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IMPLICATIONS OF LOCAL OSTEOPOROSIS ON THE EFFICACY OF ANTI-RESORPTIVE DRUG TREATMENT: A 3-YEAR FOLLOW-UP FINITE-ELEMENT STUDY IN RISEDRONATE-TREATED WOMEN

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INTRODUCTION

Hip fracture often results in injury and loss in mobility in the elderly and is a growing concern especially with increasing life expectancy and heavy socio-economic costs. Although hip fracture risk can be reduced with the aid of drugs, treated patients still face considerable risk as most people who sustain hip fracture do not have generalised osteoporosis [1]. Attention needs to be given to the local distribution of bone mass, which gives rise to the problem of focal osteoporosis, making each patient unique in terms of rate and site of bone mass deterioration. This necessitates a study of the local distribution of bone mass, which contributes to the geometry and consequently the bone strength.

METHODS

This study used data from existing quantitative computed tomography (QCT) in the period 2008-2010 of females who are 50 years of age or older and had been diagnosed with osteopenia or osteoporosis.

From the patients' QCT scan data, the BMD was categorized into osteopenic, osteoporotic and normal groups. Geometric analysis is done by reslicing perpendicular to the femoral neck axis. Profile rays are drawn along 30 degree intervals, measured from centroid of the femoral neck slice [2]. The cortical thickness and radius is obtained by averaging all the profile ray values and buckling ratio (BR) is calculated. Structural analysis is performed by use of finite element analysis (FEA) software. With the use of appropriate boundary conditions [3], fracture load (F_{cr}) is obtained from force versus displacement curves.

In our preliminary results, we have first analyzed ten patients from the risedronate group (58-82 years in baseline year, 2008), all of whom are diagnosed as osteopenic or osteoporotic over the three successive years.

RESULTS AND DISCUSSION

While the BR of the subject in Group 2 declined by 12%, the F_{cr} declined by 22% accompanied with little change in her femoral neck BMD (Table 1). Despite the decline in BR, the structural strength of the bone degraded. This required a visual inspection of her femoral neck cross-section, which exhibited a significant deviation from an annular profile at the infero-anterior region whereas Group 1 showed a relatively uniform annular profile (Figure 1).

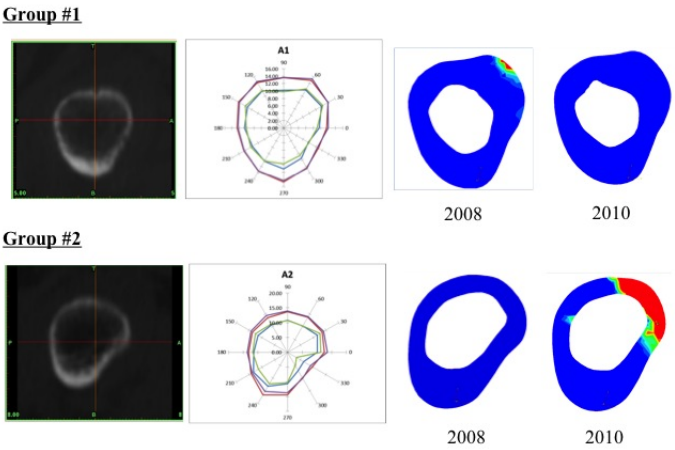

Figure 1: Geometry of cross-section of femoral neck of two groups.

The geometric changes were localized and differed between each patient, leading to the conclusion that drug treatment elicits local changes in mean outer radius (R_{mean}) and mean cortical thickness (CT_{mean}) [1]. For the subject in Group 2, despite the significant increase in cortical thickness at the infero-anterior region (K=0.39), cortical thickness significantly decreased, with K=0.90, at the supero-anterior and K=0.87 supero-posterior region. Furthermore, these two cortical thinning zones are validated by finite element analysis where critical zones were predicted at similar regions (Figure 1). It is important to note that reduced thickness of the cortical bone has been related to increased risk of fracture initiation [4] and it has been suggested that the cortical bone supports 50% of the stresses associated with normal gait [5]. Also, the maximum change in femoral neck BMD observed with all the ten patients was only 8%. Clinically, little conclusion can be drawn from just the BMD

in osteopenic/ osteoporotic patients. This emphasizes the necessity of using geometry and structure to predict fracture risk.

CONCLUSIONS

This work incorporated a simulation approach to complement the use of BMD and radiological geometric properties. Interventions that influence external bone geometry could have a profound influence on whole bone strength. Hence, from individual radar plots, we can determine if the effect of drugs had outweighed the effect of aging and thus propose a course of treatment drug better suited for the patient in the clinical scenario. Thus, we believe that focusing on a patient specific analysis for clinical diagnosis will improve diagnosis of osteoporosis and fracture prediction.

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Table 1: Geometry of cross-section of femoral neck and structural strength of one subject

Outer Diameter	+ 8%
Inner Diameter	- 3%
Cortical Thickness (CT)	- 5%
Cross-Sectional Area (CSA)	+ 7%
Buckling Ratio (BR)	- 12%
Femoral Neck (FN) BMD	+ 1%
Fracture Load (F_{cr})	- 22%