








Hip Hemiarthroplasty in Patients with Multiple Myeloma: A Retrospective Case Series and Review of the Literature

Hemiartroplastia de quadril em pacientes com mieloma múltiplo: Uma série de casos retrospectivos e revisão da literatura

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Abstract

Objectives Femoral neck fractures in multiple myeloma patients are usually managed with hemiarthroplasty or total hip arthroplasty, depending on the presence of acetabular infiltration. Due to the paucity of dedicated studies, the aim of the present study is to review the clinical outcomes of hip hemiarthroplasty in patients with multiple myeloma and to review the literature regarding the outcomes and survival in these patients' subset.

Methods There were 15 patients (16 cases), with a mean age of 71.7 years, who had myeloma and received hip hemiarthroplasty for displaced femoral neck fractures had their radiographs and clinical data assessed for this study. From those, 13 cases received bipolar and 3 unipolar hemiarthroplasty.

Results After a mean follow-up of 18.2 months since the time of surgery, 3 cases suffered periprosthetic fractures (18.75%), 4 cases (25%) had heterotopic ossification, and 1 case (6.25%) had acetabular erosion. The 1- and 5-year patient mortality rates for the study cohort were 53.3 and 73.3%, respectively.

Conclusion Hip hemiarthroplasty remains a viable treatment option in myeloma patients; however, the potentially high morbidity and mortality in these patients should be sensibly understood before the surgery to achieve satisfactory expectations.

Keywords

- ▶ femoral neck
- ▶ hemiarthroplasty
- ▶ hip fractures
- ▶ multiple myeloma

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Resumo

Objetivos As fraturas do colo femoral em pacientes com mieloma múltiplo são geralmente tratadas com hemiartroplastia ou artroplastia total do quadril de acordo com a presença de infiltração acetabular. Devido à escassez de relatos nesta área, o objetivo deste estudo é revisar os desfechos clínicos da hemiartroplastia do quadril em pacientes com mieloma múltiplo e os resultados e a sobrevida neste subconjunto de pacientes.

Métodos Um total de 15 pacientes (16 casos), com idade média de 71,7 anos e portadores de mieloma, foram submetidos à hemiartroplastia de quadril para tratamento de fraturas de colo femoral com luxação. Suas radiografias e dados clínicos foram avaliados. Destes casos, 13 passaram pela hemiartroplastia bipolar e três pela unipolar.

Resultados Após um acompanhamento médio de 18,2 meses desde o momento da cirurgia, 3 casos sofreram fraturas periprotéticas (18,75%), 4 casos (25%) tiveram ossificação heterotópica e 1 caso (6,25%) apresentou erosão acetabular. A mortalidade dos pacientes em 1 e 5 anos foi de 53,3 e 73,3%, respectivamente.

Conclusão A hemiartroplastia de quadril ainda é uma opção terapêutica viável em pacientes com mieloma. No entanto, a morbidade e a mortalidade podem ser altas nesses pacientes e devem ser compreendidas com sensatez antes da cirurgia para atingir bons resultados.

Palavras-chave

- ▶ colo do femur
- ▶ fraturas do quadril
- ▶ hemiartroplastia
- ▶ mieloma múltiplo

Introduction

Plasma cell dyscrasias represent a wide range of conditions, including monoclonal gammopathy of undetermined significance (MGUS; Kyle disease), solitary plasmacytoma of bone, and multiple myeloma.¹ Multiple myeloma is the most common primary bone malignancy and typically presents with fatigue, musculoskeletal pain, pathologic fractures, or recurrent infection.¹⁻³ The pelvis and proximal femur are common sites of osteolytic infiltrations caused by solitary or multiple myeloma lesions. These lesions usually present with pain and impending or pathological fractures.^{4,5} Surgical management of femoral neck fractures in myeloma patients includes either hemiarthroplasty or total hip arthroplasty, depending mainly on the presence of acetabular involvement.^{3,4,6}

The outcomes of prosthetic replacement in metastatic bone disease have been well studied in previous literature. However, no study has specifically evaluated the outcomes of hemiarthroplasty in myeloma fracture cases. The available studies have either reported collectively on the results of two or more of the treatment options, being open reduction and internal fixation (ORIF), hemiarthroplasty (HA) and total hip arthroplasty (THA) in myeloma,^{4,6} or reported on a cohort that included myeloma and other non-myeloma causes of bone infiltration.⁷⁻¹⁵ The aim of the present study is to report our outcomes in a series of hemiarthroplasty cases in patients with myeloma performed at a level-1 trauma center in an effort to add to the existing scarce evidence. Our main study question was whether myeloma patients would have high incidence

of complications, particularly fractures and acetabular wear after HA. We also aim to provide a literature review that includes all reported hemiarthroplasty case series in myeloma patients that have been reported in the literature.

