Original Article

No Association between Acetabular Erosion and Functional Outcomes in Moore's Endoprosthesis

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Background: The use of a cemented Moore's endoprosthesis is a very common procedure for osteoporotic hip fracture treatment in Thailand due to its relatively low cost, low dislocation rate, and short operating time. Recently, increasing concern over acetabular erosion has ignored the use of this implant.

Objective: To analyze the effects of acetabular erosion after Moore's endoprosthesis on the functional outcomes.

Materials and Methods: Fifty patients (male 23:female 27, age 61 to 93 years) who undergone Moore's unipolar hemiarthroplasty (HA) due to an osteoporotic femoral neck fracture in Chiang Mai University Hospital between 2010 and 2012 were included in the present retrospective cohort study. The effects of acetabular erosion on Harris Hip Score (HHS) functional outcomes were analyzed.

Results: The acetabular erosions were observed about 22%, 46%, and 59% after the first 12 months, 24 months, and 36 months of the implantations, respectively. Half of the patients after Moore's HA had acetabular erosion at 30.9 months. Patients 75 years or older increased 1.6 times the risk of acetabular erosion after three years follow-up. However, occurrence of acetabular erosion did not result in worse outcomes at three years after the replacements (p=0.818).

Conclusion: Physicians can overlook acetabular erosion after Moore's HA and concentrate on surgical techniques that closely restore the native hip geometry with Moore's prostheses.

Keywords: Femoral neck fracture, Hemiarthroplasty, Acetabular erosion, Hip replacement

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In Thailand, osteoporotic hip fractures are a significant and growing health problem. Over the ten year period between 1995 and 2005, the incidence of osteoporotic hip fractures has increased at an average of 2% per year[(1)], commensurate with the rapid aging of the population of the country. One of the most challenging problems in osteoporotic fractures is femoral neck fracture because it is associated with higher morbidity and mortality rate. The goal of femoral neck fracture treatment is a restoration of hip function to pre-fracture level without associated morbidity. Displaced femoral neck fractures in individuals age over 65 years have been commonly treated with either bipolar or unipolar hemiarthroplasty (HA). The unipolar head has a single articulation between the prosthesis and the acetabulum, while the bipolar has both an inner and an outer articulation. Although the bipolar head allows the surgeon to adjust limb length and hip offset to be closer to the patient's anatomy, the cost of this implant is higher than the unipolar. For that reason, most developing countries prefer using unipolar HA such as the Austin Moore and the Thompson prostheses.

The Thompson prosthesis is usually used with cement, whereas the Moore prosthesis uses no cement. Furthermore, the Moore prosthesis is frequently preferred due to the presence of calcar loading as it helps maintain the load transfer function of the calcar bone. In addition, previous studies have reported shorter operative times for unipolar HA compared to bipolar HA.

Another alternative, a modified Moore's prosthesis using cement, can achieve better control of thigh pain

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and improve mobility with less use of walking aides than an uncemented Moore's prosthesis[2]. However, with the cemented modification, there are major disadvantages including greater risk of early hip pain, implant failure, non-modularity, acetabular erosion, and protrusion.

Acetabular erosion is a very severe complication of both unipolar and bipolar HA that can occur within the first five years post-operatively. That erosion of the acetabular cartilage can result from direct injury, excessive pressure on the cartilage due to a lengthening of the leg, local stress concentration due to a mismatch between the acetabulum and the prosthetic head diameters, and penetrative wear of the hard-metallic head against soft articular acetabular cartilage. Degeneration of the articular cartilage has been found to increase with time after HA[3]. In animal studies, the majority of the cartilage loss occurred by 24 weeks after HA, which resulted from cartilage degeneration after an intense subchondral bone activity[4].

Bipolar HA has been advocated for the treatment of femoral neck fracture in active patient based on reports of positive outcomes in the previous studies[5,6]. However, the counterpart study has failed to document any advantage of bipolar over unipolar component[7]. The degree of erosion from an unipolar prosthesis would be expected to be higher due to the abrasive wear caused by the metallic head[8], however, Zhou et al[9] argued that there was a similar rate of acetabular erosion with both unipolar and bipolar HA. There is currently no agreement regarding whether bipolar or unipolar is more advantageous for the elderly. However, there is a consensus that unipolar HA in younger patients results in a higher incidence of acetabular erosion resulting from the fact that younger people are more active.

