



## Acetabular erosion following bipolar hemiarthroplasty: A role for the size of femoral head?



Paolo Schiavi<sup>a,\*</sup>, Francesco Pogliacomì<sup>a</sup>, Massimiliano Colombo<sup>b</sup>, Andrea Amadio<sup>a</sup>,  
Francesco Ceccarelli<sup>a</sup>, Enrico Vaienti<sup>a</sup>

<sup>a</sup> Orthopedic Clinic, Department of Medicine and Surgery, University of Parma, Parma, Italy

<sup>b</sup> Orthopedic and Traumatology Clinic 3, ASST Pini-CTO, Milan, Italy

### ARTICLE INFO

#### Article history:

Accepted 23 November 2018

#### Keywords:

Hemiarthroplasty  
Femoral fracture  
Acetabular erosion  
Femoral head  
Outcome  
Follow-up

### ABSTRACT

**Introduction:** Femoral neck fractures are the most frequent fractures in the elderly and hemiarthroplasty is the treatment of choice. The objective of this multicenter study is to identify predictive factors of acetabular erosion after bipolar hemiarthroplasty (bipolar surgery between 1997 and 2007) in a mobile independent population during a long-term follow-up of the patients.

**Materials and methods:** Data were prospectively collected and retrospectively analyzed. Inclusion criteria were: age >60 and <85 years, BMI <35, normal Abbreviated MiniMental Test score, ability to walk 0.8 km and live independently, non-pathological fracture, hip with no or minimal osteoarthritic changes, and availability of clinical and radiological follow-up. For each Patient were recorded: demographic data, comorbidities, time to fracture, surgery characteristics of the implant, duration of surgery. Patients included underwent clinical and radiological follow-up.

**Results:** Overall, 209 Patients met inclusion criteria. A press-fit implant was performed in 172 subjects; in contrast a cemented prosthesis was implanted in 37 patients. Nineteen patients underwent implant revision for total hip arthroplasty for acetabular erosion and pain. Classification of X-ray using Baker criteria showed a grade 0 in 51.5%, a grade 1 in 19.6%, a grade 2 in 18.1% and a grade 3 in 7.6%. Multivariate analysis revealed that the size of the femoral head (FH) was the only predictive factor of a higher risk of acetabular erosion. The Kaplan-Meier survival curve verified the risk of implant revision in Group 1 (FH sized >48 mm) and Group 2 (FH sized <48 mm). The probability of implant revision for acetabular erosion at ten years from surgery were 5.5% in Group 1 and 15.6% in Group 2.

**Conclusion:** In bipolar hemiarthroplasty smaller head size lead to a polar wear implying a higher risk of acetabular erosion and migration; in our population this risk was consistent with the use of implant head <48 mm diameter. Considering the absolute risk of a smaller FH size, the surgeon must evaluate the accuracy of measurement of the caliber, since the size can be significantly underestimated.

Published by Elsevier Ltd.

### Introduction

Femoral neck fractures are among the most frequent fractures in the elderly. Europe counts 100,000 new cases each year, and the incidence has been estimated to increase to 1 million by 2050 due to the progressive aging of the population. One year after the event mortality is between 15% and 30% and only 30%–40% of patient recover to the same degree of independence on daily living activities (DLA) they had before trauma [1–3]. Hemiarthroplasty (HA) is the treatment of choice for intracapsular fractures of the

proximal femur in elderly patients with low functional demands, because of its lower technical demand, fewer surgical time, less blood loss and simpler rehabilitation in comparison to total hip arthroplasty (THA) [4,5]. At the contrary, in younger patients with higher functional demands, especially under the age of 70, many authors report better functional and clinical results with THA [6,7]. Moreover in particular cases is reported as useful the implant of a dual mobility cup [8,9]. The risk of cotyloiditis has been described for HA, defined as progressive acetabular cartilage and bony erosion caused by friction between the head of the prosthesis and the articular surface of the acetabulum. This condition has been described as a possible cause of pain and subsequent revision to THA, but in literature there is a lack of study specifically analyzing predictive factor of acetabular erosion. The aim of this study is to investigate predictive facture of bone acetabular erosion after

\* Corresponding author at: Orthopedic Clinic, Department of Medicine and Surgery, University of Parma, Parma, Italy.  
E-mail address: [ppschiav@gmail.com](mailto:ppschiav@gmail.com) (P. Schiavi).

bipolar hemiarthroplasty in a mobile independent population during a follow-up of ten years.