Materials and Methods

After Institutional Review Board approval, a retrospective study was performed to evaluate all hemiarthroplasty patients, using the Current Procedural Terminology (CPT - American Medical Association, Chicago, IL, USA) codes. Between January 1988 and June 2023, a total of 2,488 HA cases were identified. All the cases were reviewed against our inclusion and exclusion criteria to extract the cases and data relevant for this study. The data collected included patients' demographics, clinical information, and radiographic evaluation. Detailed information about the follow-up and postoperative clinical course were collected for all cases.

Inclusion Criteria

- 1 - Patients who underwent HA for a hip fracture, either primarily after trauma or for management of femoral neck fracture nonunion.
- 2 - Patients who had a diagnosis of multiple myeloma or plasmacytoma of bone.

Exclusion Criteria

- 1 - Patients without clinical follow-up notes after HA surgery.

Results

A total of 18 cases (17 patients) of plasma cell dyscrasias that underwent HA for femoral neck fractures have been retrieved from our database. Two patients have been excluded due to having non-progressive MGUS, leaving 16 cases (15 patients) for inclusion in this study.

Of these patients, 9 were female and 6 were male, with a mean age of 71.7 years (range: 39.2–89.6) at the time of primary HA surgery. One female had bilateral femoral neck fractures, which occurred 2 months apart and received bilateral cemented unipolar HA. Fourteen patients (15 cases) had multiple myeloma, and 1 patient had a solitary bone plasmacytoma at the time of fracture that progressed to multiple myeloma later. Apart from plasma cell dyscrasias, 10 patients (11 cases) had additional significant, frequently combined medical comorbidities as shown in **Table 1**. The mean body mass index (BMI) for 12 patients was 32.9 (range: 22–52.2), while in 3 other patients, data regarding BMI was not available in their records.

All of the cases had been diagnosed with femoral neck fractures secondary to low-energy trauma (fall while walking). Nine patients had been diagnosed with multiple myeloma prior to presentation with femoral neck fractures and have received active chemotherapy, and four patients presented with femoral neck fractures as their first presenting symptom of myeloma. For those cases who had been diagnosed with myeloma prior to fracture, the average duration of the disease was 32 months (range: 1–78).

At presentation, all cases had pelvis radiographs and/ or computed tomography (CT) scans, along with long film femoral radiographs for exclusion of acetabular and skip femoral shaft osteolytic lesions. Eight out of the 16 cases had been identified as pathologic fractures secondary to myeloma lesion, in which osteolytic lesions could be recognized in the preoperative radiographs.

Fourteen different surgeons performed surgery. Thirteen cases were treated with bipolar HA, and 3 cases were treated with unipolar HA. Surgery was performed through the posterolateral approach in 10 cases while the direct lateral approach was utilized in 6 cases. Fourteen cases received cemented and two received cementless stems. Ten cases received conventional arthroplasty

stems, and 6 cases received long stems to bypass skip lesions in the femoral shaft. The average follow-up was 18.2 months (range: 1.3–79.3; **Fig. 1**). None of the cases developed cement implantation syndrome, dislocations, periprosthetic infections, aseptic loosening, or neurovascular injury.

Complications

Intraoperative Blood Loss

The average estimated blood loss in all cases was 710 ml (range: 150–2,500 ml). Four cases required intra or postoperative blood transfusion (packed red blood cells/ platelets) without further consequences.

Periprosthetic Fractures

Three cases (18.75%) were complicated by periprosthetic fractures. Of these three cases, one involved intraoperative fracture of the greater trochanter and was managed with a trochanteric hook plate and cerclage wires. The second case sustained a postoperative greater trochanteric fracture that was evident 3 weeks after surgery and managed nonoperatively. The third case involved a Vancouver type-B distal femur fracture that occurred 3 weeks after surgery due to another low energy fall; this was managed with ORIF with locking plate and cerclage wires. All the fractures occurred in association with cemented stems. To note, the surgical approaches that were utilized during the index HA surgery in the first and third cases was the posterolateral approach, while the second case had the index surgery performed through the direct lateral approach.

Heterotopic Ossification

Four cases (25%) had grade 2 or 3 heterotopic ossification (HO) involving the acetabulum and/or the trochanteric or subtrochanteric area. All 4 cases were performed through the posterolateral approach. Heterotopic ossification was radiologically evident as early as 6 weeks postoperatively and was managed nonoperatively in both cases.

Mortality

Thirteen patients (86.6%) died at a mean of 18.5 months (range: 1.3–79.1) after the primary HA surgery. Of them, 3 patients died within the first 3 months of the HA surgery (**Table 2**). For the patients that passed within 3 months of surgery, the cause of death was acute respiratory failure in 2 patients and septicemia secondary to gastrointestinal infection in one case. The median survival for all cases at the last follow-up or the date of death was 8.4 months.

