Oncology & Cancer Case Reports 2020, Vol.06, Issue 2, 001-006 **Case Report**

Are Closed Reduction and Percutaneous Pinning Sufficient in Non-Pathologic Fractures in Oncology Patients?

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Abstract

Introduction: The incidence of hip fractures in patients with a history of cancer is expected to increase, whether the fracture is pathologic or not. This study sought to answer two decision points: (1) what is the appropriate imaging modality to determine if the fracture is pathologic? (2) Is Osteosynthesis (OS) an appropriate technique in the management of femoral neck fractures in patients with a history of cancer?

Materials and Methods: We did a retrospective review of patients presenting with femoral neck fractures that underwent OS or Hemiarthroplasty (HA) at a single oncologic referral center. 127 patients were identified, 109 underwent HA and 18 underwent OS. Comparison of the imaging to the histological analysis was performed to determine the accuracy, sensitivity, specificity, Positive Predictive Value (PPV), and Negative Predictive Value (NPV) of the various imaging modalities.

Results: Analysis of radiographic imaging demonstrated the addition of advanced imaging improved the accuracy, sensitivity, specificity, PPV, and NPV compared to radiographs alone. Both HA and OS offered durable reconstructive options.

Discussion and Conclusion: Radiographs without advanced imaging for comparison are incorrect 26% of the time; advanced imaging improves the accuracy. Osteosynthesis is a durable reconstructive option in patients with a history of cancer without an underlying pathologic fracture.

Keywords: Femoral neck fractures • Closed reduction • Hip hemiarthroplasty • Metastatic cancer • Pathologic fracture

Introduction

Approximately 300,000 hip fractures occur annually in the United States with femoral neck fractures account for 50% of all hip fractures [1-3]. Nondisplaced or valgus impacted femoral neck fractures, classified as Garden I and II, account for 20% of all femoral neck fractures [4,5]. The goal of surgical treatment is to provide a durable construct that allows for early ambulation. Closed Reduction and Percutaneous Pinning (CRPP)

with can nulated screws is the conventional treatment for non-displaced or valgus impacted femoral neck fractures [6,7]. The treatment for displaced femoral neck fractures is usually Hemiarthroplasty (HA), although in the high functioning patients, total hip arthroplasty results in better function and more predictable pain relief [8]. If the patient cannot tolerate an open procedure, CRPP has been demonstrated to show good results [9].

Advances in cancer treatment has increased 5-year overall survival for the most common cancers up to 66% [10]. Additionally, estimates for the number of people living with osseous metastases have increased to 400,000 [10]. In patients with metastatic carcinoma, the pelvis and proximal femur are the most common location of osseous lesions. As a result, the incidence of hip fractures in patients presenting with a history of cancer is expected to increase, whether the fracture is directly related to their cancer or not. Independent of the underlying cause of the fracture, the goals of fixation are similar: early weight bearing, limit disability, decrease surgical morbidity, and minimize hospital length of stay.

In orthopedic oncology, treatment selection is governed by the well-established principle of "one bone, one surgery." Thus, patients with impending and pathologic fractures are treated with fixation durable for the patient's life and to prevent future surgical intervention if there is local progression of disease. It has been demonstrated in patients with metastatic lymphoma and multiple myeloma, approximately 12% of patients develop local bony disease progression but only 1% required additional surgery [11]. However, a Medicare database review has demonstrated that a diagnosis of cancer, as well as pulmonary and/or circulatory co-morbidities, peripheral vascular disease, hypertension, hypothyroidism, male gender and anemia from acute blood loss, are all independent risk factors for patients requiring conversion from CRPP to a total hip arthroplasty [12].

The primary goal of this study was to create an algorithm to guide in the management of patients with a history of cancer who present with femoral neck fractures. This study sought to answer two decision points contained within the algorithm: (1) what is the appropriate imaging to accurately determine if the fracture is pathologic? (2) Is CRPP an appropriate technique in the management of non-displaced femoral neck fractures in cancer patients? It is hypothesized that: (1) CT imaging can accurately identify pathologic lesions in cancer patients presenting with femoral neck fractures and (2) patients who present with non-pathologic valgus-impacted femoral neck fractures can be treated safely with osteosynthesis and will not require additional surgery for local disease progression.

