M2 – M1)

Figure 2. Regional CBT Averages by Vitamin D Deficiency Status

Variable	Diametaphyseal Region				Diaphysis Region			
	B	SE	β	p	B	SE	β	p
Vitamin D Deficiency	-0.267	0.295	-0.172	0.032*	-0.182	0.394	-0.083	0.273
Age	-0.007	0.005	-0.115	0.148	-0.023	0.006	-0.291	>0.001*
Sex	0.173	0.202	0.067	0.392	0.638	0.269	0.177	0.019*
R²				0.021				0.105
F				2.184				7.403

Table 1. Multivariable linear regression predicting regional CBT average by vitamin D deficiency status, age, and sex.

REFERENCES: (1) van Driel M, et al. Nutrients, 2023; (2) Oyen J, et al. Bone, 2011; (3) Force UPST JAMA, 2021; (4) Schuind FA, et al. J Bone Joint Surg Am, 1992