## Materials and methods

The study was conducted in accordance with the Declaration of Helsinki and was approved by all of the participating hospital. The Authors set up the study following the ethical recommendations of National Law Guidelines for Clinical Study. All patients signed a specific informed consensus before surgery and during clinical examination. We collect the data of each patient assigning an ID and then the database was analyzed in an anonymous form protecting the privacy of the participants. No additional procedure or examination were performed on the subjects included in the study. No external funding was received.

The present multicenter study was conducted in the University Hospital of Parma (Trauma Center) and in the Hospital of Fidenza (period of surgery January 1997–May 2007). Data were prospectively collected and retrospectively analyzed. After admission to the Hospital, Patients with a diagnosis of a displaced fracture of the femoral neck were assessed with use of Oxford hip score (OHS), Womac Score (WS) and Abbreviated Mini Mental Test (AMMT) score to investigate the prefracture grade of autonomy. The inclusion criteria were an age of more than sixty and less than eighty-five years at time of surgery, a BMI < 35, a normal Abbreviated Mini Mental Test score 15, the ability to walk 0.8 km, the ability to live independently (without reliance on a caregiver), a non-pathological fracture, and a hip with no or minimal osteoarthritic changes. The exclusion criteria included: age of less than sixty or more than eighty-five years, medical or physical comorbidities that limited the walking distance to < 0.8 km, a preexisting hip abnormality requiring total hip arthroplasty, a pathological fracture secondary to malignant disease, need of implant revision for any cause different from acetabular erosion during the ten years of follow-up or incomplete data at follow-up.

For each Patient were recorded: demographic data, BMI, comorbidities, ASA score, time from fracture to surgery, characteristics of the implant (cemented/press-fit, length of neck, size of head), duration of surgery. The healing was verified with a caliber. The operations were performed by surgeons with similar levels of training.

Patients included in the study underwent a clinical and radiological follow-up at ten years.

Only alive subjects ten years after surgery were then considered for enrollment.

At clinical follow-up were recorded: Oxford hip score and Womac Score. The radiological final follow-up comprise: antero-posterior and lateral evaluation with quantification of acetabular erosion according with Baker classification [10].

## Statistical analysis

Statistical analysis was performed using SPSS 20.0. Descriptive statistics was calculated. Non-parametric tests were performed to correlate clinical and radiographic results. A P value less than 0.05 was considered significant. The kappa coefficient was used to assess the intra- and intertester agreement. The strength of agreement from kappa values was interpreted as follows: less than 0.20, poor; 0.21 to 0.40, fair; 0.41 to 0.60, moderate; 0.61 to 0.80, good; and 0.81 to 1.00, very good. An univariate and multivariate analysis were performed to investigate the presence of predictive factor of an higher acetabular erosion. Implant survival was defined as the time from surgery to revision for acetabular erosion and was estimated with Kaplan-Meier method. Ninety-five percent confidence intervals were calculated.

## Results

Overall, 209 Patients met inclusion criteria. Demographic data were reported in Table 1. The mean time from fracture to surgery was 2.1 days (range 0–5 days). The mean duration of surgery was 53 min (range 31–64 min). A press-fit implant was performed in 172 subjects instead in 37 patients was positioned a cemented stem. In 131 subjects was implanted a medium neck, in 45 cases a short and in 33 a long neck. The distribution of the size of femoral head was reported in Fig. 1 (78 head < 48). At follow-up the mean OHS was 31.2 (range 16 to 48), the mean WS was 28.1 (range 10–51).

