

DOES THE LACUNAR-CANALICULAR PERMEABILITY OF MURINE BONE CHANGE WITH AGE?

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Introduction

The determination of lacunar-canalicular permeability is essential for understanding how bone senses the changes in the mechanical environment [Lemaire, 2011]. Due to the heterogeneity and size of the pores, experimentally measuring the lacunar-canalicular permeability is complicated. In 2008, Oyen suggested a novel poroelastic approach to measure bone permeability using nanoindentation data. The objective of this study is to use nanoindentation to characterize lacunar-canalicular permeability in murine bone as a function of age.

Methods

Nine wild type C57BL/6 female mice of different ages (8 weeks, 7 months and 12 months) were used for this study. Three tibiae from each age group were embedded in epoxy resin, cut in half and indented in the longitudinal direction using two spherical fluid cell indenter tips ($R = 238 \mu\text{m}$ and $500 \mu\text{m}$). A trapezoidal loading profile was imposed with a rising time of 10 s to a maximum load of 6 mN and a holding time of 30 s. A minimum of ten indents were made on each sample in the mid-cortex around the circumference of the bone.

Results

Measurements made with the $238 \mu\text{m}$ suggest that the value of lacunar-canalicular intrinsic permeability of murine tibia does not show a clear trend with age (Fig. 1).

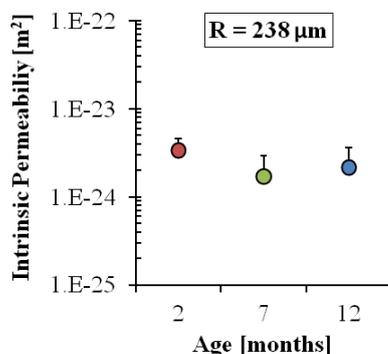


Figure 1: Intrinsic permeability as a function of age when indenting bone with a $238 \mu\text{m}$ radius tip.

Fig. 2 shows the permeability distribution captured with the $500 \mu\text{m}$ tip. Young bones have permeability values ranging from 10^{-24} to $5 \times 10^{-23} \text{ m}^2$, while old bones' permeability ranges from 5×10^{-23} to 10^{-21} m^2 .

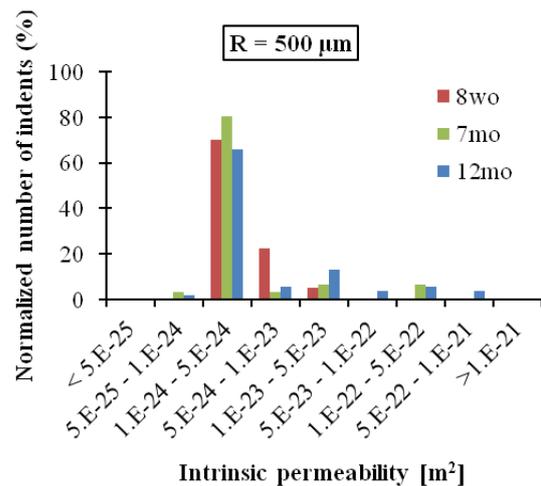


Figure 2: Intrinsic permeability distribution with the $500 \mu\text{m}$ radius tip.

Discussion

Results suggest that the mean value of lacunar-canalicular permeability of murine bone is in the order of 10^{-24} m^2 and does not change significantly with age. Larger contact sizes captured the multi-scale permeability of bone, as was observed previously by Oyen (2012), resulting in a wide permeability distribution in the case of old bones. This distribution might have an impact in the whole bone permeability, which has been reported to decrease with age [Li, 1987]. Exploring the multi-scale permeability of bone measured by nanoindentation will lead to a better understanding of the role of fluid flow in mechano-transduction.

References

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