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Optimization of Acetabular Cup Abduction by Adjusting Pelvic Pitch

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Background: The purposes of this study were to determine the accuracy of our cup positioning method and to evaluate the dislocation rate after total hip arthroplasty (THA).

Methods: After positioning the patient in the lateral decubitus position on the operation table, an anteroposterior view of the hip was taken. The pelvic pitch was measured on the X-ray. A positive pitch was defined as the caudal rotation of the upper hemipelvis. Our target abduction of the cup was 43°. We used the cup holder to guesstimate the cup abduction. In a preliminary study, we found that the weight of the cup holder increased the pelvic pitch by 5°. Thus, the target abduction of the cup holder was calculated by a formula: 43° – pelvic pitch – 5°. During the cup insertion, the cup holder was anteverted to the calculated target according to the concept of combined anteversion. We evaluated 478 THAs (429 patients), which were done with the use of the method.

Results: The mean cup abduction was 43.9° (range, 32.0°–53.0°) and the mean error of cup abduction was 2.4° (standard deviation [SD], 2.0°; range, 0.0°–11.0°). The mean cup anteversion was 28.5° (range, 10.0°–42.0°) and the mean error of cup anteversion was 6.7° (SD, 5.2°; range, 0.0°–27.6°). Of all, 82.4% of the cups (394 / 478) were within the safe zone: 30°–50° abduction and 10°–35° anteversion. During 2- to 5-year follow-up, no hip dislocated.

Conclusions: Our adjusting method according to the pelvic pitch can be a reliable option for optimizing the cup abduction in THA.

Keywords: *Total hip arthroplasty, Cup position, Treatment, Pelvic pitch*

Optimal positioning of the acetabular cup is crucial to prevent dislocation and to reduce wear of the bearing surface after total hip arthroplasty (THA).[1-3] To accurately position the acetabular component, anatomical landmarks have been used as intraoperative markers. The transverse acetabular ligament has been suggested as a guide for cup

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positioning.[4] However, the ligament is not identifiable due to central osteophytes in arthritic hips and its direction has a large variation.[5]

In 2012, Ha et al.[6] developed a method using two anatomical landmarks: transverse acetabular notch and anterior acetabular notch, to align the cup abduction and anteversion. The authors measured the acetabular abduction and anteversion on preoperative computed tomography (CT) scan and they reported an excellent accuracy. This method was not popularized due to the high cost of CT scans and associated radiation hazards.

The most common method for cup positioning is the free-hand technique and the majority of THAs are performed with the patient in a lateral decubitus position. In the conventional free-hand technique, surgeons usually use the cup holder to guesstimate the cup abduction and anteversion. They think the angle between the cup holder and the operation table represents cup abduction. Pelvic pitch is the rotation of the pelvis in the coronal plane (Fig. 1).[7] If the pelvis is not pitched, the angle between the cup holder and the operation table is the same as the cup abduction, and the cup holder would be an accurate guide for optimization of the cup abduction. However, in most humans, the shoulder width is wider than the pelvic width.[8] In the lateral decubitus position, the upper hemipelvis is pitched caudally in the coronal plane due to the discrepancy between the shoulder width and pelvic width (Fig. 2).[8] The pelvic pitch varies according to the patient's constitution, and it is a source of error in the free-hand technique using the cup holder as the guide to optimize cup abduction. In the lateral decubitus position, another source of pelvic pitch is the mass of the cup holder. Due to its weight, the holder also increases the pitch of the pelvis. Pelvic pitch due to pelvic/shoulder width ratio and the weight of the cup holder leads to an underestimation of the cup abduction in free-hand THA.

We hypothesized that if the pelvic pitch of the pelvis in the lateral decubitus position and additional pelvic pitch due to the weight of the cup holder were measured and adjusted, optimal cup abduction could be obtained. According to this assumption, we developed a simple and practical method to align cup abduction. In this method, the pelvic pitch was measured on a preoperative hip anteroposterior (AP) view, which was taken after placing the patient in the lateral decubitus position on the operation table. We aimed to estimate the accuracy of this method and evaluate the dislocation rate after THA.