Acetabular erosion is considered one of the important factors influencing functional outcome and pain. Early revision is required if there was a significant progression of acetabular erosion. Although Moore's prosthesis is a more cost-effective implant with shorter operative time, the risk of acetabular erosion is a concern when making an implant selection. The present study aimed 1) to quantify the risk of acetabular erosion after Moore's HA, 2) to evaluate the predictors for acetabular erosion, and 3) to compare any correlation between acetabular erosion and hip functional outcome after Moore's HA.

Materials and Methods

Fifty cases of osteoporotic femoral neck fracture treated with Moore's HA at Chiang Mai University between 2010 and 2012 were included in the present retrospective cohort study. The research protocol was approved by the Medicine Research Ethics Committee, ID ORT-2556-01903, from Chiang Mai University.

The sample size was estimated using a pilot study with matched gender and side. Femoral neck fractures attributed to causes such as pathologic fractures and high-velocity trauma in young adults were excluded since HA is not the standard treatment in those cases. In addition, patients with a hip disease that distorts the normal anatomy (e.g., avascular necrosis of the femoral head, dysplasia, Paget's disease, femoroacetabular impingement, and rheumatoid arthritis) and those with hip osteoarthritis, mental illness, or previous hip surgery were excluded. Patients with incomplete data were also excluded. Hence, 50 patients (23 males and 27 females) with an average age of 77 years (range 61 to 93 years) were included in the present study cohort. All patients had been fixed with cement (PALACOS; Heraeus, Germany).

Demographic data of the patients were collected including gender, age, and walking status. All operations were performed using the same posterior approach. Clinical and radiological outcomes follow-up over a period of at least two years were analyzed at 1, 3, 6, 12, 18 and 24 months after surgery, and annually thereafter. Harris Hip Score (HHS) was used to measure pain and walking outcome; scores were recorded three years after replacement[10].

Standard digitized anteroposterior X-rays of both hips in the supine position were used in measuring the degree of acetabular erosion. Although plain radiography could not directly image cartilage erosion, using the landmarks of Kohler's line (▲) allowed detection of protrusio acetabuli (acetabular protrusion)[11] as shown in Figure 1. However, the accuracy of that line depends on the angle of pelvic tilt[12]. Wada et al[13] identified the presence of acetabular erosion by measuring the distance from the upper margin of the acetabulum to the outer head of the prosthesis. However, this technique was not suitable as it was subject to a high error of measurement (SE 2 mm)[13,14]. Santos et al modified the Wada technique, using the joint line width (w) instead of the upper margin of the acetabula. A joint line decrease of more than 0.3 mm within two years or 0.4 mm in three years indicates acetabular erosion[12]. All identifications of the X-ray film were blinded with coding. The authors measured the degree of acetabular erosion using the distance between the limits of the prosthetic head and

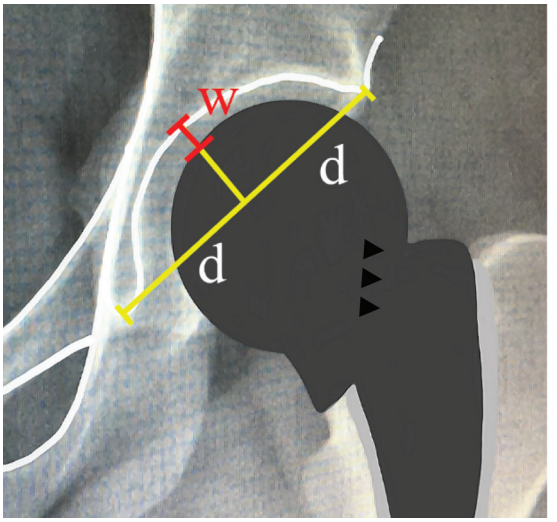

Figure 1. The method used for acetabular erosion measurement (w).

▲ indicates Kohler's line

Table 1. Demographic data of osteoporotic femoral neck fracture patients

	n = 50
Age	
<75 years (mean±SD, 67±6)	28
≥75 years (mean±SD, 82±7)	22
Gender	
Male	23
Female	27
Side	
Right	24
Left	26
Preoperative ambulatory status	
Independent ambulation	50
Assisted ambulation	-
Non-ambulation	-

a joint line measured perpendicular to the mid-point of the line (d) intersecting those structures[15] (Figure 1).