Acetabular Erosion

Despite the presence of variable degrees of osteopenia in all of the cases, only 1 case (6.25% of cases), an 82-year-old female (**Fig. 2**), presented 16 months with mild hip pain with weight bearing after the HA surgery. Plain radiographs suggested mild acetabular erosion. The patient was managed conservatively, and she is alive and under regular follow-up (21 months after the HA surgery).

Table 1 Medical comorbidities in the study patients

Chronic kidney disease	4 (1 ESRD)
Diabetes mellitus	2
Heart failure	2
Severe or morbid obesity (BMI \geq 35)	3
Hypothyroidism	1
Parkinson disease	1

Abbreviations: BMI, body mass index; ESRD, end-stage renal disease.

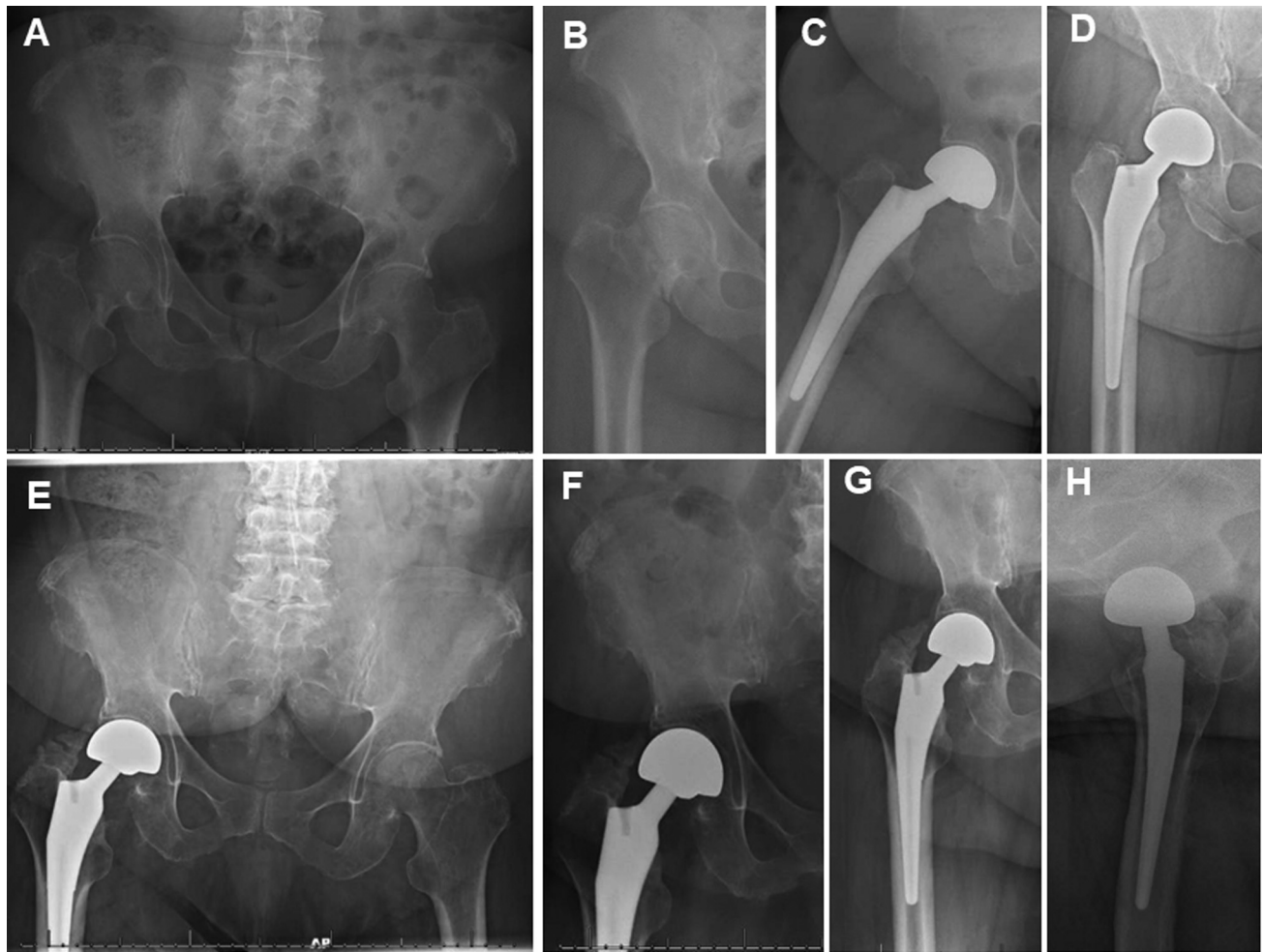


Fig. 1 (A, B) Plain pelvic and hip radiographs of a 79.2-year-old female with multiple myeloma showing right sub capital femoral neck fracture. (C) Immediate (same day) postoperative left hip plain X-ray showing cementless bipolar hemiarthroplasty. (D) 6 weeks and (E, F) 56-month, and (G, H) 70-month follow-up plain left hip radiographs showing stable, well-fixed components without evidence of acetabular erosion. Note the presence of grade-III heterotopic ossification.