METHODS

The present study was approved from Seoul National University Bundang Hospital Institutional Review Board (No. B-2102-664-109). As a retrospective study, the protocol of this study and waiver of the informed consent were approved by the institutional review board of the hospital where the study was conducted.

From January 2015 to December 2017, 543 patients (600 hips) underwent primary THA using our cup positioning method at our institution. We excluded 14 patients (16 hips) who had scoliosis (Cobb's angle > 20°) or asymmetric pelvis because we could not use the inter-teardrop

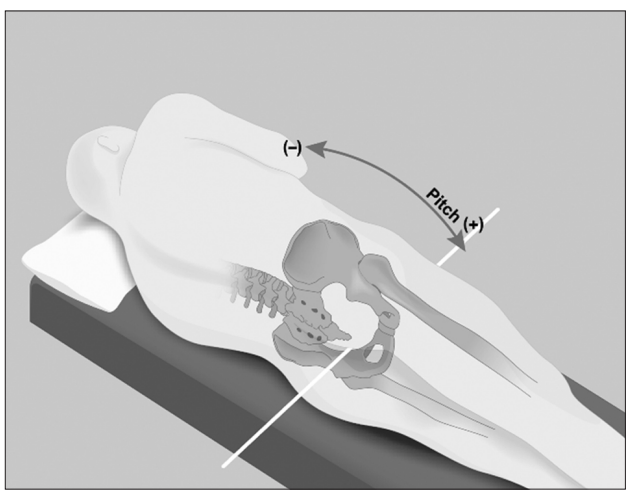

Fig. 1. Pelvic pitch is the rotation of the pelvis in the coronal plane. A positive pitch is defined as the caudal rotation of the upper hemi-pelvis in the coronal plane.

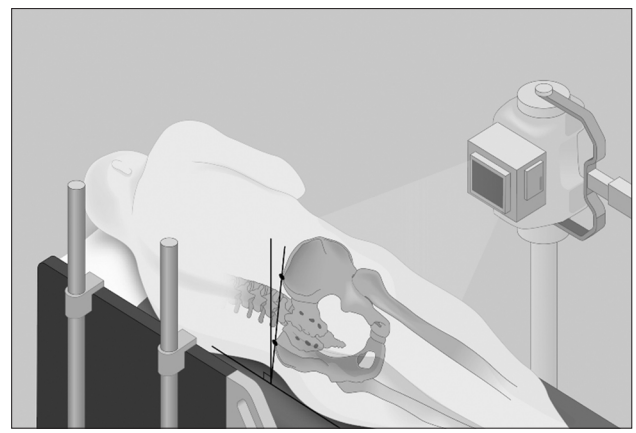

Fig. 2. The lateral decubitus position to take a hip anteroposterior view. The patient is placed in the lateral decubitus position on the operation table. The pelvis is held in the neutral tilt and neutral rotation with two posts: one posterior post that was applied against the sacrum and one anterior post applied against the symphysis pubis. The hips and knees are fully extended.

line as the reference to measure the cup abduction; 5 patients (5 hips) with fused hips because the teardrop of the acetabulum was not identifiable and 24 patients who had a leg length discrepancy > 2 cm because the predefined target abduction of the cup was not applicable due to the postoperative residual leg length discrepancy.

We also excluded 55 patients (57 hips) who had more than 10° of posterior pelvic tilt in the standing posture compared to the supine position because we could not use the anterior pelvic plane as the reference line of cup anteversion.[9] We mandated minimum 2-year follow-up for the inclusion in this study because dislocation was a primary outcome of the study. Three patients (3 hips) died and 28 patients (30 hips) were lost to follow-up before 2 years after the arthroplasty.

This left 429 patients (478 THAs): 224 men (252 THAs) and 205 women (226 THAs), who were subjects of this study. The mean age at the time of THA was 54.5 years (range, 21.8–85.9 years), and the mean body mass index was 24.9 kg/m^2 (range, 15.2-40.7 kg/m^2). The primary diagnoses for THA were femoral head osteonecrosis in 275 hips, arthritis due to hip dysplasia in 71, arthritis due to previous septic arthritis in 8, rheumatoid arthritis in 4, and femoral neck fracture in 2. These patients were followed up for 2 to 6 years (mean, 3.8 years).

