



Results of Primary Total Hip Arthroplasty Using 36 mm Femoral Heads on 1st Generation Highly Cross Linked Polyethylene in Patients 50 Years and Less with Minimum Five Year Follow-up

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Purpose: We evaluated the clinical and radiographic midterm results of primary total hip arthroplasty (THA) using a 36 mm diameter femoral head on 1st generation highly cross-linked polyethylene (HXLPE) in patients 50 years and less with minimum five year follow-up.

Materials and Methods: We retrospectively reviewed 31 patients (41 hips) aged 50 years and less underwent primary THA with a 36 mm diameter femoral head on HXLPE between 2004 and 2010. Clinical follow-ups included specific measurements like modified Harris hip scores (HHS) and Merle d'Aubigne and Postel score. For radiologic evaluations, together with position of acetabular cup at six weeks later of postoperation, we separately calculated the penetrations of femoral head into polyethylene liners during postoperation and one year later check-ups, and during one year later check-ups and final check-ups.

Results: There were no major complications except for one case of dislocation. Average modified HHS at final follow-up was 88 (81-98), and Merle d'Aubigne and Postel scores were more than 15. Mean acetabular cup inclination and anteversion were 45.81° (36.33°-54.91°) and 13.26° (6.72°-27.71°), respectively. Average femoral head penetration of steady-state wear rate determined using radiographs taken at one-year postoperatively and at latest follow-up was 0.042±0.001 mm/year.

Conclusion: Based on minimum 5 years clinical results, we think 36 mm metal head coupling with HXLPE as the good alternate articulation surface when planning THA for patients aged 50 years and less.

Key Words: Total hip arthroplasty, 36 mm femoral head, Highly cross-linked polyethylene

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INTRODUCTION

Coupling of metal on conventional polyethylene have been traditionally used as bearing surface of total hip arthroplasty (THA). However, this coupling could make debris of polyethylene resulting in an aseptic loosening over time is well known¹. Previous other studies reported young age and increased activity levels as independent risk factors for an aseptic loosening^{2,3}. For this reason, an alternate bearing surfaces such as ceramic on ceramic (CoC), metal on highly cross-linked polyethylene (HXLPE) have been used in young patients^{4,5}. Since 2004, our adult artificial joint reconstruction institute started to use a 36 mm metal head coupling with HXLPE for primary THA, if possible. To gain better artificial hip joint stability, 36 mm metal head have been used popularly⁶. Also, to reduce wear problem of polyethylene, the use of HXLPE have increased⁷. So, our institute has used 36 mm metal head coupling with HXLPE as articulation surface regardless of patient age. Currently, many papers are focusing on CoC bearing surface of THA for younger cohort⁸⁻¹⁰. On the other hand, few reports were for results of 36 mm metal head coupling with HXLPE as younger cohort's bearing surface.

The purpose of this paper is to evaluate the results of primary THA using 1st generation HXLPE in patients aged 50 years and less with minimum five year follow-up.

MATERIALS AND METHODS

A retrospective review of 52 consecutive primary THAs performed by one senior author was conducted. Among 52 cases, 11 cases were lost during follow-ups. So, we evaluated 41 hips (31 patients; 14 males and 17 females). All patients underwent THA with a 36 mm metal head on HXLPE between 2004 and 2010. Fourteen cases out of 41 cases were osteoarthritis. Osteoarthritis included 13 cases of 2nd osteoarthritis (dysplastic hip sequela 9 cases, post-traumatic sequela 4 cases, slipped capital femoral epiphysis sequela 1 case). Nine cases out of 41 cases were rheumatoid arthritis. Another 9 cases were ankylosing spondylitis and 7 cases underwent primary THA due to osteonecrosis of femoral head (Table 1). Mean patient's age was 41 years (range, 22-50

Table 1. Patient Diagnoses

| Diagnosis | Number of case |
|---|----------------|
| Osteoarthritis (including 2nd osteoarthritis) | 14 |
| Rheumatoid arthritis | 9 |
| Ankylosing spondylitis | 9 |
| Osteonecrosis | 7 |
| Sequela of infection | 1 |
| Benign bone tumor | 1 |
| Total | 41 |

