REGIONAL VARIATION IN REFERENCE POINT INDENTATION IN HEALTHY AND DISEASED CORTICAL BONE

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Introduction

Evaluation of susceptibility of bones to fracture and assessment of treatment response is currently limited to bone densitometry techniques. To address this issue, Reference Point Indentation (RPI) is proposed as a novel, minimally invasive clinical technique [Diez-Perez et al, 2010], providing a comparative measure of fracture resistance. In order to understand typical variation in RPI measurements across healthy cortical bone, entire healthy bovine, porcine and rat femurs have been examined. To investigate variation with disease, RPI measurements of protein deficient rat femurs and osteoporotic and osteoarthritic human femoral heads were conducted.

Methods

Ten indentation cycles with 10 N amplitude were applied at 2 Hz, using the Biodent™ RPI instrument (Active Life Scientific). Each loading cycle is split into three equal time periods consisting of a linear loading and unloading period with a hold period in between. Three longitudinal axes were tested in the healthy femurs: (i) anterior and posterior: (ii) medial and (iii) lateral. Next, all femoral heads were tested at multiple sites around the circumference of the head and neck, at five equidistant radial test axes. The slight offset of the ligament teres provided a suitable first test position for each radial test axis, which allowed data to be compared at matching radial locations. Tests were performed in vitro, with ethical approval and the RPI device handheld.

Results

Several parameters can be assessed from RPI measurements to evaluate cortical bone micro-cracking. In this analysis, we investigated the change in indentation depth occurring while a load is held constant for a fixed period (creep), as we hypothesize that this parameter is highly correlated to bone fragility. For healthy cortical bone in bovine, porcine and rat femurs, creep varied along the length of the femur, more notably for anterior and posterior medial axes than posterior lateral axis, as shown in Figure 1.

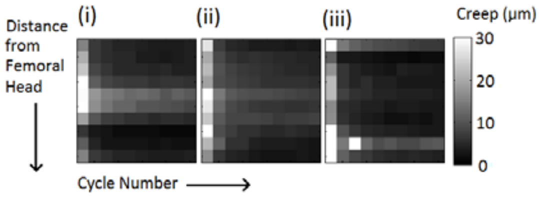

Figure 1: Creep indentation distance maps (10 cycles each) for one bovine femur, measured along the long bone axis on the (i) anterior and (ii) posterior medial and (iii) posterior lateral sides.

In non-healthy cortical bone, creep was higher in osteoporotic femoral heads, of the order of 2, compared to osteoarthritic samples. The radial axis variation also increased (Figure 2), which may reflect stress concentrations that develop in osteoporotic bone within the femoral head and neck.

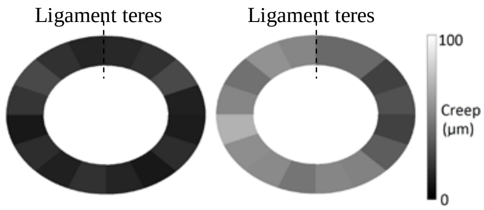

Figure 2: 1st cycle creep indentation distance, averaged across radial test axes, for (left) osteoarthritic (female, age 67) and (right) osteoporotic (female, age 62) femoral heads

Discussion

This RPI data provides further understanding of typical variation in mechanical properties found in healthy bone, aiding development of the RPI technique for future clinical use. These first results also indicate that it may be possible to distinguish osteoporotic bone with a single lateral RPI measurement.

References

Diez-Perez *et al*, J Bone Miner Res, 25(8):1877-85, 2010.