

Pressure Modulation During Loading of a Trabecular Bone Core in an Ex Vivo Model

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It has been hypothesized that the determination of bone cell response to mechanical loading is not due to the bending of the bone matrix but to the shear fluid flow at the surface of the osteocytes and osteoblasts. The purpose of this experiment was to determine the degree of deformation on a trabecular bone core that will induce pressure shifts within the marrow cavity. It is difficult to measure shear fluid flow within trabecular bone, however it is possible to measure pressure shifts of fluid within the bone marrow during loading and use this pressure shift as an indicator of changes at the cellular level. Bovine trabecular bone cores 5 mm thick 10 mm in diameter were prepared using an Exakt diamond band saw and diamond tipped drill. A confocal microscope showed rough surfaces from the saw varying 5 to 10 microns. It was necessary to determine how this rough surface influenced the deformation transfer to the bone matrix in the center of the marrow cavity. Hemodynamic measurements of pressure shifts were determined using a 1.4 Fr high-fidelity pressure catheter from Millar Instruments (Houston, Texas) in the center marrow cavity of the bone cores. The catheter has a pressure range from -50 to +300 mmHg, a flat frequency response to 10 kHz and a standardized sensitivity of 5 $\mu\text{V}/\text{V}/\text{mmHg}$. A hole was drilled through the bioreactor chamber and into the center of the bone cores using a 0.032-inch drill bit. The Millar catheter was then placed either just outside the bone core or into the center of the bone core and locked in place. After stabilization and calibration of the catheter, bone pressure tracings were recorded on commercially available Notocord software. Pressure changes were determined while using a 1 Hz loading jump waveform, to induced deformations of 5, 10, 20 and 30 microns. Thirty measurements were made at each deformation both with the Millar catheter just outside the bone core in the bioreactor chamber and with the catheter resting in the center of the marrow cavity. Pressure changes at the lower deformations were difficult to distinguish from the resting pressure values of about 0.5 mmHg. Figure 1 shows the rise in pressure in the center and outside the bone core bone from 5 to 30 microns of deformation (\pm standard deviation). Pressure modulation is directly related to deformation, an R^2 value of 0.95 was obtained from regression analysis of the inside pressures.