Two Authors independently classified final X-ray (AA, PS) with Baker criteria showing: a grade 0 in 77 patients (54.5%), a grade 1 in 49 subjects (19.6%), a grade 2 in 48 cases (18.1%) and a grade 3 in 21 patients (7.6%). Nineteen patients underwent implant revision to total hip arthroplasty for acetabular erosion (grade 2 of Baker) and pain. Two patients with grade 3 of acetabular erosion were not surgically revised because of the good results to their condition and the coexistence of several comorbidities. Statistical analysis showed a linear correlation between the clinical score (OHS, WS) and the grade of acetabular erosion ( $p = 0.023$ ).

With univariate analysis were verified the correlations between all the clinical characteristics of patients and implant and the onset of acetabular erosion. A statistically significant correlation was verified between a higher grade of acetabular erosion and BMI, the size of the femoral head. At multivariate analysis however the size of the femoral head resulted the only predictive factor of a higher risk of acetabular erosion (Table 2). In Fig. 2 was reported the Kaplan-Meier survival curve investigating the risk of implant revision in two group of patients: with femoral head sized > 48 mm (Group 1) or with femoral head sized < 48 mm (Group 2). The probability of implant revision for acetabular erosion at ten years from surgery were 5.5% in Group 1 and 15.6% in Group 2. A total hip arthroplasty was implanted in all cases of revision surgery (14 press-fit and 5 cemented implants). In two cases was registered an intraoperative femoral fracture treated with cerclage wire. One patient developed a deep vein thrombosis in postoperative period.

## Discussion

Displaced intracapsular fracture of the femoral neck can be treated with internal fixation, unipolar or bipolar hemiarthroplasty, or total hip replacement. In a metanalysis, Bhandari et al. [11] concluded that arthroplasty was associated with lower revision rates but a higher prevalence of infection, greater blood loss, and longer operative time when compared with internal fixation. In that report, no distinction was made between the use of hemiarthroplasty and total hip replacement. Other comparative studies have demonstrated that total hip arthroplasty and hemiarthroplasty are superior to internal fixation for achieving pain relief and restoring function [12–14]. Commonly HA is the treatment of choice in patients with low functional requests

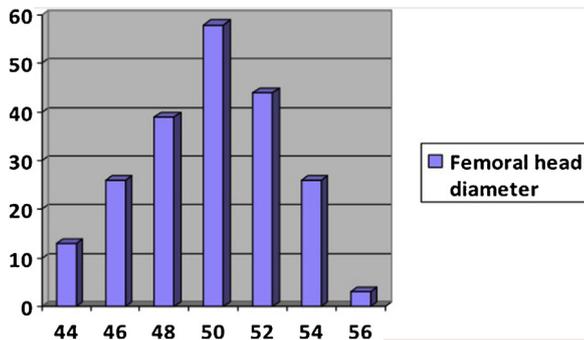
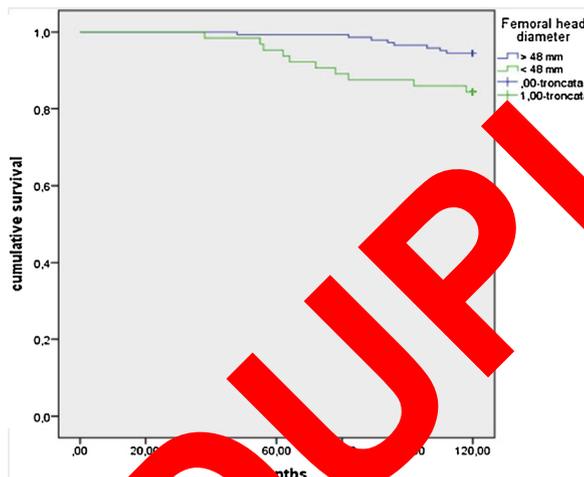
**Table 1**  
Demographic data related to patients included in the study.

Variable	Mean (+/-SD)	Range
Age	76.8 (+/-13.6)	60–84
Gender	M 62 / F 147	–
BMI	28 (+/-7.9)	23–34
ASA score (1/2/3)	62/116/31	–
Side of fracture	R 117 / L 92	–
Preoperative OHS	42 (+/-5.4)	37–46
Preoperative WS	11.2 (+/-6.8)	6–15
Time fracture/surgery (days)	2.1 (+/-0.8)	0–5
Operation time (minutes)	53 (+/-13.9)	31–64

**Table 2**

Univariate and multivariate analysis to verify correlation and predictive power for higher risk of acetabular erosion.