Discussion

This is a retrospective series of 16 hip HAs in cases with multiple myeloma. After a mean follow-up of 18 months, 1 case had acetabular wear, 4 cases had radiographically significant heterotopic ossification, and 3 cases had periprosthetic fractures. The 3-month, 1-year, and 5-year mortality rates for this series were 20, 53.3, and 73.3%, respectively.

Patients with pathological fractures secondary to malignant infiltration have a higher risk of perioperative medical complications.^{2,13-15} When it comes to orthopedic complications, the existing evidence showed conflicting results, since the available literature compared different surgical techniques, for example ORIF, HA, or THA, for different causes of bone infiltration, including primary bone malignancies and metastatic bone infiltration.^{4,6,16-23} For example, the life expectancy and the existing comorbidities differ between myeloma and other causes of bony infiltration such as lymphoma, metastatic breast, prostate, or lung cancers. Again, the indications and outcomes of HA differ from the

outcomes of ORIF and THA, and the surgical settings are different.²⁴

Excluding case reports and studies that reported on sporadic cases, the available studies in the literature that reported on hip replacement in myeloma showed different outcomes for different diagnoses and mostly compared several interventions (► **Table 3**). Of them, only two retrospective studies reported solely on a series of myeloma patients.^{4,6} Papagelopoulos et al.⁴ reported on 53 cases of myeloma who were managed with HA (33 cases) or THA (20 cases). The authors enumerated several complications, including deep infection, dislocation (1.8% each), and a 1-month mortality of 5.6%. The authors did not distinguish whether the complications occurred in HA or THA cases, which are different entities that may be affected by factors such as patients' age, medical comorbidities, activity level, and surgery duration. These factors may be translated to the reported difference in the incidence of periprosthetic infections between HA and THA in the literature, being 1.6 to 10% vs 0.2 to 0.7%, respectively.^{25,26} In another study, Park et al.⁶ reported on the in-hospital outcomes in 4,011 myeloma

Table 2 Mortality rate in the study group

Mortality at	Number of patients, %
3 months	3; 20%
1 year (+5 patients)	8; 53.3%
5 years (+3 patients)	11; 73.3%

cases who received surgery for femoral fractures, extracting the data from a national medical database. In their study, 1,288 patients received HA, 2,555 patients received ORIF, and 168 received THA. When comparing their total outcomes with non-myeloma cases, the authors found that multiple myeloma cases had a higher risk of in-hospital pneumonia, sepsis, surgical site infection, and acute renal failure as well as a lower risk of myocardial infarction. The authors, however, did not distinguish which complications occurred in HA, and which occurred in ORIF and THA.

Other studies included myeloma and non-myeloma cases, reporting on the incidence of complications amongst the total study cohorts (► **Table 3**). To the best of our knowledge, the current study is the first to report solely on the outcomes of hip hemiarthroplasty in patients with myeloma. Despite the small series, the most interesting findings are the high mortality (20% for the 3-month mortality), high incidence of periprosthetic fractures (18.75%), and the relatively low incidence of clinical or radiological acetabular erosion, given the associated osteopenia and osteoporosis that are usually present in myeloma patients.¹⁻³

In patients with multiple myeloma, the reported 1- and 5-year survival rate is about 85 and 58%, respectively.^{27,28} When hip fracture occurs, these numbers seem to significantly decline. In our study, only 46.7% of patients survived past 1 year, and 26.7% survived past 5 years from the surgery, while the median survival of all the cases was 8.4 months. Comparatively, Papagelopoulos et al.⁴ reported a median

survival of 18 months and a 2- and 5-year survival of 43 and 13%. These figures highlight the high mortality of hip fracture in myeloma patients. In the literature, the most common causes of mortality in myeloma patients are adult respiratory failure, septicemia and renal failure.²⁸ For the 1-month and in-hospital mortality, the incidence in myeloma and non-myeloma patients tends to be similar.⁶ In our study, there was no in-hospital mortality, and the first patient died 1.3 months postoperatively, after discharge from the hospital.

