TIME-DEPENDENT MECHANICAL PROPERTIES OF RAT FEMORAL CORTICAL BONE BY NANOINDENTATION

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Introduction

The purpose of this study was to investigate the cortical bone time-dependent mechanical properties related to aging at the micro scale by nanoindentation.

Methods

Femoral cortical bone from male rats RJHan: WI Wistar ages 1, 4, 9, 12, 18, 24 months old have been used. At least four samples per age and 10 indentations per sample were carried out on the longitudinal axe of the femur. The indentation tests were fitted by a quadratic rheological model allowing time dependant elastic (E_{ELAST}), viscoelastic (E_{VE1}, η_{VE1}, E_{VE2}, η_{VE2}), plastic (P) and viscoplastic (η_{VP}) properties to be assessed [Mazeran, 2012] (figure 2).

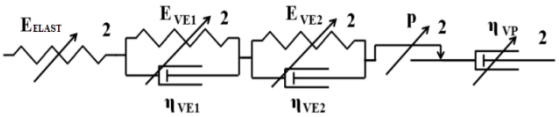

Figure1. Rheological model for fitting indentation curves.

Results

The Plastic, Viscoelastic and Viscoplastic properties obtained with different ages are illustrated in Figure 2.

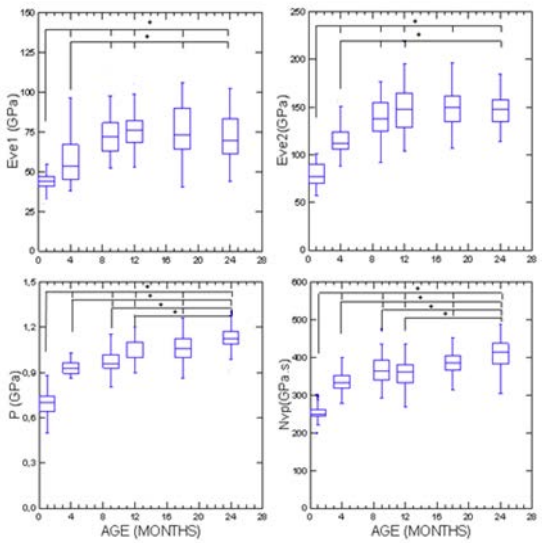

Figure2. Viscoelastic (E_{VE1}, E_{VE2}), Plastic (P) and Viscoplastic (N_{VP}) components variation with age ('' statistically significant difference $p<0.001$)*

Apparent elastic moduli function of different strain rates are shown in Figure 3.

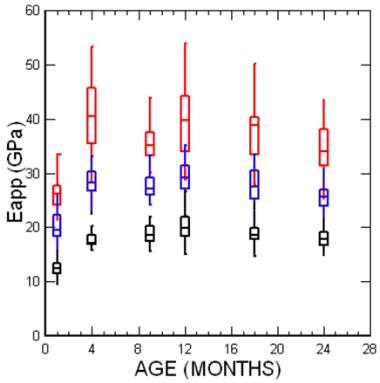

Figure3. Apparent elastic moduli function of different strain rates. From top to bottom (strain rate $\dot{\varepsilon} = \infty$, $0.05s^{-1}$, 0)

Discussion

Results show significant differences with increasing values for all mechanical properties during growth (1 to 9 months old). This variation reflects the remodeling process during earliest ages. From 12 to 24 months old: 1) Elastic and Viscoelastic properties remained steady, similarly with results obtained with morphological, mechanical and physical chemical properties [Vanleene, 2008]. 2) Plastic and Viscoplastic properties increase significantly (about 10%, $p<0.001$). From these data, the apparent elastic moduli can be calculated as a function of the strain rate. A variation of factor 2 is observed demonstrating the high time dependency of the elastic properties and the need to take into consideration in nanoindentation experiments.

Acknowledgment

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References

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