The Kaplan-Meier survival analysis was used to estimate survival variables. The log-rank test was used to compare acetabular erosion distribution. Spearman's rank-order correlation was used to assess the relationship between follow-up time and erosion. Logistic regression was used to predict the proportion of patients developing erosion as well as to study the correlation between a level of erosion and a combination of levels of other variables such as age, gender, and period of an implant in situ. The odds ratio for each variable was calculated and gave information about the relative changes that occurred in any factor. Results were considered significant at p-value smaller than 0.05.

Results

The average age of osteoporotic femoral neck fracture patients at Chiang Mai University treated with Moore's prosthesis during the period of the present research was 77 years (range 61 to 93 years). The patients were categorized into subgroups for further comparisons between the younger than 75 years and 75 years and older, since serious mental and physical debilitation increases after 75 years and is considered as a middle and very old age[16,17]. In the present cohort, all 50 cases (male:female 23:27) had independent ambulatory status prior to the injuries and underwent a hip replacement with a cemented Moore's prosthesis using a posterior approach. There was no hip dislocation and periprosthetic joint infection after the replacement. Demographic data of the patients are shown in Table 1.

Radiographic measurements are necessary because acetabular erosion cannot be accurately measured based on only clinical scores obtained in telephone interviews with patients. The use of radiologic measurements to evaluate acetabular erosion and protrusion is crucial. The incidence of acetabular erosion was recorded at each follow-up period. It is clear that the incidence of acetabular erosion increased exponentially with the period of an implant in situ (correlation efficiency 0.98) (Figure 2). In the first-year post-replacement, the chance of measurable acetabular erosion was about 22%. At the 24-month follow-up period, 23 of 50 patients (46%) with Moore's prostheses displayed acetabular erosion. At the 36-month follow-up, the numbers were 29 of 50 patients (59%). This demonstrated that the acetabular erosion was significantly correlated with the period of an implant in situ (p=0.008).

Survival analysis after Moore's HA using the occurrence of acetabular erosion as the end outcome was evaluated. The median probability of acetabular erosion after Moore's HA was 30.9 months, as illustrated by Kaplan-Meier estimation curve (Figure 3a). That means acetabular erosion can be expected to occur in 50% of the cases treated with Moore's endoprosthesis within two and a half years

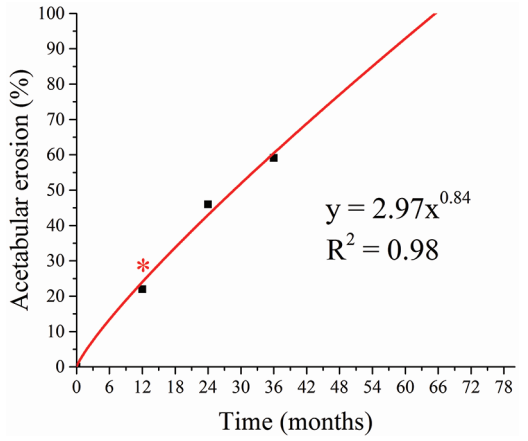

Figure 2. Percentage of patients with acetabular erosion after Moore's prosthesis

* indicating the statistical significance

after the replacement. In the present cohort, male developed acetabular erosion earlier than females (a mean time of 30.97 versus 34.10 months). However, no statistically significant difference in erosion probability was observed between male and female (log-rank test, Chi-square, p=0.778) (Figure 3b).

At three years after Moore's HA, female patients (53% versus 46%) and age 75 years or older (54% versus 42%) had a higher risk of acetabular erosion when compared to male and age less than 75 years. Considering other confounding variables including 1) age, 2) gender, and 3) time periods after Moore's HA using logistic regression, any patient with Moore replacements of more than 12 months significantly increased a risk for acetabular erosion regardless to age and gender (p=0.008). Although both gender and age had no statistically significant predictors for acetabular erosion in the present cohort, patients whose age is 75 years or older increased the risk of acetabular erosion 1.6 times more than those under 75 (odds ratio 1.6, p=0.419). Either male or female shared the same risk for acetabular erosion (odds ratio 0.9, p=0.886).

