The Influence of Dislocation-prone Maneuvers on Impingement and Dislocation in Total Hip Arthroplasty

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INTRODUCTION: Dislocation continues to be a common complication of total hip arthroplasty (THA). Many factors affect the prevalence of dislocation after THA, including soft-tissue laxity, surgical approach, component position, patient factors, and component design [1]. Restoration of soft-tissue tension around the hip joint has been thought to be a crucial factor in preventing dislocation, and recent studies have suggested that dislocation mechanisms exist without prosthetic or bony impingements and the soft-tissue might play an important role for dislocation [2, 3]. The finite element (FE) method has been used to investigate dislocation propensity but so far the influence of muscle and soft-tissue remains little explored. In this study, we developed the FE model capable of predicting the dislocation stability considering soft-tissue tension. The objective of this study was to investigate the dislocation stability with regard to impingement and range of motion (ROM) in different maneuvers as well as the corresponding stress in the ultra-high molecular weight polyethylene (UHMWPE).

METHODS: Three-dimensional FE model of hybrid THA components with 26 mm femoral head (4-U; Nakashima Medical, Okayama, JP [4]) were generated using ANSYS (ANSYS, Inc. Canonsburg, PA ) (Fig.1). Femoral side mesh involved only the head and neck, which were modeled as rigid bodies. The neck had reduced portion at both anterior and posterior surface with 9.0 mm in thickness that impinge on the UHMWPE in this study. The acetabular component composed of 1754 hexahedral solid elements with a linear elastic modulus and poison ratio [5]. The acetabular component was implanted into the acetabulum in 20 degrees of anteverision and 45 degrees of inclination relative to the pelvic reference coordinate system. The 54 mm of outer diameter assumed to be rigidly supported by Ti backing. The bearing surface had 26 mm hemispherical plus 1 mm flat depth. Starting with the femoral component oriented relative to the pelvic coordinate, in a manner corresponding to the hip being flexed to implant-to-implant impingement occurrence angle at 0°, 10°, 20° and 30° of internal-rotation, the explicit FE simulation was driven by input of a series of incremental flexion moments. Concurrently, a series of hip joint force corresponding to each femoral component position was applied. The contact force data were derived from previous literature that calculates the hip joint contact force using a three-dimensional computer model assuming passive movement [6]. This numerical model simulated intraoperative condition, so only passive muscle forces were considered. Dislocation was defined to occur at the instant when the line of action of the resultant hip force vector moved from the bearing surface onto the lip chamfer. At this point, the resisting moment and the flexion angle were calculated.

RESULTS: Fig. 2 shows von Mises stress distribution of the UHMWPE just before dislocation with 30° of internal-rotation. The load data were assumed passive movement; so stress value was lower than the yield stress of UHMWPE. Fig.3 shows the calculated flexion angle at the impingement and the dislocation when analyzed four internal-rotation angles. The angle of internal-rotation affected the range of hip flexion both prior to impingement and prior to dislocation. Fig.4 shows the calculated peak resisting flexion moment at the dislocation when analyzed four internal-rotation angles. The maximum value of peak resisting moment to dislocation was observed at 30° of internal-rotation.

DISCUSSION: The present study represents the influence of dislocation-prone maneuvers on resisting moment and ROM of impingement and dislocation. Excessive flexion with internal-rotation has been thought to be the risk of posterior dislocation. Although the ROM prior to impingement was restricted by increase of internal-rotation, however, resisting moment at the dislocation also increase with increase of internal-rotation. It may be difficult to cause dislocation.

This study demonstrated that impingement and dislocation should be treated as independent outcome occurrences. Because, though impingement damage UHMWPE, it does not necessarily result in dislocation.