Outcomes of press-fit uncemented versus cemented hip arthroplasty in the oncologic patient

Christopher G. Larsen (MD)^{a,*}, William K. Crockatt (MD)^b, Michael Fitzgerald (MD)^a, Nanette Matos^b, Howard J. Goodman (MD)^a, Samuel Kenan (MD)^a, Shachar Kenan (MD)^a

^a Department of Orthopaedic Surgery, North Shore-Long Island Jewish Medical Center, Northwell Health, 270-05 76th Avenue, New Hyde Park, NY, 11040, USA

^b Zucker School of Medicine at Hofstra-Northwell Health, 500 Hofstra University, Hempstead, NY, 11549, USA

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ABSTRACT

Background and objectives: Cemented hip arthroplasty is considered the standard of care for treating both osteoporotic femoral neck fractures and pathologic disease of the proximal femur due to the ability to achieve strong fixation in poor quality bone. There is minimal literature evaluating uncemented arthroplasty for pathologic disease of the proximal femur. This objective of this study is to compare outcomes of patients undergoing cemented and uncemented arthroplasty of the proximal femur for an oncologic indication.

Methods: Patients who underwent hip arthroplasty procedures in one health system for an oncologic indication were identified. Demographics, cancer history, operative history, and complications were collected retrospectively. Harris Hip Scores (HHS) and Musculoskeletal Tumor Society Scores (MSTS) were prospectively collected via telephone.

Results: 41 patients met criteria for review. 18 underwent cemented and 23 underwent uncemented arthroplasty. There were no significant differences in age, demographics, complications, 30-day mortality, intraoperative blood loss, transfusion requirements, average HHS, or average MSTS.

Conclusion: No significant differences were found for patients undergoing hip arthroplasty for an oncologic indication regardless of whether or not the femoral component was cemented. Our results suggest that cemented and uncemented techniques are both safe and effective methods to be used at the oncologic surgeon's discretion.

1. Introduction

Skeletal metastatic disease represents a significant source of morbidity and mortality for cancer patients. The leading cause of death in a patient with a cancer diagnosis is metastasis, and bone is the third most common site of metastatic disease after the lungs and the liver.¹ Given the improvement of cancer treatment modalities over the past few decades, the prognosis for many patients has improved. As a result, orthopedic surgeons are more often tasked with the treatment of skeletal metastases in order to preserve function and optimize quality of life in oncologic patients.

To achieve this goal, the surgeon must consider the patient's cancer type, location of metastases, life expectancy, pain, lesion size, functional status, and degree of fracture displacement or risk of pathologic fracture.² The proximal femur is the most common site of long bone skeletal metastasis, increasing the risk of pathological fractures in this area.³ In the non-oncologic elderly population, cemented hip hemiarthroplasty has been the gold standard for treating femoral neck

fractures. Studies show that cement achieves strong fixation in osteoporotic bone, decreases the risk of periprosthetic fracture, and provides more reliable pain relief when compared to press-fit implants, hereby referred to simply as uncemented arthroplasty.^{4–13} Despite these findings, uncemented arthroplasty implants are still widely used in clinical practice for the treatment of femoral neck fractures, which speaks to the highly controversial nature of this topic.

Given the proven durability of cemented implants for the treatment of osteoporotic femoral neck fractures, cemented arthroplasty has also been the treatment of choice for metastatic disease of the proximal femur due to concerns about bone quality in the oncologic population. The use of cement as a fixation method and cavity filler allows the implant to not only bypass metastatic lesions but also maintain short- and long-term implant stability. Houdek et al. reported 88% 5-year survival of cemented proximal femur endoprosthetic implants in the setting of malignancy.¹⁴ Additionally, cement fixation avoids the need for bony ingrowth, which is theoretically impaired in irradiated or pathologic bone.³ However, cemented arthroplasty has several

* Corresponding author.

E-mail address: clarsen@northwell.edu (C.G. Larsen).

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disadvantages including increased surgical time, difficulty with revision surgery, weakness in torsion, and more rarely, pulmonary complications, such as bone cement implantation syndrome (BCIS) and allergic reactions to cement components.^{4–13,15–17}

Evidence regarding morbidity and mortality related to cementation is mixed. A retrospective review by Parvizi et al. on 38,488 arthroplasties, 14,469 of which were cemented, revealed 23 intraoperative deaths with no deaths reported in the uncemented group.¹⁸ A recent retrospective review on 10,677 patients however, concluded that cementing does not increase the immediate risk of postoperative mortality in patients undergoing arthroplasty for osteoarthritis or osteoporotic fracture, though this patient cohort did not include oncologic patients and did not specify whether or not long femoral stems were used.¹⁹ Furthermore, patients with metastatic disease of the proximal femur have higher rates of mortality and medical complications following hemiarthroplasty as compared to their counterparts without oncologic disease, therefore the risks of cementing may be more impactful in this population.²⁰ In a recent retrospective cohort study of oncologic patients (94% with bony and 48% with lung metastases at the time of surgery), 74% of patients exhibited symptoms of BCIS, defined as hypoxia, hypotension, and/or unexpected loss of consciousness occurring around the time of cementation, and these patients had increased perioperative pressor use and longer hospital stays.²¹