Preoperative Planning

Measurement of pelvic pitch in the lateral decubitus position

The patient was placed in the lateral decubitus position on the operation table. The pelvis was held in the neutral tilt and neutral rotation with two posts: one posterior post that was applied against the sacrum and one anterior post applied against the symphysis pubis. The hips and knees were fully extended. Then, an AP view of the hip was taken. On this X-ray, the pelvic pitch was estimated by measuring the angle between a vertical line drawn from the teardrop of the opposite hip and the inter-teardrop line (Fig. 3). A positive pitch was defined as the caudal rotation of the upper hemi-pelvis in the coronal plane (Fig. 1).

Additional pelvic pitch due to weight of the cup holder

The cup holder, which was used in this study, weighed 550 g. When the cup holder was not hung up for the measurement of cup holder abduction, its weight increased the caudal pitch of the pelvis. Thus, we conducted a preliminary study to estimate the increase of pelvic pitch due to the weight of the cup holder. In 30 patients, we took 2 hip AP radiographs (one with the cup holder and one without the cup holder) in lateral decubitus position after insertion of the cup and measured the change of the pelvic pitch due to the cup holder weight. The cup holder increased the pelvic pitch by a mean of 5° (± 2.3°).

Calculation of target abduction of the cup holder

Our target abduction of the cup was 43°.[6] When using the cup holder as the guide to optimize the cup abduction, the target abduction of the cup holder should be reduced by the pelvic pitch in the lateral decubitus position (γ°) and the additional pelvic pitch of 5° due to the weight of the cup holder (Fig. 4). Thus, the adjusted target angle of the

Fig. 3. The pelvic pitch is the angle (γ°) between a vertical line drawn from the teardrop of the opposite hip and the inter-teardrop line on a lateral decubitus hip view. A positive pitch is defined as the caudal rotation of the upper hemi-pelvis in the coronal plane.

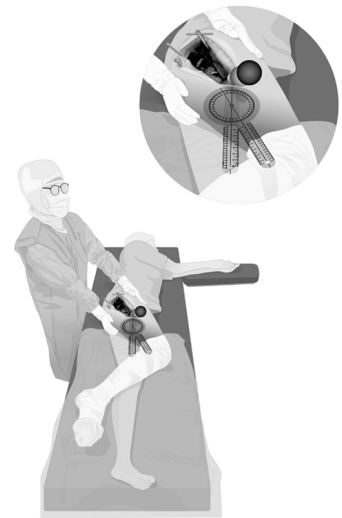

Fig. 4. A goniometer is placed on the contralateral thigh, and the cup holder is aligned to the target anteversion of the cup.

cup holder was calculated by a formula: 43° – γ° – 5°.

Operative Technique and Cup Positioning

All operations were done using a posterolateral approach in the lateral position by two senior surgeons (KHK and YKL). According to the concept of combined anteversion, we prepared the femoral side first and measured the stem version using the rasp trial.[10] The angle between the tibial axis and the neck of the final rasp was measured with a goniometer to obtain the stem anteversion. The target anteversion of the cup was calculated by the following formula: the cup anteversion = 37.3° – 0.7 × stem anteversion.[10] However, we did not antevert the cup less than 10° or more than 35°.

A 12-inch goniometer was used for the alignment of the cup holder. Before adjusting the abduction, we aligned the cup holder to the calculated anteversion. After reaming of the acetabular cartilage, a goniometer was placed on the contralateral thigh, and the cup holder was aligned to the target anteversion of the cup. As the cup holder is straight, one limb of the goniometer was matched in line with the cup holder and the other limb represented the horizontal axis (Fig. 4).

