THE STRESS LEVEL ANALYSIS FOR DYNAMIC CASES AT HUMAN HIP JOINT

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INTRODUCTION
The estimation of hip joint stress level is very useful for both preoperative planning and postoperative rehabilitation. Since 1980’s, Bergmann and his research group have been pursuing the instrumented hip implants with telemetric data transmission. Their collected gait data were recorded in HIP98, and updated in 2001[1]. So far it is unique gait database of the human hip contact force simultaneously measured in vivo. It is well recognized, however, that intrinsic pathomechanical changes in articulator cartilage depends upon local stress levels rather than upon global joint loading, and the abnormal mechanical stress upon hip joint cartilage is one of the main causes of osteoarthritis. In this paper, based on the Hertzian elasticity contact theory[2] and the hip dynamic measured data in vivo for the human various daily activities[1], such as walking slowly, walking normal, walking fast, going up stairs, going down stairs, standing up, sitting down and knee bending, a realistic stress level analysis for dynamic cases at the human hip joint are presented.

METHODS

1 Coordinate Systems
The three coordinate systems are established for the purpose of describing relationships between the hip motion and resultant load. They are, respectively, X, Y, Z system, Xc, Yc, Zc system and a spherical coordinate system \( \rho, \theta, \phi \), as shown in Figure 1.

2 Stress Distributions on the Hip
The Hertzian theory for the elastic contact of two bodies with nonconforming geometrical shapes, which is suitable to the specific case of a sphere contacting inside a sphere, is employed to calculate the stress distributions on the hip[2]. The formulas are given in the following:

\[
s_1(\theta, \phi) = \frac{3F(t)}{2\pi r^2} \left[ 1 - \frac{d_1^2(\theta, \phi)}{r^2} \right]^{3/2} \tag{1}
\]

where

\[
r(t) = \left[ \frac{3\pi}{8} F(t) \left( 1 - \frac{v_1^2}{\pi E_h} - \frac{1 - v_3^2}{\pi E_c} \right) \left( 1 - \frac{1}{D_h} - \frac{1}{D_c} \right) \right]^{1/3} \tag{2}
\]

\[
d_2(\theta, \phi) = \frac{D_c}{2} \sin^{-1} \left( \sin \theta \sin \phi \cos (\beta - \phi_1(t)) + \cos \theta \cos \phi_1(t) \right) \tag{3}
\]

3 Gait Data in vivo for Routine Activities

Figure 1  The peak stress comparisons at the hip joint for the human eight routine activities; (a) for walking cases: slowly, normal, and fast; (b) for going up stairs and going down stairs cases; (c) for standing up, sitting down, and knee bend cases.

REFERENCES