While there are many studies comparing cemented and uncemented arthroplasty for the general population, there is a relative paucity of data regarding patients undergoing arthroplasty of the proximal femur for oncologic indications.^{3–13,20,22,23} Thein et al. retrospectively reviewed the outcomes of uncemented arthroplasty for metastatic disease of the hip and found comparable results with cemented arthroplasty when considering the following factors: prosthesis longevity, patient survival, postoperative function, and overall complication rate.³ Similarly, a study of patients with metastatic disease of the proximal femur due to multiple myeloma showed favorable outcomes for patients undergoing uncemented arthroplasty.²³ A 2018 Musculoskeletal Tumor Society (MSTS) survey by Reif et al. supports no clear consensus on implant choice for treating pathologic disease of the proximal femur, but did note that when hemiarthroplasty was performed, 86.4% of respondents favored cemented hemiarthroplasty over uncemented hemiarthroplasty.²⁴

This study seeks to expand on the limited literature regarding cemented versus uncemented arthroplasty for patients with metastatic disease of the proximal femur. Our goal was to compare both the short- and long-term outcomes and complications of uncemented hip arthroplasty and cemented hip arthroplasty in patients who underwent surgery for oncologic lesions of the proximal femur (Fig. 1).

2. Methods

2.1. Inclusion criteria

After institutional review board (IRB) approval was obtained, patients were retrospectively identified who underwent either hip hemiarthroplasty, total hip arthroplasty (THA), or proximal femoral replacement (PFR) for a known or suspected diagnosis of metastatic or primary bone tumors involving the proximal femur. All patient diagnoses were verified using final resected specimens. All procedures were performed by one of two fellowship trained orthopaedic oncologic surgeons at a tertiary referral academic medical center between October 2012 and July 2018. Procedures performed for these patients fell under the following CPT (current procedural terminology) Codes: 27125, 27134, 27236, and 27599. There were no institutional guidelines regarding the choice between cemented and uncemented stems, and this choice was left to individual surgeon preference.

Patients who received a minimum duration of six months of follow-up care were included in the study. Patients with insufficient follow up

Fig. 1. Postoperative radiographs for the different types of implants. (A) cemented hemiarthroplasty, (B) uncemented hemiarthroplasty, (C) cemented proximal femur replacement, and (D) uncemented proximal femur replacement.

Fig. 2. A flow chart depicting the process of selecting patients for inclusion in the study.

due to known mortality documented in the medical record were also included in the study since the implant was known to have lasted for the remainder of the patient's life and therefore served its intended functional purpose (Fig. 2).

Patients still deemed to be alive at the time of data collection were contacted to see if they would be interested in participating in an outcomes portion of the study conducted via telephone surveys. For those patients who were agreeable, informed consent was obtained verbally over the phone, and the surveys were administered.

2.2. Exclusion criteria

Those patients with less than six months of follow up or who had not been confirmed as deceased were excluded from this study. Patients without confirmed oncologic disease of the proximal femur were also excluded. Patients receiving different orthopaedic procedures, such as intramedullary nailing, for metastatic lesions of the proximal femur, were not included in the study.

2.3. Data collected

Qualitative data points included patient demographic data, comorbid conditions, oncologic history, past orthopaedic surgical history, type of procedure performed, construct used, laterality, complications of the procedure, adjuvant or post-operative radiation, chemotherapy treatment, use of osteogenic agents, revision surgeries, and final pathologic diagnosis. Quantitative data points included estimated blood loss during the procedure, transfusion requirements, and age of implant at last follow up or upon death. For those patients that were identified as living, additional follow up telephone surveys were conducted to assess functional status as determined by Musculoskeletal Tumor (MSTS) and Harris Hip Scores (HHS). Date of death, as listed in the medical record or obtained when attempting to contact patients by telephone, was documented for patients identified as deceased, and this was used to calculate the age of the implant at the time of death.

2.4. Data analysis

Data analysis was performed for each cohort in Microsoft Excel using the Student's T-test and Chi-square analysis. T-test was used to compare quantitative variables, whereas Chi-square analysis was used to compare the cohorts with regards to qualitative variables. P values of less than 0.05 were used to indicate significance for a given variable and two-tailed tests were used.