Patients with multiple myeloma have weak and osteoporotic bones.^{1-3,29,30} This may explain the higher incidence of periprosthetic fractures following prosthetic replacement in our study (3 patients; 18.75%). This agrees with the results of Peterson et al.,¹⁸ who reported one periprosthetic fracture (PPF) (20%) in 5 HA myeloma cases and required revision. Despite this, Papagelopoulos et al.⁴ did not report any PPF in their series of 53 HA and THA myeloma cases. In our study, all the fractures occurred in association with cemented stems. Since the current study has only 2 cases who received uncemented stems, we could not make a recommendation regarding the impact of stem type on the occurrence of periprosthetic fractures in myeloma patients.

Regarding heterotopic ossification (HO), this complication has been rarely reported in patients with multiple myeloma, most likely since it is a less serious complication. Seraj et al.³¹ reported it in one patient with multiple myeloma who underwent right hip internal fixation. Due to the small number and the non-comparative nature of the current study, we could not conclude whether the HO cases in our study were related to myeloma or the HA surgery itself. The incidence of radiologically significant HO in our study is 25%, which is less than the reported incidence of HO in HA in general, which reached 27% in one study.³²

Osteoporosis and osteomalacia are known risk factors for acetabular protrusion in native hips.^{33,34} When it comes to acetabular wear after hip arthroplasty, the effect of preexisting osteoporosis is controversial.³⁵⁻³⁷ The incidence of

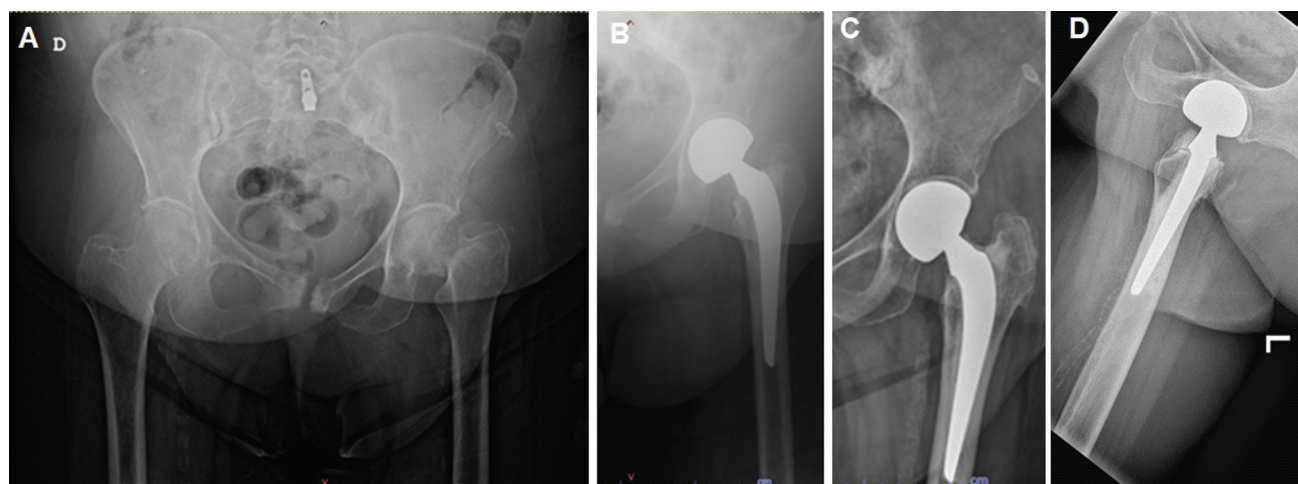


Fig. 2 (A) Plain pelvic radiographs of an 82-year-old female showing left displaced femoral neck fracture. (B) Immediate postoperative left hip plain X-ray showing cemented bipolar hemiarthroplasty. (C, D) 16-month postoperative plain left hip radiographs showing acetabular erosion. The patient complained of groin pain with movement and was managed conservatively.

Table 3 Review of the literature regarding the studies that reported about the outcomes of prosthetic replacement in a series of myeloma patients (excluding case reports)