	Baker grade 0-1	Baker grade 2-3	Univariate p	Multivariate p
Number	152	57	–	–
Age (years)	74.2	76.8	0.128	0.235
Gender (male/female)	64/88	22/35	0.752	0.831
BMI	27	30	<b>0.023</b>	0.086
ASA score (1/2/3)	45/86/21	17/30/10	0.637	0.549
Time fracture/surgery (days)	2.2	1.9	0.714	0.628
Operation time (minutes)	58	51	0.571	0.786
Cemented/press-fit	128/24	44/13	0.329	0.252
Neck (medium/short/long)	107/24/21	24/21/12	0.858	0.762
Head diameter (>48/<48)	108/44	23/34	<b>&lt;0.001</b>	<b>0.002</b>

**Fig. 1.** Distribution of femoral head diameter among population of this study.**Fig. 2.** Kaplan-Meier curve analysis of cumulative hemiarthroplasty survival calculated with 95% confidence interval.

instead THA is performed in high demanding young subjects [15,16]. In this study we investigated the long term results of HA implanted in mobile independent patients with particular attention to the risk factor of acetabular erosion.

Rates of acetabular erosion vary between series from 3.7% at 40 months to 47% at 5 years [17,18].

In a randomized, prospective study of octogenarians who had sustained a displaced fracture of the femoral neck, Calder et al. [19] reported that the rate of acetabular erosion at two years postoperatively was 2.2% for hips that had been treated with a unipolar prosthesis and 0% for hips that had been treated with a bipolar prosthesis. However, Soreide et al. [20] reported an acetabular protrusion rate of 26% for patients older than seventy-five years of age who had been managed with a bipolar Christiansen prosthesis.

In the study by D'Arcy and Deery [21], 361 femoral neck fractures were treated with a Thompson hemiarthroplasty with cement. Acetabular erosion developed in 41% of the procedures. Importantly, acetabular erosion occurred more frequently in younger patients.

In a study of 69 patients with a Thompson hemiarthroplasty Phillips et al. [22] reported that the patient physical activity level and the duration of follow-up had the highest correlation with the severity of acetabular erosion. In addition, obesity was also reported as a risk factor for the development of acetabular erosion. Kwok et al. [23] reported on 599 patients with Moore and Thompson prostheses assessing head size, neck length, stem-shaft angle, and acetabular seating, and their relationship with the severity of the hemiarthroplasty. Those authors surmised that if too much femoral neck was removed, the leg would be short, leading to low abductor musculature and possible dislocation. In contrast, leaving a longer neck may cause over-tightening of the remaining soft tissues leading to increased stress across the hip joint, and resultant increased wear. In addition, inappropriate sizes may cause early cartilage wear: polar wear is expected with smaller diameter heads and equatorial wear with larger heads [24]. A small head distributes all forces to a rather small area of articular cartilage within the acetabulum, while a larger head transmits all of the force initially at the entrance to the acetabulum [23,24].

Wu et al. [25] studied the wear behavior in prosthetic hips with computer simulation verifying that the larger femoral head may induce larger wear volume, but gives a smaller wear depth and that wear depth and volume loss are apparently nonlinear related to the femoral head diameter.

The accuracy in head measurement was investigated by some studies. In vitro studies by Harris [26] have shown that if the femoral head is undersized by only 1/16 inch, the maximum pressure on the articular cartilage is double that found with a congruent hemiarthroplasty fit. In the study of D'Arcy et al. [21] the surgeons used a hemiarthroplasty head design that allowed sizing increments of only 3.2 mm with incidence of acetabular erosion of 11%. In a study of Squires [27], was reported the use of acetabular components with head sizes that were available in 2-mm increments and reported a 36% rate of revision because of acetabular erosion. Instead in a more recent study of the same Authors [10] was reported the use of hemiarthroplasty head sizes that were available in 2-mm increments founding that 66% of the patients had acetabular erosion. Moreover some Authors have investigated the accuracy of the different system of measurement.

