Computational modeling of the behaviour of the ceramic head

for total hip joint endoprosthesis

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Abstract

Functioning of every joint in human organism is ensured by the kinematic pair between two adjoining bones. Loss of the functionality of the kinematic pair in the form of pathologic changes to contact surfaces means that the joint loses its functionality. The most frequent cause of these changes consists in degradation changes in cartilages, sometimes leading to entire disappearance. The joint function can be reestablished by surgery – implanting of the total endoprosthesis (currently mostly hip, knee and elbow).

Instances of in vivo fractures of the ceramic (Al₂O₃) heads fixed to the austenitic steel stem have been recorded lately in a statistically significant number of patients having total hip joint endoprosthesis (see Fig. 1). The results of computational and experimental modelling have shown that one of the causes for the above damage lies in the shape deviations from the ideal shape of the conical contacting surfaces of the head and the stem [Fuis (2009)]. These deviations can be divided into macro-shape (deviations from global parameters, e.g. taper and ovality) and micro-shape that are superposed on the macro-shape deviations [Fuis (2009)]. The shape deviations of the cone contact areas increase the tensile stresses in the ceramic head (calculated using FEM system ANSYS) and therefore reduce the head’s reliability based on the Weibull weakest link theory [Bush (1993)]. Mentioned analyses were realized under conditions (ISO 7206-5 - testing of the ceramic heads, or oblique loading) where the head’s loading is different from the physiological loading during the gait process [Bergmann et al. (1993); Bergmann et al. (2010)].

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Figure 1. In vivo destructed hip joint ceramic heads
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References