Then, the cup was gradually press-fitted into the acetabulum by multiple tapping. We repeatedly checked the abduction of the cup holder (Fig. 5). During the measurement of the cup holder position, all the retractors were removed, the pelvis was placed in neutral tilt and neutral rotation, and the hip was fully extended. After implantation, the posterior capsule and short external rotators were repaired using a transosseous suture to 3–4 drill holes in the trochanteric crest.[11]

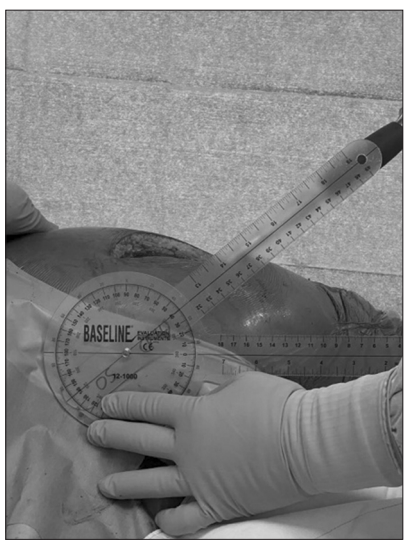

Fig. 5. The cup is gradually press-fitted into the acetabulum by multiple tapping. During this procedure, abduction of the cup holder should be repeatedly checked.

A cementless acetabular cup (Mirabo; Corentec, Cheonan, Korea), cementless stem (M stem; Corentec), and Delta ceramic-on-ceramic bearing (Biolox Delta: CeramTec AG, Plochingen, Germany) were used in all hips. The diameter of the ceramic bearing was 28 mm in seven cups of 44/46 mm, 32 mm in 213 cups from 48 to 52 mm, and 36 mm in 258 cups ≥ 52 mm. On postoperative day 1, patients were permitted to walk with the aid of two crutches. The crutches were used for 4 weeks. Follow-up evaluations were performed at postoperative 6 weeks, at 6 and 12 months, and annually thereafter.

Measurement of Cup Abduction and Anteversion

Two independent observers (JHP and HSK), who did not participate in the THAs, measured the cup position and performed radiological evaluations. Cup position was measured on postoperative 6-week radiographs. Cup abduction was measured on the AP radiograph using the method of Engh et al.[12] and cup anteversion was measured on the cross-table lateral radiograph using the method of Woo and Morrey.[13] The safe zone of the cup position was defined as 30° to 50° abduction and 10° to 35° anteversion.[14]

Radiological and Clinical Evaluations

Radiological evaluations included prosthetic loosening, ceramic wear, and osteolysis. The fixation of the femoral stem was assessed using the method of Engh et al.[15] and the fixation of the acetabular cup with use of the method of Latimer and Lachiewicz[16] Ceramic wear was calculated according to the method developed by Livermore et al.[17] Osteolytic lesions were defined according the criteria of Engh et al.[12] The lesions were recorded in the 3 zones described by DeLee and Charnley[18] on the acetabular side, and the 7 zones described by Gruen et al.[19] on the femoral side. Clinical evaluations were done using modified Harris hip score system.[20]

RESULTS

Amount of Pelvic Pitch in Lateral Decubitus Position

The pelvic pitch (γ°) measured on the lateral decubitus view ranged from –5° to 17° (mean, 4.5°; standard deviation [SD], 3.0°). Only 18 patients (3.8%) had negative (cephalic) pelvic pitch and most patients (96.2%, 460 patients) had positive (caudal) pitch.

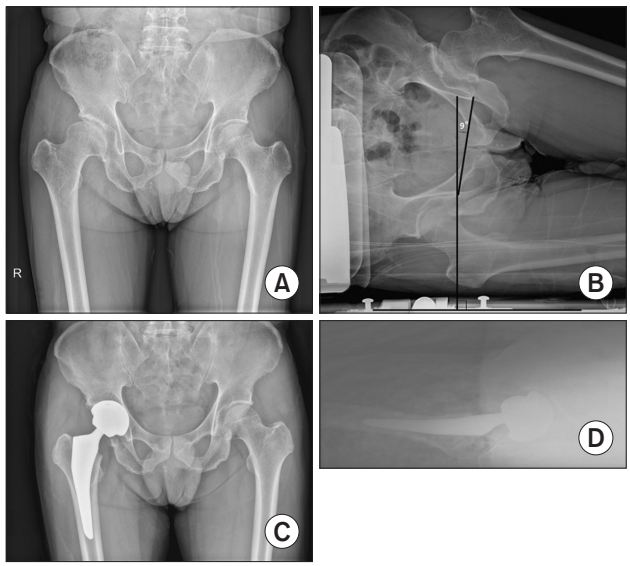

Fig. 6. (A) A 55-year-old man had osteoarthritis in the right hip. (B) The pelvic pitch in lateral decubitus view is 9°. (C) On the postoperative 6-week anteroposterior radiograph, the cup abduction is 43°. (D) On the translateral radiograph, the cup anteversion is 27°.