Study/Year	Diagnosis (number of cases)	Intervention (number of cases)	Complications in myeloma cases (number of cases)	Notes
Papagelopoulos et al. 1997 ⁴	Multiple myeloma (53)	HA (33) THA (20)	Intraoperative severe blood loss (1) Intraoperative pulmonary distress (1) 1-month mortality (3) Aseptic loosening (1) Dislocation (1) Deep Infection (1) Superficial infection (1) Persistent wound drainage (4)	Two revisions, resection arthroplasty for infection or dislocation (1 each) The authors did not distinguish whether the complications occurred in HA or THA cases.
Schneiderbauer et al. 2005 ⁷	Multiple myeloma (31) Other tumors (298)	Hemiarthroplasty	Patients who underwent HA for tumor lesions had a significantly higher incidence of dislocation compared to other indications.	The authors did not mention the number of complications in myeloma cases.
Parker et al., 2011 ⁸	Multiple myeloma (9) Other tumors (136)	HA, THA, or ORIF	Patients with Myeloma had the longest mean survival, compared to lymphoma, breast, lung and prostate metastatic lesions.	The authors did not mention the number of complications in myeloma cases, nor the types of interventions.
Alvi et al., 2013 ⁹	Multiple myeloma (17) Other tumors (79)	Shoulder Arthroplasty, ORIF, THA and HA (not mentioned)	One case, managed with cemented long stem calcar replacement HA had radiological myeloma disease progression noticed 4 months after the index surgery.	The authors have not mentioned how many of the patients received which implant.
Park et al., 2016 ⁶	Multiple myeloma (4,011), comparing in hospital complications with non-myeloma cases.	ORIF (2,555) Hemiarthroplasty (1,288) THA (168)	Patients with multiple myeloma had a higher risk of in-hospital pneumonia (5.4%), sepsis (1.4%), surgical site infection (2.8%), and acute renal failure (9.6%). While there was no difference in DVT, pulmonary embolism, respiratory failure, and in-hospital mortality, multiple myeloma patients had less incidence of myocardial infarction.	The authors did not distinguish which complications occurred in HA and which occurred in ORIF and THA.
Peterson et al., 2016 ¹⁰	Myeloma (5) Other metastatic lesions (17)	Long stem hemiarthroplasty	Sciatic nerve injury (1) Stroke (1) Periprosthetic fracture (1) 1-month mortality (1) 1-year mortality (2)	1 revision for peri prosthetic fracture
Stevenson et al., 2018 ¹¹	Myeloma (6) Other tumors (94)	Proximal femoral replacement HA (6)	No dislocations, No revisions for pain or acetabular erosion.	The series reported four infections and three revisions; however, the authors did not distinguish whether the complications occurred in myeloma or other cases.
Seglam et al., 2019 ¹²	Multiple myeloma (19) Other tumors (114)	Proximal femoral replacement HA (18) Proximal femoral replacement HA (1)	15 patients expired at a mean follow up of 35.11 ± 22.38 months. 12 patients had class 1 or 2 radiological acetabular erosion.	Two revisions, for aseptic loosening and for dislocation (1 each).

Table 3 (Continued)

Study/Year	Diagnosis (number of cases)	Intervention (number of cases)	Complications in myeloma cases (number of cases)	Notes
Schwarzkopf et al., 2019 ¹³	Myeloma (15) Other cases (359 cases)	HA and THA	11/15 myeloma cases had bone cement implantation syndrome, without intraoperative death.	The authors did not distinguish whether complications occurred in HA or THA cases.
Hayden et al., 2021 ¹⁴	Multiple myeloma (25) Other tumors (139)	HA (15) THA (10)	The authors did not find significant differences in the incidence of complications between THA and HA.	The authors did not mention the number of complications in Myeloma cases.

Abbreviations: DVT, deep vein thrombosis; HA, hemiarthroplasty; ORIF, open reduction and internal fixation; THA, total hip arthroplasty.

acetabular wear in the current study (6.25%) is comparable to the reported incidence after hip HA in general, which ranges between 0.7 and 17.2%.^{38–40} Considering these results, HA remains a viable option for management of proximal femoral fractures in myeloma patients. However, patients' expectations regarding the associated morbidities and mortality should be clearly presented as regard to the presented evidence. The lower survival rates in myeloma patients and in this study could potentially have affected the incidence of acetabular erosion in myeloma patients with such osteoporotic bone.

In myeloma patients undergoing hip HA, surgeons should be aware of the incidence of specific complications, especially the potential risk of increased intraoperative blood loss and perioperative PPFs. It is imperative also for the surgeon to properly assess the acetabulum and the entire femur for the presence of osteolytic lesions using CT scans, long film femur radiographs, and even magnetic resonance imaging,⁴¹ to detect the presence of skip myeloma lesions and, hence, allow the surgeon to choose the suitable implant.

The current study has several limitations. This is a small series and is limited by the non-comparative and retrospective study design. A large multicenter study may be required to better evaluate the outcomes of prosthetic replacement in myeloma patients when compared to the general population.

Conclusion

Hip HA is a reasonable option for the management of femoral neck fractures in patients with multiple myeloma. Provided that the acetabulum is free from tumor invasion, the incidence of acetabular erosion is relatively small. The surgeons should be aware of the associated high morbidity and mortality in such patients.

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Conflict of Interests

The authors have no conflict of interests to declare.

