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HIGHER BONE STRAIN IS RELATED TO KNEE PAIN IN PATIENTS WITH KNEE OSTEOARTHRITIS

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ABSTRACT

INTRODUCTION: Osteoarthritis (OA) is a painful joint diseased marked by cartilage degeneration and altered morphology and mechanical properties of underlying subchondral bone. The cause of OA-related pain cause is unknown. Cartilage is aneural (lacking nerves) whereas bone is highly innervated, making bone a potential initiatory site of pain, with altered bone morphology and mechanics as the source. Previous research indicated that lower proximal tibial bone mineral density (BMD) is associated with joint pain. Lower BMD may equate with increased bone deformation, resulting in pain. To investigate this further, the objective of this research was to compare measures of bone strain, acquired using subject-specific finite element (FE) modelling, in individuals with knee OA exhibiting different levels of joint pain.

METHODS: The preoperative knee of 42 subjects scheduled for total knee replacement was scanned using quantitative computed tomography (QCT) (isotropic voxel size: 0.625mm). We used subject-specific QCT-FE to acquire principal compressive strain of cortical and trabecular bone of subchondral, epiphyseal, and metaphyseal regions of the proximal tibia. FE modelling parameters were as follows: 8-noded hexahedral elements; side length = 0.625mm; isotropic linear material properties). Elastic moduli (E) of the tibia and fibula were mapped using an experimentally-derived equation linking QCT-imaged bone mineral density (BMD) to E ($E=0.00323(BMD)^{2.1}$, $\nu = 0.3$), The femur was assumed to be rigid (E=500GPa, $\nu = 0.3$). Soft tissue was modelled as incompressible (E=10MPa, $\nu = 0.495$). A meshless, element-by-element FE solver was used to obtain mechanical strain outcomes. Pain was assessed using WOMAC. Participants were categorized into three groups based on total and nocturnal pain scores: ‘no pain’, ‘moderate pain’, and ‘severe pain’. We assessed relationships between OA-related pain and strain using Spearman’s rank correlation (ρ). We contrasted regional strain outcomes of moderate and severe pain groups to the no pain group using MANCOVA, with age and sex as covariates.

RESULTS: Principal compressive strain at most lateral regions was positively associated with pain, with ρ ranging from 0.31-0.51 for nocturnal pain and 0.46-0.56 for total pain ($p<0.05$). Participants with severe pain had greater principal compressive strain compared to the no pain group (55-91% for nocturnal pain, 71% for total pain).

CONCLUSION: Study findings suggest that higher bone strain is related to pain in individuals with knee OA, which may be important for understanding OA-related pain pathogenesis. Study findings also indicate that subject-specific QCT-FE may offer insight into the mechanical role of bone in OA and warrants application in future studies.

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