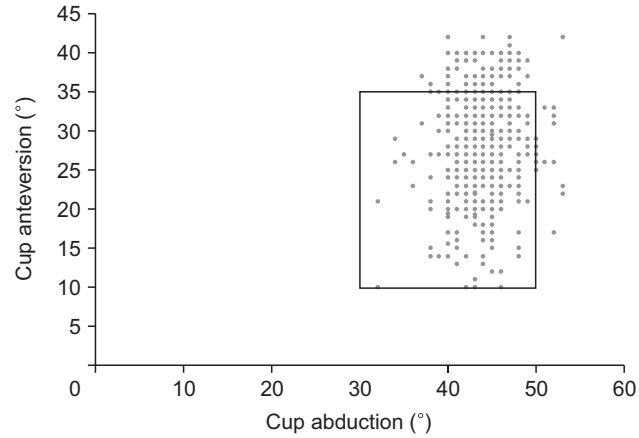

Fig. 7. Scatterplot of cup abduction and anteversion. Three hundred ninety-four of 478 cups (82.4%) are within the safe zone (marked as a bold square): 30°–50° abduction and 10°–35° anteversion.

Target Abduction of Cup Handle

The target abduction of cup handle calculated according to the formula (43° – γ° – 5°) ranged from 21° to 43° (mean, 33.5°; SD, 3.0°).

Cup Abduction and Version

The mean cup abduction was 43.9° (range, 32.0°–53.0°) and the mean error of cup abduction compared with the target abduction of 43° was 2.4° (SD, 2.0°; range, 0.0°–11.0°). The mean cup anteversion was 28.5° (range, 10.0°–42.0°) and the mean error of cup anteversion compared with the target anteversion, which was calculated using the formula (37.3° – 0.7 × stem anteversion but not less than 10° and not more than 35°) was 6.7° (SD, 5.2°; range, 0.0°–27.6°) (Fig. 6). In the scatterplot of cup abduction and anteversion, 82.4% of cups (394/478) were within the safe zone. When considering only the cup abduction angles, 97.9% of the patients were within the safe zone (Fig. 7).

Dislocations, Radiological Changes, and Harris Hip Score

During the follow-up, no hip dislocated. There was no detectable wear of ceramic parts, and no hip showed radiographic signs of focal osteolysis or component loosening. The mean preoperative Harris hip score of 53.1 points improved to 87.7 points at the latest follow-up.

DISCUSSION

Our study shows that the new method using the lateral decubitus view and the concept of pelvic pitch was reliable in the cup positioning. Adequate alignment of the acetabular cup is a challenging issue in THA. Several methods have been introduced to provide surgeons with reliable and accurate information on cup positioning during THA. Intraoperative radiographs are widely used for appropriately positioning the implants. However, some studies found that intraoperative radiographs are related to longer operation time without prominent benefits in outcomes of THAs.[21,22] To adjust pelvic pitch in the current study, the radiographs were taken before the incision after patient positioning. Therefore, this method was not related to longer operation time or elevated infection risk.