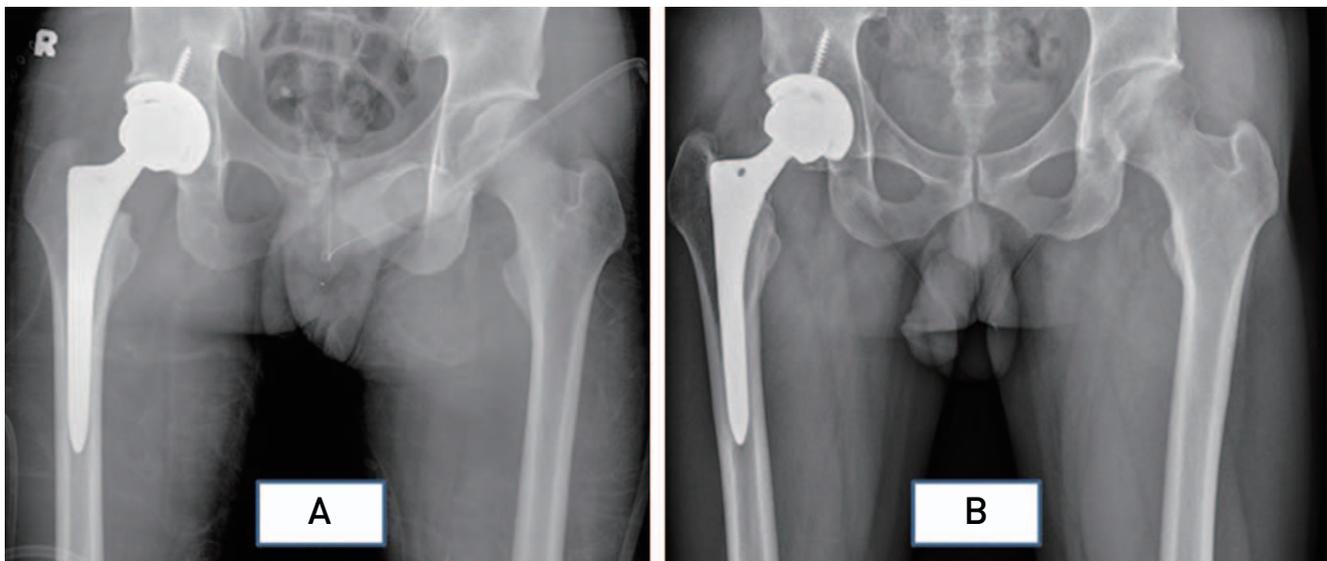


Fig. 1. A man aged 22 years underwent with primary total hip replacement arthroplasty with 36 mm femoral head due to femur neck pathologic fracture due to benign bone tumor, anteroposterior view of postoperation (A) and of 139 months after index operation (B).

years), and mean follow-up duration was 83 months (62-139 months). A cementless acetabular cup with a porous coating (Trilogy[®]; Zimmer Inc., Warsaw, IN, USA) and a HXLPE with an inner diameter of 36 mm (Longevity[®]; Zimmer Inc.) were placed in all patients. Acetabular components had an average outer diameter of 54 mm (range, 50-60 mm). The polyethylene liners were machined from GUR (Zimmer Inc.) 1050 polyethylene, which had been pre-heated and cross-linked with a 9.5 Mrad electron-beam. The preforms were then melted to eliminate the remaining free radicals and sterilized using a gas plasma. Fiber Metal Taper (FMT[®]; Zimmer Inc.) components were used in 32 cases underwent cementless femoral fixation (Fig. 1) and Versys[®] (Zimmer Inc.) components in 9 cases underwent cemented femoral fixation.

All surgical procedures was modified Hardinge's approach with the patient in the lateral position. All acetabular components were inserted using a press fit technique with under reaming of the acetabulum by 1 to 2 mm. To secure initial mechanical stability of the acetabular component, we used adjunctive acetabular screw when needed. If cementless femoral stem had a rotational instability when subject to rotational stress

test after femoral trial stem insertion, we used cemented femoral fixation regardless of patient's age. All cementless stems were inserted using standard press fit techniques to insure longitudinal and rotational stability, and all cemented femoral stems were inserted using meticulous third generation cementing techniques. Prophylactic antibiotics were administrated to all 41 cases, and the same postoperative protocol was used in all. Patients were allowed to sit on the first postoperative day and stand with supports, according to ability, after blood drainage removal. No range of motion limitation was present immediately after surgery, and no abduction pillow was used in any patient.

