Computer system for determination of hip joint contact stress distribution from antero-posterior pelvic radiograph

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Background. *A computer system* HIPSTRESS *is described. The system can be used for the determination of the contact stress distribution in the hip joint for a known body weight and some characteristic pelvic and hip geometrical parameters which can be determined directly from the standard antero-posterior radiograph.* ***Conclusions.*** *The system can be applied in clinical practice to predict an optimal stress distribution in different operative interventions in the hip.*

Key words: antero-posterior radiograph, hip joint contact stress, pelvis

Introduction

The studies of the distribution of the contact stress[1-4] in the hip joint are important to explore the pathomechanics of the degenerative joint diseases[4-6] as well as to predict an optimal stress distribution after certain operative interventions in order to improve their efficiency.[2,6,7]

In this work, we describe the computer system HIPSTRESS which can be used for the determination of the hip joint contact stress distribution for individual patients[2,3,8,9]. The system needs, as the input data, the body weight of the patient and some characteristic geometrical parameters of the pelvis and hip which can be determined from the antero-posterior (AP) radiograph of the pelvis with both hips.[10-12]

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Material and methods

The system HIPSTRESS[2,3,8,9] is suitable to use on any personal computer with installed TURBO PASCAL. The system consists of two programs; one for the determination of the hip joint contact stress distribution[2,3] and the other for the determination of resultant hip joint force **R**.[8,9]

The hip joint contact stress distribution can be calculated by solving a relatively simple single non-linear algebraic equation.[2,3] The program for the determination of the hip joint contact stress distribution[2,3] requires, as the input data, the magnitude and the direction of the resultant hip joint force **R**, the center-edge angle of Wiberg (ϑ_{CE}) and the radius of the hip joint articular surface (r) (Figure1).

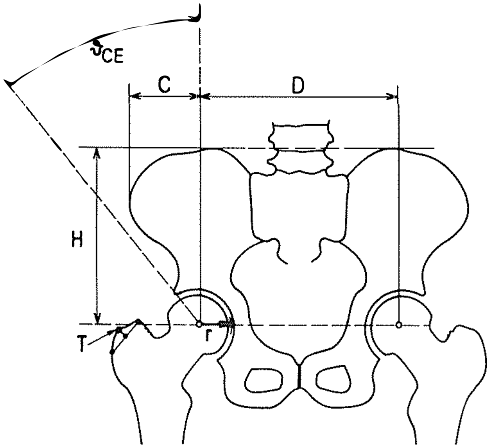

Figure 1. Schematic presentation of the pelvic and hip geometrical parameters that are used in corrections of the reference coordinates of the model muscle attachment points and in calculation of the contact stress distribution in the hip joint articular surface.

The resultant hip joint force **R** is calculated by the program based on the mathematical model of the hip joint in the one-legged stance body position[8,9,13-15] which requires, as the input data, the distance between the two femoral head centers (*D*), the coordinates of the greater trochanter (point T), the height of the pelvis (*H*), the horizontal distance between the most lateral point on the crista iliaca and the femoral head center (*C*) (Figure1) and the body weight. The values of the model muscle attachment points are adapted for each patient individually where the measured values of *D*, *H* and *C* and the position of the greater trochanter (point T) from AP radiographs for each patient are taken into account. The reference values of the model muscle attachment points were taken from Dostal and Andrews.[16]

The described geometrical parameters of the pelvis and the hip (*D*, *H*, *C*, point T, ϑ_{CE}, *r*) can be determined directly from the AP radiographs or by computer systems.[11,17,18] The magnification rate should be taken into account. The computer systems HIJOMO[17] and ANXRAY[18] use a digitized profile of standard AP radiograph of the pelvis and both proximal femurs as input data. The curves that represent the head of the prosthesis and the femoral head were fitted by the circles using the least squares method.[17]

Results and conclusions

Figure 2 shows the calculated hip joint contact stress distribution in the female hip (age 76). The AP radiograph was taken from the archives of the authors.

