Evaluation of bony impingement after total hip arthroplasty using Euler angle

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Purpose: The purpose of this study is to provide a new method to simulate internal rotation (IR) limit regarding bony impingement after THA using Euler angle based on CT images and to compare measured intra-operatively.

Method: 108 joints in 103 subjects comprising 16 males and 87 females, were all subjects of a primary THA. The hip diagnoses were osteoarthritis in 93, osteonecrosis in 13, rheumatoid arthritis in 2. The patients were aged 62 in average (40 to 48), had an average weight of 53.4 kg and an average height of 152 cm. Almost all the operations were carried out consecutively between May 1998 and June 2000 with a postero-lateral approach using a lateral positioner. The implant used was the Perfix stem (Kyocera co.,Kyoto,Japan) with an alumina head of 28mm diameter, a neck of 13mm diameter at the base and a head/neck ratio of 2.15, the acetabular side an ABS Cup (Alumina Bearing Surface Cup). The acetabular liner was flat for all cases and had no marginal lips. The oscillation angle of the implant was 120 degrees. The short external rotators were detached with the posterior capsule, reattached after placement of the implant, and finally restored using complete posterior capsular and muscular repair. We checked prosthetic impingement intra-operatively and excluded cases of prosthetic impingement from the present study. Two days after surgery, patients were permitted weight bearing as tolerable, with weight-bearing activities encouraged as soon as possible.

CT scans (GE HiLight Scanner , GE Medical Systems, Milwaukee, Wisconsin) were employed for this study. The area of the hip joint from the anterior superior iliac spine to below the lesser trochanter and several 3-mm-slices through the distal femoral condyles were scanned to obtain 3-mm-thick transverse slices spaced 3 mm apart.

IR limit for posterior stability

We represented the proximal femur as the closest point to the pelvis during internal rotation (IR) at 90 degrees hip flexion and neutral adduction/abduction. The maximum IR limit prior to a bony impingement has been calculated by coordinate conversion using Euler angle.

Taking the center of the femoral head as the origin, the cephalo-caudal direction as the X axis, the dorso-ventral direction as the Y axis, and the left-right direction as the Z axis, the spatial coordinate of the position of the proximal femur is described from the CT images. Using the Euler angles, we calculated the spatial coordinates of the position of the proximal femur, after its position was converted by a movement into a flex position of 90 degrees, and a further IR limit until the proximal femur reach the iliac wall(Fig 1). We used calculating software to represent the state of the art in software for matrix computation “MATLAB” (The Math Works Inc.) Intra-operatively, after placement of the implant, the IR limit prior to impingement was measured with a goniometer, before the short external rotators and the ilio tibial ligament were repaired, at 90 degrees hip flexion and neutral adduction/abduction, which are positions thought to cause posterior dislocation. We forced the IR until subluxation occurred because of intercalated soft tissues between the greater trochanter and the iliac wall. The IR limit was defined as the angle between the axis of the tibia and the horizontal plane. We excluded cases of prosthetic impingement from the present study.

Results: The calculated IR limit was 60.4 degrees in average (between 33.4 and 84.4 degrees). The IR limit intra-operatively was 49 degrees in average (between 30 and 70 degrees). The correlation between the IR limit at an intra-operative hip flexion of 90 degrees and a neutral adduction/abduction (Y), and the calculated IR limit (X), was Y=21.0+0.46X (R=0.60) (p < 0.0001) (Fig.2).

Conclusion: We provided a new method to simulate bony impingement after THA using Euler angle based on CT images.