Patients were followed at 6 weeks, and at 3, 6, and 12 months postoperatively. After then, we asked patients to visit every 6 months. The clinical and radiographic examinations were performed by another orthopedic surgeon. Clinical follow-ups included specific assessments of possible dislocation. In addition, modified Harris hip scores (HHS) and Merle d'Aubigne and Postel score were determined. Modified HHS were classified as excellent (91-100), good (81-90), fair (71-80), or poor (61-70), and the Merle d'Aubigne and Postel scores were used to categorize patients to six grades according

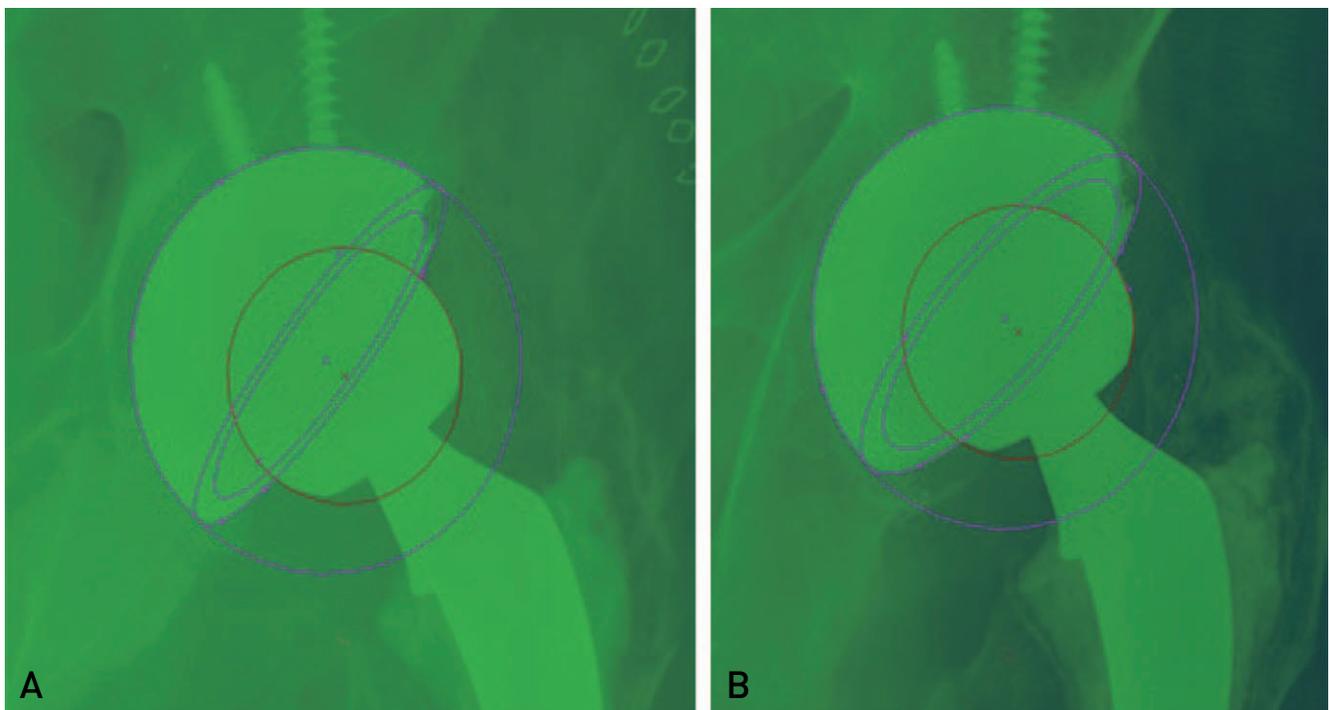


Fig. 2. If we designate 3 points at outer-shape of head and cup, PolyWare Pro three-dimensional program (distal version 5.10; Draftware Inc., Vevay, IN, USA) make circle-line automatically. The program calculates the penetration rate with comparing between initial X-ray circle line (A) and follow-up X-ray circle-line (B).

to level of pain (1-6), mobility (1-6), and the ability to walk (1-6). In cases that underwent uncemented fixation, the status of fixation of femoral component was assessed using the method of Engh et al.¹¹⁾, and in cases that underwent cemented fixation, femoral components were assessed the amount of cement filling using the method of Barrack et al.¹²⁾, using immediate postoperative radiographs. All radiographic examinations included an anteroposterior (AP) view of the pelvis centered over the pubis, and axial view by a shoot through lateral of the hip. Acetabular cup abduction angles were measured using the methods of Engh et al.¹³⁾ and Kennedy et al.¹⁴⁾. Acetabular cup anteversion angles were measured using the method of Widmer¹⁵⁾. The evidence of linear radiolucencies, bony ingrowth, fracture, and osteolysis were determined using sequential radiographic views, which also allowed comparative assessments of component position versus immediate postoperative views to determine the presence of component migration and/or loosening.