References

- Guedes A, Becker RG, Teixeira LEM. Multiple Myeloma (Part 1) - Update on Epidemiology, Diagnostic Criteria, Systemic Treatment and Prognosis. *Rev Bras Ortop* 2023;58(03):361–367
- Guedes A, Becker RG, Teixeira LEM. Multiple Myeloma (Part 2) - Update on The Approach to Bone Disease. *Rev Bras Ortop* 2023;58(03):368–377
- Gianakos AL, Patel JN, Miller JM, Sonnylal L, Wittig JC. Metastatic Disease, Myeloma, and Lymphoma Affecting the Hip. *J Hip Surg* 2019;3(01):34–40
- Papagelopoulos PJ, Galanis EC, Greipp PR, Sim FH. Prosthetic hip replacement for pathologic or impending pathologic fractures in myeloma. *Clin Orthop Relat Res* 1997;(341):192–205
- Moura M, Sanches DP, Pinto ÁF, Milano SS, Villela MM. Evaluation of Intramedullary Methods with Polymethylmethacrylate for Fixation of Bone Lesions of the Extremities. *Rev Bras Ortop* 2021;56(06):772–776
- Park KJ, Menendez ME, Mears SC, Barnes CL. Patients With Multiple Myeloma Have More Complications After Surgical Treatment of Hip Fracture. *Geriatr Orthop Surg Rehabil* 2016;7(03):158–162
- Schneiderbauer MM, Sierra RJ, Schleck C, Harmsen WS, Scully SP. Dislocation rate after hip hemiarthroplasty in patients with tumor-related conditions. *J Bone Joint Surg Am* 2005;87(08):1810–1815
- Parker MJ, Khan AZ, Rowlands TK. Survival after pathological fractures of the proximal femur. *Hip Int* 2011;21(05):526–530
- Alvi HM, Damron TA. Prophylactic stabilization for bone metastases, myeloma, or lymphoma: do we need to protect the entire bone? *Clin Orthop Relat Res* 2013;471(03):706–714
- Peterson JR, Decilveo AP, O'Connor IT, Golub I, Wittig JC. What Are the Functional Results and Complications With Long Stem Hemiarthroplasty in Patients With Metastases to the Proximal Femur? *Clin Orthop Relat Res* 2017;475(03):745–756
- Stevenson JD, Kumar VS, Cribb GL, Cool P. Hemiarthroplasty proximal femoral endoprostheses following tumour reconstruction: is acetabular replacement necessary? *Bone Joint J* 2018;100-B(01):101–108
- Saglam F, Baysal O, Sirin E, Sofulu O, Kesimer MD, Erol B. Is bipolar hemiarthroplasty an appropriate type of hip articulation following proximal femoral or total femoral resections for musculoskeletal malignancies? *Arch Orthop Trauma Surg* 2022;142(02):331–341
- Schwarzkopf E, Sachdev R, Flynn J, Boddapati V, Padilla RE, Prince DE. Occurrence, risk factors, and outcomes of bone cement implantation syndrome after hemi and total hip arthroplasty in cancer patients. *J Surg Oncol* 2019;120(06):1008–1015
- Hayden BL, Varady NH, Abdeen A, Lozano-Calderon SA, Chen AF, Ready JEP. Pathologic Fracture Study Group. No Difference Between Hemiarthroplasty and Total Hip Arthroplasty in the Treatment of