Mechanical guides have been used to align the cup abduction and anteversion with respect to the sagittal and coronal planes of the patient's pelvis, but they still result in large variations of cup abduction and anteversion.[23-25] These devices do not consider hip/shoulder width ratio, caudal pelvic pitch in the lateral decubitus position, and intraoperative motion of the pelvis. Previous studies reported high percentages of inadequate cup positions with the use of mechanical guides.[1,23,26,27]

The hip navigation was introduced in the early 1990s. This system has not been popularized due to criticisms including the extra costs, additional radiation exposure, time-consuming preoperative planning, and intraoperative matching procedures.[28-30] Currently, only 1.9% of THAs are performed with use of the navigation system in the United States.[31]

We note several limitations. First, our study was

done in East Asia. The hip/shoulder width ratio and the caudal pelvic pitch might be different according to ethnicity. Second, the method was used in THAs with the patients in the lateral position using a specific hemispherical cup design. However, the hemispherical cup is the most common design among currently used acetabular components. Third, the pelvic pitch change caused by the cup holder could be different not only according to the type of implant but also due to the diversity of cup holders even for the same acetabular implant. Various cup holders from other manufacturers were measured and the weight ranged from 468 to 682 g (mean, 533.5 g). We assume that the change of pelvic pitch due to the cup holders are probably not significant but further studies are warranted. Fourth, our method is not applicable when the teardrop of the acetabulum is not identifiable, such as in fused hips. Moreover, in patients who have severe imbalance of pelvic alignment in the coronal plane, adjusting the position of the acetabular cup using this method could be more complex. Fifth, there was no comparison group in this study and further randomized controlled studies are warranted for more reliable conclusions.

The strength of this study is that the accurate cup positioning was possible only using the preoperative radiograph with the patient in the lateral position. Despite the recent increase in the use of the anterior approach, the mainstream approach in THA is still the posterolateral or lateral, which is performed with the patient in the lateral position. Moreover, our method requires only preoperative radiographs and therefore does not necessitate intraoperative radiographs that consume the operation time or additional navigation system.

In the lateral decubitus position, there is a considerable pelvic pitch, which leads to underestimation of perceived cup abduction in THA. Our method adjusting the pelvic pitch could be useful for the adjustment of cup abduction in free-hand THA.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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REFERENCES

1. Paterno SA, Lachiewicz PF, Kelley SS. The influence of patient-related factors and the position of the acetabular component on the rate of dislocation after total hip replacement. J Bone Joint Surg Am. 1997;79(8):1202-10.
2. Turner RS. Postoperative total hip prosthetic femoral head dislocations: incidence, etiologic factors, and management. Clin Orthop Relat Res. 1994;(301):196-204.
3. Dorr LD, Wolf AW, Chandler R, Conaty JP. Classification and treatment of dislocations of total hip arthroplasty. Clin Orthop Relat Res. 1983;(173):151-8.
4. Archbold HA, Mockford B, Molloy D, McConway J, Ogonda L, Beverland D. The transverse acetabular ligament: an aid to orientation of the acetabular component during primary total hip replacement: a preliminary study of 1000 cases investigating postoperative stability. J Bone Joint Surg Br. 2006;88(7):883-6.
5. Yoon BH, Ha YC, Lee YK, Jo WL, Lee KM, Koo KH. Is transverse acetabular ligament a reliable guide for aligning cup anteversion in total hip arthroplasty?: a measurement by CT arthrography in 90 hips. J Orthop Sci. 2016;21(2):199-204.
6. Ha YC, Yoo JJ, Lee YK, Kim JY, Koo KH. Acetabular component positioning using anatomic landmarks of the acetabulum. Clin Orthop Relat Res. 2012;470(12):3515-23.
7. Gonzalez Della Valle A, Shanaghan K, Benson JR, et al. Pelvic pitch and roll during total hip arthroplasty performed through a posterolateral approach: a potential source of error in free-hand cup positioning. Int Orthop. 2019;43(8):1823-9.
8. Canturk M, Hakki M, Kocaoglu N. Hip/shoulder width ratio alters the spread of spinal anesthesia: a prospective observational study. Ulutas Med J. 2018;4(1):32-7.
9. Maratt JD, Esposito CI, McLawhorn AS, Jerabek SA, Padgett DE, Mayman DJ. Pelvic tilt in patients undergoing total hip arthroplasty: when does it matter? J Arthroplasty. 2015;30(3):387-91.
10. Dorr LD, Malik A, Dastane M, Wan Z. Combined anteversion technique for total hip arthroplasty. Clin Orthop Relat Res. 2009;467(1):119-27.