Penetrations of femoral head into polyethylene liners were calculated as two-dimensional linear penetrations on AP radiographs of the pelvis using PolyWare Pro three-dimensional distal version 5.10 software (Draftware Inc., Vevay, IN, USA) by well-trained one chief resident. At intervals of one week, one resident measured wear rates twice. We regarded wear rates as average of two values (Fig. 2). In this program, wear rate is calculated through the 3-point marked on edges of the femoral head and acetabular cup using serial plain radiograph. This program allowed us to know volumetric wear size using pelvis AP and axial view. However, hip axial showed irregularity could make some errors of measuring wear rate. So, we decided to check linear wear rate using serial pelvis AP view only. We checked bedding in state wear using postoperative and post one year operative pelvis AP view¹⁶⁾. To check steady state wear rate, we used postoperative one year and final follow-up pelvis AP view. This program divided the result with the number of year and let us know annual wear rate automatically.

RESULTS

Average modified HHS at final follow-up was 87 ± 5 (range, 81-98), and it was better than 'good' in all cases, and Merle d'Aubigne and Postel scores were more than 15 (range, 15-18) in all cases. Radiographic final

follow-up exams showed stable fixation in all patients with uncemented femoral components, and Barrack type A or B in all patients with cemented femoral components. Mean acetabular cup inclination and anteversion were 45.81° (range, 36.33° - 54.91°) and 13.26° (range, 6.72° - 27.71°), respectively. There was no radiographic evidence of osteolysis in the pelvis or proximal femur, and no acetabular cup or femoral stem failing due to aseptic loosening. But, one patient developed a hip dislocation.

In all patients, average femoral head penetration during the first postoperative year (predominantly representing polyethylene creep) was 0.064 ± 0.002 mm/year, and the average steady-state wear rate determined using radiographs taken at one year postoperatively and at latest follow-up was 0.042 ± 0.001 mm/year.

DISCUSSION

Surgeon must focus on two aspects when conducting primary THA to younger patients. First is high activity of young cohort, second is patient's remained long life span. This condition will result in more wear rates of articulation surfaces compared with old. Improvement in prosthetic design and bearing surfaces has eliminated in concerns of wear problem in younger patients. Many surgeons advocated using CoC bearing surface. CoC bearings showed less than 0.001 mm/yr wear rate *in vitro*¹⁷⁾. However, concerns of CoC bearing surface's negative property remained^{18,19)}. Besides problems of squeaking and fracture of ceramic head, some paper reported possibility of increasing stress on trunnion compared with metallic head when using big size of femoral head²⁰⁾.

Our institute has used 36 mm metal head coupling with HXLPE as an articulation surface regardless of patient's age. It has been shown that HXLPE wear rates decreased by 58% to 74% over the ultra-high molecular weight polyethylene *in vitro* study²¹⁾. During midterm follow-up for this cohort, steady-state wear rate was 0.042 ± 0.001 mm/year. This result is less than 0.1 mm/year regarded as osteolysis threshold wear rate established by Dumbleton et al²²⁾. But, there are also some trade-offs in using 36 mm metal head coupled with HXLPE. This highly cross-linking is made by exposures of gamma radiation. Unfortunately, the increase in gamma radiation dose is associated with the

degradations of other mechanical properties including a decrease in tensile yield strength and fatigue strength and resultant liner breakage²³). Previously, our institute reported a liner rim area breakage case in THA after using 1st generation HXLPE mated against 36 mm metal head²¹). This patient was 58 years old male suffered from osteonecrosis of femoral head. There are few reports of 1st generation HXLPE breakage²⁴). Majority of these reports pointed out high body mass index (BMI), improper acetabular cup position, thin liner thickness and impingement between femoral stem and liner, etc. as causes of liner breakage. This patient belonged to normal BMI and proper acetabular cup position so called 'safe zone' on radiographs. We assumed thin liner thickness as the possible causative factors for liner breakage. So, we conducted revision with larger acetabular cup than index operation to apply thicker liner. The average liner thickness of this 41 cohorts was 7.46 mm (range, 6.8-9.9 mm). In this cohort, there was no liner breakage during follow-up periods.