- Pathologic Femoral Neck Fractures. *J Arthroplasty* 2021;36(11):3662–3666
- 15 Lin JS, Santiago-Torres JE, Everhart JS, Zayan NE, Mayerson JL, Schar Schmidt TJ. When is hemiarthroplasty preferable to intramedullary prophylactic fixation of malignant lesions of the proximal femur? *J Surg Oncol* 2017;116(08):1132–1140
 - 16 Thein R, Herman A, Chechik A, Liberman B. Uncemented arthroplasty for metastatic disease of the hip: preliminary clinical experience. *J Arthroplasty* 2012;27(09):1658–1662
 - 17 Swanson KC, Pritchard DJ, Sim FH. Surgical treatment of metastatic disease of the femur. *J Am Acad Orthop Surg* 2000;8(01):56–65
 - 18 Harrington KD. Orthopaedic management of extremity and pelvic lesions. *Clin Orthop Relat Res* 1995;(312):136–147
 - 19 Rock M. The use of Bateman bipolar proximal femoral replacement in the management of proximal femoral metastatic disease. In: Yamamoto T, ed. *New developments for limb salvage in musculoskeletal tumours*. Tokyo: Springer-Verlag; 1989:437
 - 20 Randall RL, Aoki SK, Olson PR, Bott SI. Complications of cemented long-stem hip arthroplasties in metastatic bone disease. *Clin Orthop Relat Res* 2006;443(443):287–295
 - 21 Nucci M, Anaissie E. Infections in patients with multiple myeloma in the era of high-dose therapy and novel agents. *Clin Infect Dis* 2009;49(08):1211–1225
 - 22 Stanley A, Young A. Primary prevention of venous thromboembolism in medical and surgical oncology patients. *Br J Cancer* 2010;102(Suppl 1, Suppl 1):S10–S16
 - 23 Nucci M, Anaissie E. Infections in patients with multiple myeloma. *Semin Hematol* 2009;46(03):277–288
 - 24 Tsukamoto S, Errani C, Kido A, Mavrogenis AF. What's new in the management of metastatic bone disease. *Eur J Orthop Surg Traumatol* 2021;31(08):1547–1555
 - 25 Masters J, Metcalfe D, Ha JS, Judge A, Costa ML. Surgical site infection after hip fracture surgery: a systematic review and meta-analysis of studies published in the UK. *Bone Joint Res* 2020;9(09):554–562
 - 26 de Jong L, Klem TMAL, Kuijper TM, Roukema GR. Factors affecting the rate of surgical site infection in patients after hemiarthroplasty of the hip following a fracture of the neck of the femur. *Bone Joint J* 2017;99-B(08):1088–1094
 - 27 SEER*Explorer: An interactive website for SEER cancer statistics [Internet]. Surveillance Research Program, National Cancer Institute [accessed february 23, 2023] Available from: <https://seer.cancer.gov/explorer/on>
 - 28 DeVita VT, Lawrence TS, Rosenberg SA. *Cancer: Principles and Practice of Oncology*. 12th ed. Philadelphia: Wolters Kluwer; 2022
 - 29 Miceli TS, Colson K, Faiman BM, Miller K, Tariman JD International Myeloma Foundation Nurse Leadership Board. Maintaining bone health in patients with multiple myeloma: survivorship care plan of the International Myeloma Foundation Nurse Leadership Board. *Clin J Oncol Nurs* 2011;15(0, Suppl):9–23
 - 30 Moura M. Treatment of Metastasis in the Appendicular Skeleton. *Rev Bras Ortop* 2022;57(02):200–206
 - 31 Seraj SM, Al-Zaghal A, Østergaard B, Høiland-Carlson PF, Alavi A. Identification of Heterotopic Ossification Using 18F-NaF PET/CT. *Clin Nucl Med* 2019;44(04):319–320
 - 32 Corrigan CM, Greenberg SE, Sathiyakumar V, et al. Heterotopic ossification after hemiarthroplasty of the hip - A comparison of three common approaches. *J Clin Orthop Trauma* 2015;6(01):1–5
 - 33 Weber W, Moore J, Cheema N. Traumatic Acetabular Protrusion. *Clin Pract Cases Emerg Med* 2018;2(03):260–261
 - 34 Bible MW, Pinals RS, Palmieri GM, Pitcock JA. Protrusion acetabuli in osteoporosis and osteomalacia. *Clin Exp Rheumatol* 1983;1(04):323–326
 - 35 Karayiannis P, Walls A, Cassidy R, Beverland D. Rapidly Progressive Osteoarthritis and Acetabular Bone Loss Outcomes for Patients Undergoing Primary Total Hip Replacement. *Arthroplast Today* 2020;6(03):289–295
 - 36 Adenikinju A, Slover JD, Egol KA. Rapid Acetabular Chondrolysis following Hemiarthroplasty of the Hip: A Poor Prognostic Sign. *Case Rep Orthop* 2019;2019:7328526
 - 37 Trueba Davalillo C, Minueza Mejía T, Gil Orbezo F, Ponce Tovar V, García Velasco R. Factores de riesgo que influyen en la erosión acetabular posterior a una hemiartroroplastía de cadera en el tratamiento de las fracturas subcapitales. [Risk factors that have influence on acetabular erosion after a hip hemiarthroplasty in the treatment of subcapital fractures] *Acta Ortop Mex* 2007;21(03):121–127
 - 38 Grosso MJ, Danoff JR, Murtaugh TS, Trofa DP, Sawires AN, Macaulay WB. Hemiarthroplasty for Displaced Femoral Neck Fractures in the Elderly Has a Low Conversion Rate. *J Arthroplasty* 2017;32(01):150–154
 - 39 Theil C, Möllenbeck B, Gosheger G, et al. Acetabular Erosion After Bipolar Hemiarthroplasty in Proximal Femoral Replacement for Malignant Bone Tumors. *J Arthroplasty* 2019;34(11):2692–2697
 - 40 Emre F, Ertaş ES, Bozkurt M. Factors associated with acetabular degeneration and protrusion in bipolar hip hemiarthroplasty. *Genel Tip Derg* 2022;32(05):564–570
 - 41 Guedes A, Oliveira MBDR, Melo AS, Carmo CCMD. Update in Imaging Evaluation of Bone and Soft Tissue Sarcomas. *Rev Bras Ortop* 2021;58(02):179–190