Consequence of reduced necrotic bone elastic modulus in a Perthes’ hip

Introduction
Perthes is a destructive hip joint disorder characterized as a malformation of the femoral head which affects young children. Several studies have shown the change of mechanical properties of the femoral head in Perthes’ disease. However, the consequence of the changes in bone mechanical properties in a Perthes’ hip is not well established. Due to the material differences, changes in bone mechanical properties might lead to localization of stress and deformation. Thus, the objective of this study was to investigate the effects of reduced elastic modulus of necrotic bone in the femoral head using Finite Element Analysis (FEA).

Methods
The femoral and necrotic bone of the affected hip of a Perthes’ patient was segmented from the MR images using Simpleware. The segmented parts were exported to SolidWorks to build the 3D solid model and Comsol for FEA. A load of 750 N (300% body weight) was applied on the top of the femoral head. The distal part of the femur was fixed. The same Poisson’s ratio 0.3 was set for the femoral and necrotic bone. The elastic modulus (E) of femoral bone was 500 MPa. To investigate the effects of reduced elastic modulus, the necrotic bone E was reduced as 400 MPa, 100 MPa, 10 MPa and 1 MPa.

Results
The results show that the bone deformation markedly increased when the necrotic bone E was 1 MPa. The maximum displacements were 1.79 mm, 1.80 mm, 1.92 mm and 3.74 mm for E = 400 MPa, E = 100 MPa, E = 10 MPa and E = 1 MPa, respectively. The displacement patterns were uniformly distributed when the necrotic bone E was 400 MPa and 100 MPa. Conversely, the displacements were more localized (concentrated at the necrotic bone) when the necrotic bone E was 10 MPa and 1 MPa.

Conclusions
The deformation patterns of a Perthes’ hip reveals that the disease may be more aggravated due to localization of bone deformation as a result of reduction of the elastic modulus of necrotic bone. The method in this study may be useful in surgical planning.

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