FINITE ELEMENT ANALYSIS FOR BONE HEALTH ASSESSMENT IN CUSHING'S SYNDROME

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Introduction

Cushing's Syndrome (CS) is a rare endocrine disease characterized by cortisol hyper-secretion. Since adequate diagnosis is often delayed 2–5 years, hypercortisolism exerts its harmful effect for a long time before it is diagnosed and treated [1]. Evidence from recent decades shows that, after effective treatment, usually obtained by the surgical removal of the tumor, the normalization of cortisol secretion is not constantly followed by the complete remission of the associated complications [2]. One among the several clinical manifestations in treated patients is persistent bone disease [1,2]. In an effort to uncover parameters that could be associated to eventual chronic deterioration, this study aims at evaluating femoral bone-related mechanical properties in female patients with long-term remission of CS.

Methods

Sixty-six female subjects were included in this study and stratified in two groups: (a) 34 long-term remission of Cushing's syndrome cases, and (b) 32 healthy control patients. Images of the total hip were obtained using Dual X-ray Absorptiometry (DXA) and Quantitative Computed Tomography (QCT). QCT-images were used to derive patient-specific Finite Element (FE) models of the proximal femora. Bone was simulated as elastic and heterogeneous material, with stiffness distribution derived from QCT images. A sideways-fall impact was simulated for each subject and the resulting stress values were compare among the two different groups. Areal Bone Mineral Density (aBMD) and volumetric Bone Mineral Density (vBMD) were also studied. Statistical analyses were conducted in order to determine whether CS treated patients had similar femoral density and mechanical properties than control subjects.

Results

Figure 1 shows bone stiffness and Von Mises (VM) stresses for a patient's model. Based on stiffness values, we can identify cortical/trabecular bone regions.

As shown in Table 1, while aBMD measurements on the Total Hip (TH) and Femoral Neck (FN) of treated patients do not differ from those of control patients, vBMD and VM stress measurements show differences between the two different groups. Note that maximum stresses are higher in treated patients, indicating that these subjects may more easily reach the ultimate strength threshold under the same loading conditions and, as a result, they present a higher risk of fracture.

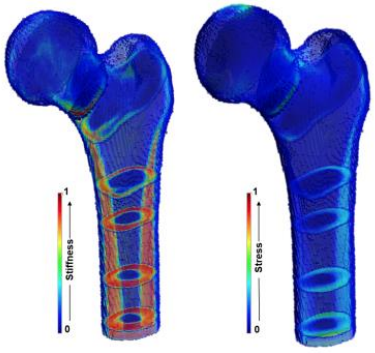

Figure 1: Normalized stiffness (left) and stress (right) volumetric distributions in a patient's femora.

Parameter	Treated patient	Control patient	p-value
TH aBMD	0.91±0.23	0.91±0.11	**0.955**
FN aBMD	0.75±0.09	0.81±0.15	**0.063**
TH trab BMD	131.73±16.39	127.79±42.59	**0.609**
TH cort vBMD	827.89±266.97	976.30±117.30	**0.004**
FN trab vBMD	138.98±20.93	165.28±59.98	**0.014**
FN cort vBMD	867.80±309.03	1073.2±265.2	**0.003**
FN mean stress	23.30±4.03	22.69±3.36	**0.511**
FN max stress	126.71±33.04	105.13±20.10	**0.003**

Table 1: Parameters expressed in mean ± SD. P-values < 0.05 indicate that there is statistically significance to reject that subject's groups have similar properties.

Discussion

CS female patients in remission have reduced vBMD, and impaired mechanical properties regardless of the menopausal status. These abnormalities may contribute to persistently elevate fracture risk even after long-term resolution of cortisol excess.

References

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