3. Results

49 patients underwent hip arthroplasty procedures for oncologic indications during the study period. Of those 49 patients, 41 had adequate follow-up to be included in the study: 18 underwent cemented procedures and 23 underwent uncemented arthroplasty (Table 1). The procedures were performed as follows: 8 cemented hemiarthroplasty, 3 cemented THA, 7 cemented PFR, 16 uncemented hemiarthroplasty, 0 uncemented THA, and 7 uncemented PFR. There were no significant differences in age or demographics between the two groups ($p > 0.05$). The most frequent cancer types were lung ($n = 10$), prostate ($n = 8$), breast ($n = 6$), and renal cell carcinoma ($n = 4$), followed by a variety of both primary and metastatic diseases.

61% of patients with cemented arthroplasty implants received chemotherapy, compared to 86% of patients with uncemented implants, which trended towards significance ($p = 0.06$). Regarding radiation, 22% of patients with cemented implants received neoadjuvant radiation compared to 13% of patients receiving uncemented implants ($p = 0.44$). 11% of patients with cemented implants received adjuvant radiation compared to 22% of patients with uncemented implants ($p = 0.37$). 11% of patients with cemented implants received osteogenic agents, such as bisphosphonates and other drugs that modify bone metabolism, compared to 17% of patients with uncemented implants ($p = 0.57$).

19 patients were determined to be deceased at the time of data

Table 1

Comparison of cemented and uncemented hip arthroplasty for pathologic disease of the proximal femur.

	Cemented	Uncemented	P value
Age (years)	Range: 51-91 Mean: 70	Range: 34-85 Mean: 67	0.39
BMI	Range: 17-37 Mean: 25	Range: 16-39 Mean: 27	0.17
Cancer Diagnosis			
Prostate	3 (16.7%)	7 (30.4%)	
Lung	4 (22.2%)	4 (17.4%)	
Breast	4 (22.2%)	2 (8.7%)	
Renal Cell	2 (11.1%)	2 (8.7%)	
Primary bone or soft tissue tumor	3 (16.7%)	3 (13.0%)	
Other *	2 (11.1%)	5 (21.7%)	
Chemotherapy	11 (61%)	20 (86%)	0.06
Neoadjuvant Radiation (n=7)	4 (22%)	3 (13%)	0.44
Adjuvant Radiation (n=7)	2 (11%)	5 (22%)	0.37
Osteogenic Agents (n=6)	2 (11%)	4 (17%)	0.57
Implants	18	23	
Hemiarthroplasty	8 (44%)	16 (70%)	
Diaphyseal grit blasted	–	13 (81%)	
Metaphyseal coated	–	3 (9%)	
Total Hip Arthroplasty	3 (17%)	0 (0%)	
Proximal Femur Replacement (fully porous)	7 (39%)	7 (30%)	
Average Intraoperative Blood loss (mL)	557	502	0.84
Average Intraoperative Transfusion Requirements (units)	0.75	0.83	0.98
Deceased	9 (50%)	10 (43.5%)	0.68
Age of implant at patient death (days)	Range: 11-345 Mean: 127	Range: 2-1401 Mean: 302	0.12
Complications			
Total	16.7%	21.7%	0.53
30-day mortality	5.6%	8.7%	0.65
Pulmonary complications	5.6%	4.3%	0.77
Musculoskeletal Tumor Society Score (MSTS)	Range: 10-25 Mean: 17.9	Range: 10-30 Mean: 19.6	0.63
Harris Hip Score (HHS)	Range: 37-83 Mean: 58.7	Range: 32-87 Mean: 61.9	0.72

collection, 9 patients (50%) in the cemented group, and 10 patients (43.5%) in the uncemented group ($p = 0.68$) (Table 1). For deceased patients, average implant age at time of death was 219.26 days. The average age of cemented implants at time of death was 127 days as compared to 302 days for uncemented implants ($p = 0.12$), which did not reach significance due to a wide range of implant ages at time of death. No significant differences were found between cemented and uncemented groups for total complications (16.7% vs. 21.7%, $p = 0.53$), pulmonary complications (5.6% vs. 4.3%, $p = 0.77$), or 30-day mortality (5.6% vs. 8.7%, $p = 0.65$). Intraoperative blood loss (502.2 mL vs. 557.6 mL, $p = 0.85$) and transfusion requirements (0.83 U vs. 0.75 U, $p = 0.98$) were not significantly different between uncemented and cemented groups. Complications included dislocation, thromboembolic events, peripheral nerve injury, and mortality. No cases of return to the operating room or revision arthroplasty were identified.

We were able to collect patient reported outcomes from 9 patients for each group, and no significant differences were seen for average HHS (61.9 vs. 58.7, $p = 0.72$), or average MSTS (19.6 vs. 17.9, $p = 0.63$). This represented a 90% response rate for living patients with cemented implants, and a 64.3% response rate for living patients with uncemented implants.