After the hip replacements, all patients could walk with a cane or walking aids. Although some patients tried to walk independently, they were advised to use walking aids to prevent future falls. Analyzing within a pain subset of the HHS, 58% of the patients had no pain (score 44), 26% had slight pain with no compromise in activity (score 40), and 16% had mild pain with no effect on average activity (score 30). No significant correlation between HHS pain score and acetabular erosion was observed in the present

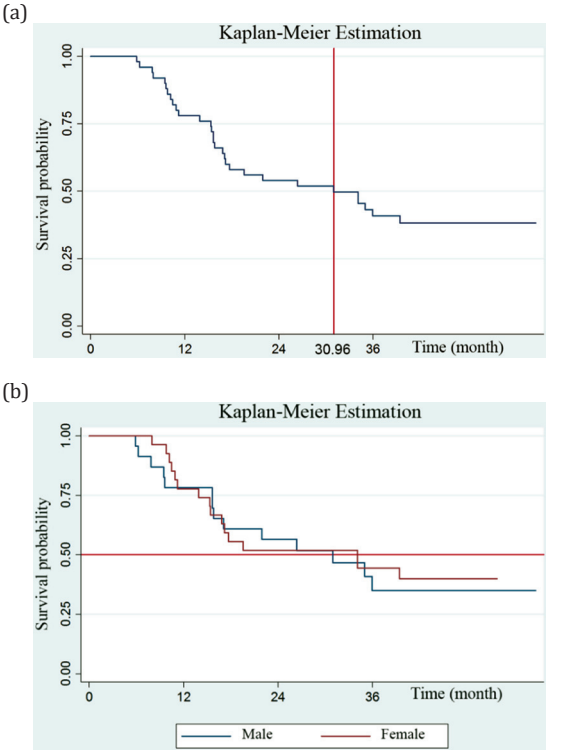

Figure 3. Kaplan-Meier survivor estimation of acetabular erosion for patients treated with Moore's HA (a), and distribution curve of acetabular erosion between male and female (b).

study (p=0.818). None of the patients with acetabular erosion had symptoms significant enough to justify a reoperation.

Discussion

A high rate of acetabular erosion after Moore's HA was observed in the present cohort. At the 24-month follow-up, 46% of the patients with Moore's HA displayed acetabular erosion; 59% did so at the 36 months follow-up. The median time for the onset of acetabular erosion was 30.96 months after the replacement. Similar results were reported by Inngul et al[18], with a unipolar HA group displaying an initially high incidence of acetabular erosion (16% of patients after four months), but with no further increase over time. Hedbeck et al[8] reported that at the 12-month follow-up, 10 of 49 patients (20%) in the unipolar HA group displayed acetabular erosion. Baker et al[19] reported acetabular erosion in 21 of 32 patients treated with a unipolar HA after a mean follow-up of 39 months, an overall rate of acetabular erosion of 66%. Despite the unipolar HA, bipolar HA

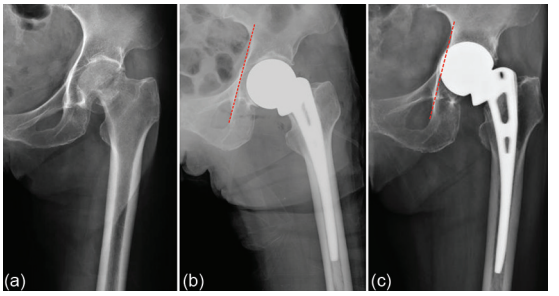

Figure 4. Femoral neck fracture treated with Moore's prosthesis (a), Kohler's line (dash line) illustrating acetabular erosion (b), and illustrating protrusio acetabuli after two years (c).

also led to acetabular erosion[9,20-22]. Jia et al[23] reported a similar incidence of erosion between unipolar and bipolar was observed two years post-operatively. The causes of acetabular erosion are multifactorial including patient factors, degrees of activity demands, and implant factors.

Patients 75 years of age or older had 1.6 times risk of acetabular erosion than patients under 75 years. The increased incidence of erosion in older patients (75 years of age or older) may be the result of degenerative cartilages and bones being more fragile, i.e., greater differences between the properties of the metallic head and the natural bone. Thus, in the case of elderly patients, a higher incidence of erosion could be expected.