During follow-ups, one patient developed a hip dislocation. She sustained car accident and had injury of femoral head posterior dislocation with acetabular fracture. After acetabular fracture fixation, she underwent THA due to secondary hip osteoarthritis. After one year of operation, she had a dislocation. In this patient, anteversion of the index cup was 8°. The patient underwent isolated acetabular revision just after second dislocation, and has done routine indoor activity well since then.

Our study has some limitations. First, we did not evaluate the volumetric wear. There were some reports 36 mm metal head could result in high volumetric wear compared with 28 mm metal head²⁵). PolyWare software could measure volumetric wear size using pelvis AP and axial view. However, hip axial we conducted during follow-up periods showed irregularity could result in some errors of measuring wear rate. So, we decided to check linear wear rate using serial pelvis AP view only. Second, cohort distribution leaned much towards inflammatory disease. Among 41 cases, inflammatory disease including rheumatoid arthritis and ankylosing spondylitis were 18 cases. It is well known inflammatory disease cohort show a lower activity compared with other disease cohort²⁶). Third, our study has some limitations on measuring wear rate. As to method of wear measurement, radiostereometric analysis (RSA) is

the most accurate tool for *in vivo* assessment of polyethylene wear²⁷). However, many radiographic *in vivo* studies of polyethylene wear in THA are restricted to measurements on plain radiographs because the RSA set-up is expensive and not widely available. Our institute used PolyWare software, which uses plain radiographs. PolyWare software does not supply the accuracy required, and for such situations we recommend RSA. For assessment of medium-term or long-term wear measurements in larger groups of patients, It is known as the PolyWare method is optimal, simple, and in relatively close agreement with the gold standard of RSA.

CONCLUSION

Based on this finding, we think 36 mm metal head coupling with HXLPE as the good alternate articulation surface when planning THA for patients aged 50 years and less.

CONFLICT OF INTEREST

The authors declare that there is no potential conflict of interest relevant to this article.

REFERENCES

- Schmalzried TP, Jasty M, Harris WH. *Periprosthetic bone loss in total hip arthroplasty. Polyethylene wear debris and the concept of the effective joint space. J Bone Joint Surg Am. 1992;74:849-63.*
- Babovic N, Trousdale RT. *Total hip arthroplasty using highly cross-linked polyethylene in patients younger than 50 years with minimum 10-year follow-up. J Arthroplasty. 2013;28:815-7.*
- Delasotta LA, Rangavajjula AV, Porat MD, Frank ML, Orozco FR, Ong AC. *What are young patients doing after hip reconstruction? J Arthroplasty. 2012;27:1518-25.e2.*
- Heisel C, Silva M, Schmalzried TP. *Bearing surface options for total hip replacement in young patients. J Bone Joint Surg Am. 2003;85:1366-79.*
- Yoo JJ, Kim YM, Yoon KS, Koo KH, Song WS, Kim HJ. *Alumina-on-alumina total hip arthroplasty. A five-year minimum follow-up study. J Bone Joint Surg Am. 2005;87:530-5.*
- Bistolfi A, Crova M, Rosso F, Titolo P, Ventura S, Massazza G. *Dislocation rate after hip arthroplasty within the first postoperative year: 36 mm versus 28 mm femoral heads. Hip Int. 2011;21:559-64.*
- Geller JA, Malchau H, Bragdon C, Greene M, Harris WH, Freiberg AA. *Large diameter femoral heads on highly cross-linked polyethylene: minimum 3-year results. Clin*