Jeffery et al. [18] verified that the caliber estimation of femoral head size underestimates the head size by a mean of 0.72 mm when compared with measurements taken using the full circular templates. A statistically significant difference was found between those measurements taken using the calipers and those taken using full circular measuring templates. p: 0:002). Kosashvili et al. [24] reported the same result affirming that caliber measurements

tend to undersize the actual sphere diameter of the femoral head at the weight bearing region.

In this study we verify that a correct head sized is of primary importance to prevent acetabular erosion leading to a correct load distribution. Mostly in bipolar HA smaller head size lead to a polar wear implying an higher risk of acetabular erosion and superomedial migration. In this analysis, with Kaplan-Meier survival curve, was possible to verify that, dividing implant in head > 48 mm or < 48 mm diameter, a statistically significant difference merged. Considering the absolute risk of a smaller head size the surgeon must evaluate that the caliber, as reported in two previous studies, significantly underestimate the size. The result of this study could also be influenced by the fact that caliber was used in all the surgical procedure.

The Level IV of evidence design of the study is the main limitation. Other limitations are: the small number of participants, the exclusion from the study of all patients who underwent to HA revision for cause different from acetabular erosion and the lack of some postoperative data that could influence acetabular erosion (physical activity and leg length discrepancy).

## Conclusion

In conclusion, we found that, in our group analysis of patients with bipolar HA, a smaller head diameter could be a risk of higher acetabular erosion and incidence of implant revision but surgeon have to consider that caliber underestimates size of femoral head leading to an aggravation in polar wear.

### Conflict of interest

All Authors declares the absence of any conflict of interest.

