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Biomechanical conditions predisposing to hip dislocation after arthroplasty.

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Streszczenie w języku angielskim

Total hip arthroplasty (THA) is an effective and widely used treatment for advanced osteoarthritis of the hip joint. Despite excellent clinical outcomes, prosthetic dislocation remains one of the most serious complications, with an incidence reaching up to 10–25% in high-risk patient groups. The main causes of hip joint instability after THA are technical inaccuracies in the placement of prosthetic components within the bony sockets, as well as coexisting clinical factors affecting the biomechanical balance of the hip joint.

The aim of this dissertation is to evaluate the influence of acetabular cup and femoral stem placement on the level of prosthetic dislocation risk. The study was carried out **as a computational study** using numerical biomechanical modeling based on the finite element method (FEM). Based on a three-dimensional pelvic model developed from computed tomography of a healthy individual, simulations were performed for various configurations of acetabular cup and femoral stem placement by modifying cup inclination and anteversion angles, femoral stem insertion depth, and femoral head offset. Mechanical loads applied to the

prosthesis corresponded to single-leg stance body weight, and additional muscle forces acting on the implant were determined based on literature data.

The obtained results showed that only the configuration considered optimal as a result of over eight decades of observations and clinical experience (cup: 45° inclination, 15° anteversion; standard offset; correct stem depth) provides biomechanical equilibrium of forces acting on the prosthetic joint, which was confirmed by high safety factor (SF) values of 9–12. In configurations deviating from this placement of prosthetic components, a significant decrease in SF values to the level of 2–5 was observed, particularly in the anterosuperior and posterosuperior quadrants of the acetabulum, indicating an increased risk of dislocation. The obtained results confirmed previous clinical observations.

They indicate the role of prosthetic component placement in hip joint dislocations when additional triggering factors occur, such as trauma sustained by the patient, unintended limb movements (falling down stairs, being hit by a car, epileptic seizure), and patient predispositions (such as excessive pelvic tilt, muscle atrophy, surgical approach—i.e., iatrogenic detachment of muscle attachments, etc.), confirming the conclusions of previous observations that the configuration considered most favorable minimizes the risk of subsequent implant dislocation in the presence of additional predisposing factors.

The conducted study confirms that the finite element method is a valuable tool for predicting biomechanical stability of hip prostheses. The obtained results are of practical importance and may be used to optimize surgical techniques, component selection, and the use of supportive technologies (computer navigation, robotics) to minimize the risk of dislocation. They also indicate the necessity of individualized treatment and consideration of the full clinical context in surgical planning.

Based on the literature review, it was indicated that prosthetic instability may be influenced by, among others, neurological, anatomical, and surgical factors, as well as noncompliance with postoperative recommendations.