Although acetabular erosion was significantly greater observed after the first year of Moore's HA, there was no relation between acetabular erosion and clinical outcome. Pain and walking ability did not decline significantly three years post-implantation in patients with radiological evidence of erosive deterioration.

In terms of patients' activity status, Moore's HA is better suited for low-activity patients. High load and shear stress contributing to wear and osteolysis of acetabular bone are more common for unipolar HA since metallic head rolls directly on the acetabulum. A cadaveric motion study of bipolar prostheses showed motion occurred at both inner bearings with the stems loaded at less than 10 kg. If a loading of 20 kg or more is applied, only the outer articulation can move and leads to no difference of motions between unipolar and bipolar HA[9]. Therefore, an increased rate of acetabular erosion is observed more often in younger patients (60 to 74 years) with bipolar HA, since higher activity levels were expected[24]. This indicates that using a bipolar HA for younger, more active patients can contribute to greater hip loading and greater acetabular wear, similar to the situation with Moore's prostheses.

In addition to penetrative wear of the hard metallic head against soft articular acetabular cartilage, erosion of the acetabular cartilage can also result from direct trauma, excessive pressure on the cartilage due to mismatched reconstruction between native hip and implanted hip[3]. Leg lengthening or shortening after implantations leads to local stress concentration and precipitate wear propagations. The lack of capability on adjusting offset, head-neck length, and hip version leads to abnormal loading on the hip joint resulting in acetabular erosion (Figure 4). Modular adjustment of the bipolar implant may minimize these potential problems.

The limitation of the present study is the low threshold of plain radiographic measurements for an acetabular erosion. Using CT and/or MRI techniques would detect the acetabular erosion earlier and more accurately. Another limitation is the follow-up time observed, which is only the first three years. Therefore, long-term correlations between the acetabular erosion and clinical outcomes are not available.

Although acetabular erosion after Moore's HA seems to be inevitable, it does not affect the outcome within three years after the operations. Groin pain and walking status after Moore's HA does not relate to acetabular erosion. The additional inner articulation of a bipolar HA also does not improve the functional outcomes[20,23]. Previously reported poor outcomes could have resulted from mismatched offset and neck-length between Moore's prosthesis and patient's hip anatomy. Improved surgical techniques and implant designs of Moore prostheses to restore normal hip anatomy accurately will increase patient functional outcomes.

Conclusion

The present study suggests that Moore's HA is a suitable implant option for patients with low activity demands. Moore's HA is also appropriate for developing countries that cannot afford the bipolar and total hip prostheses where the higher cost of those options could be prohibitive. Although Moore's HA in very old age (75 years or older) increases 1.6 times the risk of acetabular erosion 12 months post-surgery, it has no impact on clinical outcomes. Improvements in the offset design of Moore prostheses and surgical techniques to be more-closely mimicking the normal hip geometry could further increase the viability of this option. In terms of long-term outcome in active

patients under 75 years old and where cost is not a consideration, Moore's HA is definitely not the implant of choice.

In summary, the Moore's HA is a viable option for older patients with low functional demands. Even though a high rate of acetabular erosion is observed, there is no concern of worse outcome within three years after the replacement. Better outcome of Moore's HA would be expected if normal hip geometry would be restored.

What is already known on this topic?

Previous studies reported a high rate of acetabulum erosion after Moore's HA compared to total hip arthroplasty (THA). Therefore, clinical guidelines for treatment of osteoporotic femoral neck fracture ignored the use of Moore's HA for an expensive bipolar, and THA. There has not been any study that reported the consequence of acetabular erosion on functional outcome and failure of the implants.

What this study adds?

In countries where cost is the main consideration, the low-cost implant like Moore's prosthesis is still necessary. This study highlights key factors:

• Acetabular erosion is an unavoidable condition after Moore's HA, which mostly occurred at 30.96 months after the implantations.

• Although very-old age (75 years or older) increases the risk for acetabular erosion by 1.6 times, longer periods of implantation is the only factor predicting the acetabular erosion.

• The occurrence of acetabular erosion is not related to walking and pain outcomes after three years of Moore's HA.

Surgeons can ignore detecting the acetabular erosion after Moore's HA as it does not have any clinical significance. Moore's HA is still be an optional implant for low-active elderly patients.

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Conflicts of interest

The authors declare no conflict of interest.

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