FE ANALYSIS OF THE SHOULDER CERAMIC PROSTHESIS

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Introduction

Damages of the shoulder joint lead to painful and restricted movement. Efficacy in relieving pain and restoring functions of the joint lead to high popularity of the prosthesis. This work deals with a static FE analysis of the influence of a load in a human shoulder on a ceramic humeral head with and without ribs. In order to use a finite element analysis as a successful tool in a shoulder prosthesis development, the validated input forces are important.

The most cited source of data on a load of a shoulder joint was for many years a study of Poppen and Walker [1]. Based on 2D model they have determinated a force of 90% BW in scapula plane for normal abduction. To a certain point a breaking study was in-vivo telemetric measurement in shoulder endoprosthesis published by Bergmann [2], later by Westerhoff [3].

Materials and Methods

These are the results of Bergmann [2] which were used in this finite element analysis of the shoulder endoprosthesis. The Bergman's results are accessible online on Orthoload [4].

As the movement, the abduction test in standing position has been chosen. A 72 years old man of 83 kg elevated a 2 kg load up to 120 deg. The experimental results of Bergman are illustrated on FIG. 1. The resulting force of 1760 N was applied to the FE model in reference point coupled to outside glenoid surface.

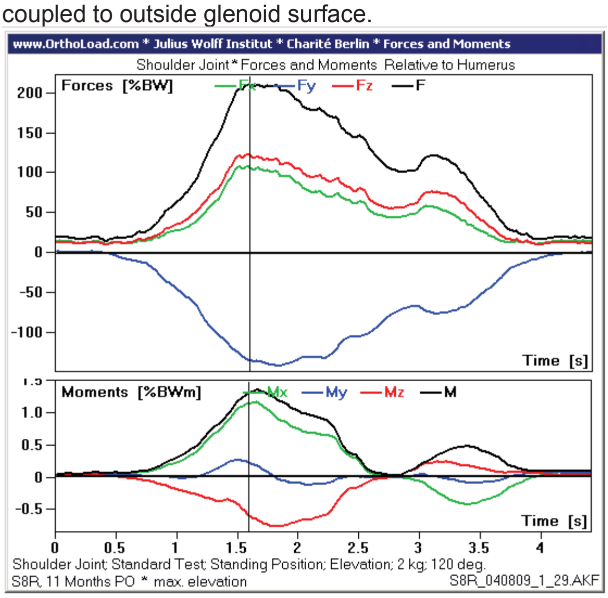

FIG. 1. Load of shoulder [4].

Geometric and finite element model (C3D10M elements) of upper limb with the implanted shoulder endoprosthesis are illustrated in the following FIG. 2 as well as the detail of two ceramic humeral heads (made of ZrO_2, with and without ribs) which were analysed in this work.

The following parts of the endoprosthesis were calculated in the analysis: ceramic head with/without ribs, neck, neck insert, humeral shaft, humerus and simplified glenoid.

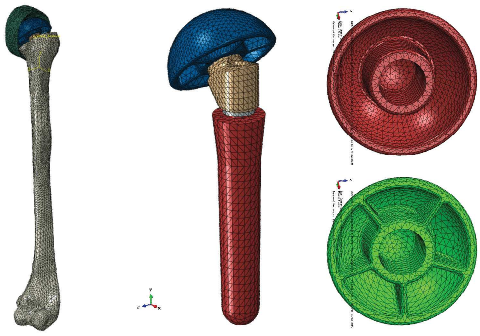

FIG. 2. Geometry model, details of humeral heads.

Results and Discussion

The load applied into the model was adopted from the experimental study presented in OrthoLoad [30] database. The static force of 1760 N has been chosen to prove the appropriate geometry of the humeral head in both constructions. See the FIG. 3 for the stress distribution (according to HMH theory) on the surface of both ceramic humeral head. The maximal stresses of 58 MPa resp. 33 MPa demonstrates the right construction solution of the head with resp. without ribs at least in the abduction test used in this study.

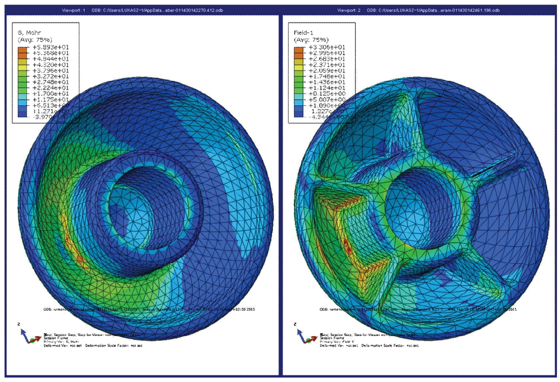

FIG. 3. Stress distribution (according to Mohr) on surface of ceramic humeral head [MPa].

Conclusions

The aim of this work was to validate the construction of ceramic humeral head with and without ribs. The results proved the right construction of both zirconia heads. Since the maxima of stresses according to Mohr are deeply below the strength of the material, the challenging problem is the manufacturing of the endoprosthesis.

Acknowledgments

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