11. Ji HM, Kim KC, Lee YK, Ha YC, Koo KH. Dislocation after total hip arthroplasty: a randomized clinical trial of a posterior approach and a modified lateral approach. J Arthroplasty. 2012;27(3):378-85.
12. Engh CA, Griffin WL, Marx CL. Cementless acetabular components. J Bone Joint Surg Br. 1990;72(1):53-9.
13. Woo RY, Morrey BF. Dislocations after total hip arthroplasty. J Bone Joint Surg Am. 1982;64(9):1295-306.
14. Murphy WS, Yun HH, Hayden B, Kowal JH, Murphy SB. The safe zone range for cup anteversion is narrower than for inclination in THA. Clin Orthop Relat Res. 2018;476(2):325-35.
15. Engh CA, Massin P, Suthers KE. Roentgenographic assessment of the biologic fixation of porous-surfaced femoral components. Clin Orthop Relat Res. 1990;(257):107-28.
16. Latimer HA, Lachiewicz PF. Porous-coated acetabular components with screw fixation: five to ten-year results. J Bone Joint Surg Am. 1996;78(7):975-81.
17. Livermore J, Ilstrup D, Morrey B. Effect of femoral head size on wear of the polyethylene acetabular component. J Bone Joint Surg Am. 1990;72(4):518-28.
18. DeLee JG, Charnley J. Radiological demarcation of cemented sockets in total hip replacement. Clin Orthop Relat Res. 1976;(121):20-32.
19. Gruen TA, McNeice GM, Amstutz HC. "Modes of failure" of cemented stem-type femoral components: a radiographic analysis of loosening. Clin Orthop Relat Res. 1979;(141):17-27.
20. Vishwanathan K, Akbari K, Patel AJ. Is the modified Harris hip score valid and responsive instrument for outcome assessment in the Indian population with pertrochanteric fractures? J Orthop. 2018;15(1):40-6.
21. Bingham JS, Spangehl MJ, Hines JT, Taunton MJ, Schwartz AJ. Does intraoperative fluoroscopy improve limb-length discrepancy and acetabular component positioning during direct anterior total hip arthroplasty? J Arthroplasty. 2018;33(9):2927-31.
22. Brown NM, McDonald JF 3rd, Sershon RA, Hopper RH Jr. The effect of intraoperative radiographs on component position and leg length during routine posterior approach total hip arthroplasty. Hip Pelvis. 2021;33(3):128-39.
23. Digioia AM 3rd, Jaramaz B, Plakseychuk AY, et al. Comparison of a mechanical acetabular alignment guide with computer placement of the socket. J Arthroplasty. 2002;17(3):359-64.
24. Hassan DM, Johnston GH, Dust WN, Watson G, Dolovich AT. Accuracy of intraoperative assessment of acetabular prosthesis placement. J Arthroplasty. 1998;13(1):80-4.
25. McCollum DE, Gray WJ. Dislocation after total hip arthroplasty: causes and prevention. Clin Orthop Relat Res. 1990;(261):159-70.
26. DiGioia AM, Jaramaz B, Blackwell M, et al. The Otto Aufranc Award. Image guided navigation system to measure intraoperatively acetabular implant alignment. Clin Orthop Relat Res. 1998;(355):8-22.
27. Pellicci PM, Salvati EA, Robinson HJ. Mechanical failures in total hip replacement requiring reoperation. J Bone Joint Surg Am. 1979;61(1):28-36.
28. Jolles BM, Genoud P, Hoffmeyer P. Computer-assisted cup placement techniques in total hip arthroplasty improve accuracy of placement. Clin Orthop Relat Res. 2004;(426):174-9.
29. Nogler M, Kessler O, Prassl A, et al. Reduced variability of acetabular cup positioning with use of an imageless navigation system. Clin Orthop Relat Res. 2004;(426):159-63.
30. Schlenzka D, Laine T, Lund T. Computer-assisted spine surgery. Eur Spine J. 2000;9 Suppl 1(Suppl 1):S57-64.
31. Boylan M, Suchman K, Vigdorchik J, Slover J, Bosco J. Technology-assisted hip and knee arthroplasties: an analysis of utilization trends. J Arthroplasty. 2018;33(4):1019-23.