- Orthop Relat Res.* 2006;447:53-9.
8. Hannouche D, Devriese F, Delambre J, et al. *Ceramic-on-ceramic THA implants in patients younger than 20 years.* *Clin Orthop Relat Res.* 2016;474:520-7.
 9. Kim YH, Choi Y, Kim JS. *Cementless total hip arthroplasty with ceramic-on-ceramic bearing in patients younger than 45 years with femoral-head osteonecrosis.* *Int Orthop.* 2010;34:1123-7.
 10. Sentuerk U, von Roth P, Perka C. *Ceramic on ceramic arthroplasty of the hip: new materials confirm appropriate use in young patients.* *Bone Joint J.* 2016;98-B(1 Suppl A):14-7.
 11. Engh CA, Bobyn JD, Glassman AH. *Porous-coated hip replacement. The factors governing bone ingrowth, stress shielding, and clinical results.* *J Bone Joint Surg Br.* 1987;69:45-55.
 12. Barrack RL, Mulroy RD Jr, Harris WH. *Improved cementing techniques and femoral component loosening in young patients with hip arthroplasty. A 12-year radiographic review.* *J Bone Joint Surg Br.* 1992;74:385-9.
 13. Engh CA, Griffin WL, Marx CL. *Cementless acetabular components.* *J Bone Joint Surg Br.* 1990;72:53-9.
 14. Kennedy JG, Rogers WB, Soffe KE, Sullivan RJ, Griffen DG, Sheehan LJ. *Effect of acetabular component orientation on recurrent dislocation, pelvic osteolysis, polyethylene wear, and component migration.* *J Arthroplasty.* 1998;13:530-4.
 15. Widmer KH. *A simplified method to determine acetabular cup anteversion from plain radiographs.* *J Arthroplasty.* 2004;19:387-90.
 16. Penmetsa JR, Laz PJ, Petrella AJ, Rullkoetter PJ. *Influence of polyethylene creep behavior on wear in total hip arthroplasty.* *J Orthop Res.* 2006;24:422-7.
 17. Willmann G. *Ceramic femoral head retrieval data.* *Clin Orthop Relat Res.* 2000;(379):22-8.
 18. Capello WN, D'Antonio JA, Feinberg JR, Manley MT, Naughton M. *Ceramic-on-ceramic total hip arthroplasty: update.* *J Arthroplasty.* 2008;23(7 Suppl):39-43.
 19. Jarrett CA, Ranawat AS, Bruzzone M, Blum YC, Rodriguez JA, Ranawat CS. *The squeaking hip: a phenomenon of ceramic-on-ceramic total hip arthroplasty.* *J Bone Joint Surg Am.* 2009;91:1344-9.
 20. Nam D, Barrack T, Johnson SR, Nunley RM, Barrack RL. *Hard-on-hard bearings are associated with increased noise generation in young patients undergoing hip arthroplasty.* *Clin Orthop Relat Res.* Published online February 24, 2016.
 21. Lee JH, Lee BW, Lee BJ, Kim SY. *Midterm results of primary total hip arthroplasty using highly cross-linked polyethylene: minimum 7-year follow-up study.* *J Arthroplasty.* 2011;26:1014-9.
 22. Dumbleton JH, Manley MT, Edidin AA. *A literature review of the association between wear rate and osteolysis in total hip arthroplasty.* *J Arthroplasty.* 2002;17:649-61.
 23. Pruitt LA. *Deformation, yielding, fracture and fatigue behavior of conventional and highly cross-linked ultra high molecular weight polyethylene.* *Biomaterials.* 2005;26:905-15.
 24. Tower SS, Currier JH, Currier BH, Lyford KA, Van Citters DW, Mayor MB. *Rim cracking of the cross-linked longevity polyethylene acetabular liner after total hip arthroplasty.* *J Bone Joint Surg Am.* 2007;89:2212-7.
 25. Johnson AJ, Loving L, Herrera L, Delanois RE, Wang A, Mont MA. *Short-term wear evaluation of thin acetabular liners on 36-mm femoral heads.* *Clin Orthop Relat Res.* 2014;472:624-9.
 26. Mont MA, Maar DC, Krackow KA, Jacobs MA, Jones LC, Hungerford DS. *Total hip replacement without cement for non-inflammatory osteoarthritis in patients who are less than forty-five years old.* *J Bone Joint Surg Am.* 1993;75:740-51.
 27. Stilling M, Larsen K, Andersen NT, Søballe K, Kold S, Rahbek O. *The final follow-up plain radiograph is sufficient for clinical evaluation of polyethylene wear in total hip arthroplasty. A study of validity and reliability.* *Acta Orthop.* 2010;81:570-8.