## References

- [1] Court-Brown Heckmann, McQueen Tornetta. *Rockwood and green's fractures in adults*. 8th ed. Lippincott Williams & Wilkins; 2018.
- [2] Vestergaard P, Rejnmark L, Mosekilde L. Has mortality of a hip fracture increased? *J Am Geriatr Soc* 2007;55(11):1720–6.
- [3] Petersen MB, Jørgensen HL, Hansen K, Duus BR. Factors affecting postoperative mortality of patients with displaced femoral neck fractures. *Injury* 2006;37(8):705–11.
- [4] Van den Bekerom MP, Hilverdink EF, Bevelde L. A comparison of hemiarthroplasty with total hip replacement for displaced intracapsular fracture of the femoral neck: a randomised controlled multicentre trial in patients aged 70 years and over. *J Bone Joint Surg Am* 2010;92(10):1422–8.
- [5] Hedbeck CJ, Enocson A, Lapidus G, Blomfeldt R, Törnkvist H, Ponzer S, et al. Comparison of bipolar hemiarthroplasty with total hip arthroplasty for displaced femoral neck fractures: a one-year follow-up of a randomized trial. *J Bone Joint Surg Am* 2012;94(5):445–50.
- [6] Blomfeldt R, Törnkvist H, Enocson A, Söderqvist A, Ponzer S, Tidermark J. A randomised controlled trial comparing bipolar hemiarthroplasty with total hip replacement for displaced intracapsular fractures of the femoral neck in elderly patients. *J Bone Joint Surg Br* 2009;91(2):160–5.
- [7] Phillips TW. Thompson hemiarthroplasty and acetabular erosion. *J Bone Joint Surg Am* 1971;53(6):913–7.
- [8] Carulli C, Macera A, Matassi F, Civinini R, Innocenti M. The use of a dual mobility cup in the management of recurrent dislocations of hip hemiarthroplasty. *J Orthop Traumatol* 2016;17(June (2)):131–6.
- [9] Mohammed R, Hayward K, Mulay S, Bindi F, Wallace M. Outcomes of dual-mobility acetabular cup for instability in primary and revision total hip arthroplasty. *J Orthop Traumatol* 2015;16(1):9–13.
- [10] Baker RP, Squires B, Gargan MF, Bannister GC. Total hip arthroplasty and hemiarthroplasty in mobile, independent patients with a displaced intracapsular fracture of the femoral neck. A randomized, controlled trial. *J Bone Joint Surg Am* 2006;88(12):2583–9.
- [11] Bhandari M, Devereaux PJ, Swiontkowski MF, Tornetta 3rd P, Obrensky W, Koval KJ, et al. Internal fixation compared with arthroplasty for displaced fracture of the femoral neck. A meta-analysis. *J Bone Joint Surg Am* 2003;85-A(9):1673–81.
- [12] Bartels S, Gjersten JE, Frihagen F, Rogmark C, Utvåg SE. High failure rate after internal fixation and beneficial outcome after arthroplasty in treatment of displaced femoral neck fractures in patients between 55 and 70 years. *Acta Orthop* 2017;15:1–6.
- [13] Swart E, Roulette P, Leas D, Bozic KJ, Dunakar M. ORIF or arthroplasty for displaced femoral neck fractures in patients younger than 65 years old: an economic decision analysis. *J Bone Joint Surg Am* 2017;99(1):65–75.
- [14] Lu Q, Tang G, Zhao X, Guo S, Cai L. Hemiarthroplasty versus internal fixation in super-aged patients with displaced femoral neck fractures: a 5-year follow-up of randomized controlled trial. *Arch Orthop Trauma Surg* 2017;137(1):27–35.
- [15] González Quevedo M, Martínez T, Sánchez Sánchez JM, Escribano ER, Granero Molina EJ, Enriquez JB, et al. Post survival and surgical re-intervention predictors for intracapsular hip fractures. *Injury* 2017;48(8):1831–6.
- [16] Johnson DL, Greenberg SE, Sattelmair V, Thakore R, Ehrenfeld JM, Obrensky W, et al. Relationship between the Charlson Comorbidity Index and hip fractures: implications for bundled payment. *J Orthop Traumatol* 2017;18(2):209–13.
- [17] Lindholm M, Puranen J, Järvenpää P. The Moore vitallium femoral head prosthesis in the treatment of the femoral neck. *Acta Orthop Scand* 1976;47: 70±8.
- [18] Perry T, Ong A. Femoral head measurement in hemiarthroplasty: assessment of interobserver error using 3 measuring systems. *Injury* 2000;31(3):135–8.
- [19] Calder SJ, Anderson GH, Jagger C, Harper WM, Gregg PJ. Unipolar or bipolar prosthesis for displaced intracapsular hip fracture in octogenarians: a randomised prospective study. *J Bone Joint Surg Br* 1996;78:391–4.
- [20] Soreide Ø, Kjaerøen R, Alho A. The risk of acetabular protrusion following prosthetic replacement of the femoral head. *Acta Orthop Scand* 1982;53:791–4.
- [21] Barry J, Devas M. Treatment of fractures of the femoral neck by replacement with the Thompson prosthesis. *J Bone Joint Surg Br* 1976;58:279–86.
- [22] Phillips TW. Thompson hemiarthroplasty and acetabular erosion. *J Bone Jt Surg (Am)* 1989;71:913–7.
- [23] Kwok DC, Cruess RL. A retrospective study of Moore and Thompson hemiarthroplasty. A review of 599 surgical cases and an analysis of the technical complications. *Clin Orthop Relat Res* 1982;179–85.
- [24] Kosashvili Y, Backstein D, Safir O, Ran Y, Loebenberg MI, Ziv YB. Hemiarthroplasty of the hip for fracture—what is the appropriate sized femoral head? *Injury* 2008;39(2):232–7.
- [25] Wu JS, Hung JP, Shu CS, Chen JH. The computer simulation of wear behavior appearing in total hip prosthesis. *Comput Methods Programs Biomed* 2003;70(1):81–91.
- [26] Harris WH, Rushfeldt PD, Carlson CE, Scholler J, Mann RW. Pressure distribution in the hip and selection of hemiarthroplasty. The hip, proceedings of the third open scientific meeting of the hip society 1975;1975:93–8.
- [27] Squires B, Bannister G. Displaced intracapsular neck of femur fractures in mobile independent patients: total hip replacement or hemiarthroplasty? *Injury* 1999;30:345–8.