Due to the simplifications in the mathematical models[2,3] we cannot accurately predict the contact stress in the hip joint in detail or give an absolute stress distribution. However, the model predicts global averages which are in accordance with the relevant experimental in vivo data in the literature.[19-21]

In order to establish the clinical relevance of the determination of the hip joint contact stress distribution the computer system should be applied to various populations of patients where the correlation between the clinical status and the hip stress should be studied.

Recently, the system HIPSTRESS has been used in order to determine the peak contact stress in the articular surface of the hip joint from standard AP radiographs for 37 male and 44 female healthy hips of patients subject to trauma of the other hip.[12] It was shown that the peak contact stress is considerably higher (cca 20%) in the female population than in the male population. The results are in favor of the hypothesis that the increased hip joint contact stress in the female population could contribute to greater incidence of arthrosis in the female population relative to the male population.

To conclude, the described computer system HIPSTRESS can be used for the determination of the contact stress distribution from standard AP radiographs. The system can be applied in clinical practice to predict an optimal stress distribution in different operative

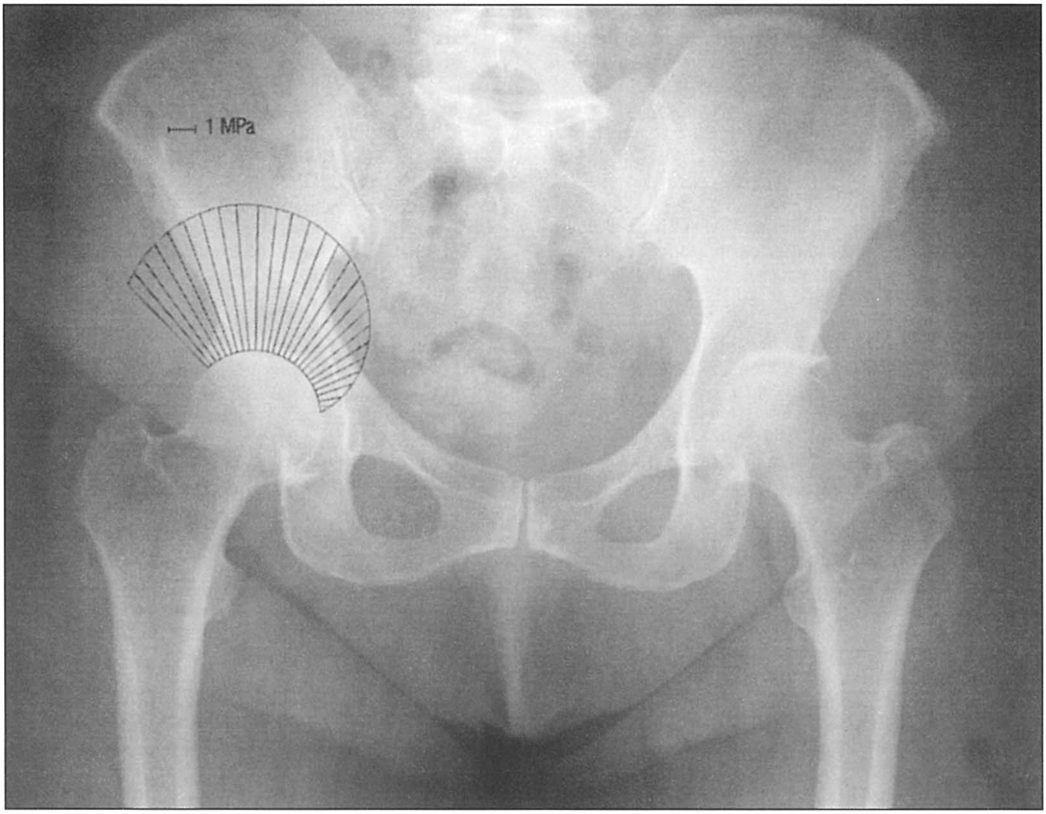

Figure 2. The hip joint contact stress distribution of the 76 year old female person (body weight 800 N, ϑ_{CE} = 44°, r = 2.27 cm) determined by the computer system HIPSTRESS.

interventions in the hip and to analyze the short and long term outcome of treatment of various conditions of the hip.

Acknowledgments

The computer system HIPSTRESS is available from the authors only to be used for scientific purposes and according to ethical principles.

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