4. Discussion

The goal of the current study was to directly compare the outcomes of patients treated with cemented and uncemented arthroplasty for oncologic disease of the proximal femur. Our data shows that

uncemented arthroplasty has a comparable incidence of overall complications, pulmonary complications, and 30-day mortality to cemented arthroplasty procedures. There were also no significant differences in intraoperative blood loss or transfusion requirements among the groups. Overall mortality for the duration of the study period was similar between both groups. Among patients who were still alive at the time of this cross-sectional study, patient reported outcomes were not significantly different between the groups with regards to HHS and MSTs. No revision procedures were performed for either type of implant. We did however note that patients who received cemented implants trended towards having a lesser age of the implant at time of death.

The argument against the use of press-fit implants for oncologic disease of the proximal femur is that they may not achieve robust fixation and ingrowth in patients with bone that is of poor quality due to pathologic lesions or that has been or will be irradiated.³ Traditionally, cementing of stems has been the gold standard for arthroplasty of the proximal femur in patients with osteoporotic femoral neck fractures due to the poor quality of osteoporotic bone.^{4–13} The use of bone cement can improve fixation of the implant in poor quality bone, however cementing is not an entirely benign procedure and has been associated with increased surgical time and thromboembolic disease from pressurization of the canal.^{4–13,16,17} Recent research has shown that comparable outcomes can be achieved with press-fit arthroplasty for patients with osteoporotic femoral neck fractures.^{4–13} Similarly, Yuasa et al. showed that uncemented total hip arthroplasty was not associated with a higher complication rate in patients over 80 years of age when compared to younger patients, indicating that the current press-fit technology allows for stable fixation in relatively lower quality bone.²⁵ It is our observation that orthopaedic oncologists routinely use both cemented and press-fit implants to treat pathologic disease of the proximal femur, despite a lack of high-quality evidence to support the use of either type of implant.

Prior retrospective studies by Thein et al. and Baptista et al. have provided some support for the use of uncemented press-fit implants in the management of metastatic disease of the proximal femur.^{3,23} Thein et al. performed both uncemented THA and hemiarthroplasty on 60 proximal femurs for pathologic disease causing pathologic fracture or impending fracture and reported positive results with minimal complications and no apparent cases of periprosthetic fracture.³ Baptista et al. reported on 34 cases of arthroplasty procedures of the proximal femur performed with uncemented stems for multiple myeloma and again showed good outcomes, however their main conclusion was that cementing the cup for a THA did not have an impact on the length of hospitalization or time to ambulation.²³ Neither of these studies included comparison groups of hip arthroplasty with cemented stems, so it is difficult to make any conclusions based off these limited studies.

There are several limitations to our study. The first is that this study is mostly retrospective. The second is that it lacks randomization. The choice of using press-fit or cemented implants was decided by the surgeon alone, which likely introduces a selection bias. It is possible that cemented implants were chosen for the patients with more advanced oncologic disease and worse bone quality. If patients with more advanced oncologic disease received cemented implants, this could explain why patients with cemented implants trended toward having a lesser age of their implant at the time of death compared to their uncemented counterparts.

Despite the limitations of our study, we believe it is the first to directly compare groups of patients undergoing cemented and uncemented hip arthroplasty procedures for oncologic disease of the proximal femur. It supports the notion that uncemented hip arthroplasty implants can be used safely and effectively by the orthopaedic oncologist and can outlive the remaining lifespan of the patient. While our study suggests non-inferiority of uncemented hip arthroplasty for oncologic disease of the proximal femur, a well-designed prospective controlled trial should be performed before abandoning the

use of cemented implants.

5. Conclusions

In this retrospective cross-sectional study, no statistically significant differences regarding function, pain, or complication rates were found for patients undergoing cemented versus uncemented hip arthroplasty for oncologic disease of the proximal femur. Retrospective nature limits this study, however these results suggest that press-fit and cemented techniques are both safe and effective methods to be used at the oncologic surgeon's discretion. Ultimately, the goal remains to offer a durable implant that will outlive a patient's lifespan, while effectively stabilizing the bone and minimizing complications.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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CRediT authorship contribution statement

Christopher G. Larsen: Methodology, Formal analysis, Data curation, Writing - original draft, Writing - review & editing, Visualization. **William K. Crockatt:** Conceptualization, Methodology, Investigation, Writing - original draft, Writing - review & editing, Visualization. **Michael Fitzgerald:** Formal analysis, Data curation, Writing - original draft, Writing - review & editing, Visualization. **Nanette Matos:** Investigation. **Howard J. Goodman:** Conceptualization, Methodology, Supervision. **Samuel Kenan:** Supervision. **Shachar Kenan:** Conceptualization, Methodology, Writing - review & editing, Supervision.

Declaration of competing interest

None.

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