Chronological Changes Of Functional Cup Positioning At A Minimum Follow-up Of 7 Years After Total Hip Arthroplasty

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Introduction: Positioning of the acetabular cup has a significant effect on the postoperative outcome of total hip arthroplasty (THA). Cup malpositioning can cause impingement and edge loading, possibly resulting in dislocation, polyethylene wear, and aseptic loosening. Recently, several authors proposed the concept of functional cup positioning defined as the combination of the implant alignment in bone and pelvic orientation in relation to the body. Patients showing a significant difference between radiographic and functional cup positioning ideally require a unique adjustment in cup positioning to maximize stability and range of motion. Previous studies reported contradictory results regarding predictability of postoperative pelvic orientation. Furthermore, considering the long-term results of THA, postoperative chronological changes of pelvic orientation should be also taken into account. While the pelvic tilt is considered as a major determinant of the functional cup positioning, previous studies have found mixed results for its postoperative changes. These studies have relatively short follow-up periods and as such do not necessarily reflect progressive degenerative changes with aging. The purpose of this study was to clarify the chronological changes of functional cup positioning at a minimum follow-up of 7 years after THA and to identify risk factors for a significant difference between radiographic and functional cup positioning.

Methods: Between March 2002 to December 2005, 92 primary THAs were performed for unilateral hip osteoarthritis. Fourteen patients were lost to follow up. Thirty-four patients were excluded from this study because the radiographs were not suitable for evaluation. Therefore, a total of 44 patients were included in this study. Anteroposterior pelvic radiographs in supine and standing position were obtained before, 3 weeks after, and every year after the surgery. Lateral pelvic radiographs in supine and standing position were obtained before the surgery. At the final follow-up, all patients were asked if they had vertebral fractures or spinal surgeries during postoperative follow-up period.

The pelvic tilt in the sagittal plane was expressed as APP angle, which was measured on lateral pelvic radiographs. Radiographic cup positioning was measured on anteroposterior pelvic radiographs in supine position, while functional cup positioning was measured in standing position. Statistical analysis was performed with the SPSS 16.0 software. Chronological changes in the functional cup positioning were evaluated with one-way ANOVA with repeated measurements. A multiple regressions analysis was conducted to determine which of pre- and post-operative variables were significantly correlated with the differences in angles between radiographic and functional cup positioning at the final follow up. Potential explanatory variables included age, sex, preoperative APP angle in supine and standing position, the difference in preoperative APP angle between supine and standing position (dAPP), and a history of vertebral fractures or spinal surgeries during postoperative follow-up period. A significant difference was set at p < 0.05.
Results: There were 41 females and 3 males. The mean age of patients at surgery was 67 years old (range 36-81), and the mean follow up period was 9 years (7-11). All implants showed radiographic stability and absence of radiolucent lines at the final follow-up.

The mean pre-operative APP angle was $-8.8° (-40.2$ to $4.8)$ in standing position, $-2.6° (-27.6$ to $11.7)$ in supine position, and the mean dAPP was $-6.2° (-32.4$ to $7.0)$. Positive values of the dAPP represent a change toward forward rotation of the pelvis, while negative values represent a change toward backward rotation of the pelvis.

Functional cup anteversion (F-Ant) and abduction (F-Abd) immediately after surgery were significantly greater than radiographic cup anteversion (R-Ant) and abduction (R-Abd) respectively. The differences between F-Ant and R-Ant significantly increased over time ($F = 3.832, p = 0.011$), while the differences between F-Abd and R-Abd did not(Fig.1). The percentages of patients with cup positioning inside Lewinnek’s safe zone significantly decreased from 71% to 41% at the final follow-up ($p<0.001$)(Fig.2). Preoperative posterior pelvic tilt in standing position and spinal fractures / surgeries after THA were significant predictors of increasing F-Ant.

![Fig.1: Chronological changes in angle differences between radiographic and functional cup positioning. *p<0.05 vs After 3w.](image1)

![Fig.2: Scatter diagrams showing the distribution of radiographic cup positioning at 3 weeks after surgery (a),](image2)
functional cup positioning at 3 weeks after surgery (b), and functional cup positioning at the final follow-up (c).

**Discussion:** The most important findings in this study were: 1) Functional cup anteversion significantly increased over 7 years’ follow-up period, resulting in more outliers compared to immediately after surgery. 2) Preoperative posterior pelvic tilt in standing position and spinal fractures / surgeries after THA were significant predictors of increasing functional cup anteversion. Although radiographic cup positioning immediately after surgery was almost acceptable, functional cup positioning at the final follow-up was outside the Lewinnek’s safe zone in more than half of patients. This study strongly supports the concept of functional cup positioning. Surgeons should be aware of differences between radiographic and functional cup positioning, as well as the chronological changes of functional cup positioning. Our results showed that only functional cup anteversion, not abduction, significantly increased over 7 years follow-up period. Sagittal spinopelvic alignment is more affected by aging than coronal alignment. Aging of the spine is characterized by facet joint arthritis, degenerative discs, degenerative lumbar diseases and atrophy of extensor muscles, resulting in a loss of lumbar lordosis and an increase of pelvis tilt. Patients with such degenerative changes in the spine are potential candidates for spinal surgeries. In addition, vertebral fractures frequently occur in the aging spine. Therefore, attention should be paid to the postoperative changes of spinopelvic alignment especially in the sagittal plane. Because anteroposterior pelvic radiographs in standing position are more influenced than in supine position by the postoperative changes of spinopelvic alignment, postoperative follow-up examinations should include anteroposterior pelvic radiographs in standing position. In conclusion, functional cup anteversion significantly increased over 7 years’ follow-up period, resulting in more outliers compared to immediately after surgery. Preoperative posterior pelvic tilt in standing position and spinal fractures / surgeries after THA were significant predictors of increasing functional cup anteversion. The chronological changes of functional cup positioning should be taken into account to achieve long-term success in THA. We recommend that cup anteversion should be reduced by approximately 10° in patients with large posterior pelvic tilt in standing position.

**Significance:** Functional cup anteversion significantly increased over 7 years’ follow-up period, resulting in more outliers compared to immediately after surgery.

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