Materials and Methods

We conducted a retrospective chart review of the medical records of all patients who underwent osteosynthesis or HA for definitive management of femoral neck fractures between January 2010 and December 2020 at our tertiary oncologic referral centre. Patients treated with femoral stems greater than 155 mm were excluded, as these patients were presumed to have evidence of disease distally in the ipsilateral femur requiring stabilization of entire femur. The following CPT codes were utilized to search the institutional database to identify patients with cancer who presented with fractures: 27187, 27235, 23736, 27244, 27245, and 27125. Presence of metastatic disease at the femoral neck fracture was confirmed through review of pathologic reports, while treatment was confirmed with a direct review of each patient's pre- and postoperative imaging.

Of 127 patients identified in the database, 109 underwent short-stemmed hemiarthroplasty and 18 underwent CRPP. Among the 109 patients who underwent HA, 36 patients had fractures assessed by histopathology to be non-pathological, while the remaining 73 patients had underlying metastatic disease. Data from the 54 patients with non-pathologic fractures were analyzed to compare the durability of CRPP (n=36) with that of HA (n=18). Demographic data are presented in Table 1.

The 109 patients who underwent HA had the femoral neck and head assessed, as pathology specimens in all cases functioned as a suitable cohort to determine the accuracy of advanced imaging in the identification of an underlying pathologic lesion. The histologic evaluation of the resected specimen was considered the gold standard in identifying the underlying pathology of the fracture. Based on the histologic assessment, fractures were identified as either pathologic or non-pathologic. Imaging-based classifications of the fractures as pathologic or non-pathologic

Table 1. The demographic breakdown of the three groups of patients identified: non-pathologic fractures that underwent CRPP, non-pathologic fractures that underwent HA, and pathologic fractures.

Variables	OS (%)	Non-pathologic HHA (%)	Pathologic HHA (%)
N	18	36	73
Age ≥ 70 years	7 (39%)	22 (61%)	18 (25%)
Sex			
Male	8 (44%)	12 (33%)	22 (30%)
Female	10 (56%)	24 (67%)	51 (70%)
Cancer			
Breast cancer	2 (11%)	3 (8%)	29 (40%)
Cervical cancer	--	--	2 (3%)
Colorectal cancer	1 (6%)	4 (11%)	1 (1.5%)
Leukemia	2 (11%)	2 (5%)	1 (1.5%)
Lung cancer	2 (11%)	8 (22%)	11 (15%)
Lymphoma	--	5 (14%)	2 (3%)
Melanoma	--	--	2 (3%)
Multiple myeloma	1 (6%)	1 (3%)	2 (3%)
Pancreatic cancer	2 (11%)	2 (5%)	1 (1.5%)
Prostate cancer	--	5 (14%)	10 (14%)
Renal cell carcinoma	1 (6%)	--	3 (4%)
Squamous cell carcinoma	4 (22%)	--	--
Other types of cancer	--	3 (8%)	5 (7%)
Two different types of cancer*	3 (17%)	3 (8%)	--
Unknown primary	--	--	2 (3%)

Note: CRPP: Osteosynthesis; HA: Hip Hemiarthroplasty; OS: Open Surgery.
*Other tumor types included: amyloidosis, bladder cancer, gastric cancer, glioblastoma, ovarian cancer, carcinoid tumor, and sarcoma.

were made according to the radiologists' and nuclear radiologists' final interpretations. Analysis of the imaging accuracy compared to the histologic evaluation of resected specimens was performed to determine the accuracy, sensitivity, specificity, Positive Predictive Values (PPV), and Negative Predictive Values (NPV) of radiographs and advanced imaging modalities, including CT, MRI, Technetium 99 bone scan, and PET scan. The cohort was subdivided into multiple groups. Eleven patients had only radiographs prior to surgery. Forty-six patients had radiographs prior to surgery or the radiograph was performed and read prior to obtaining advanced imaging, eliminating the opportunity to compare the radiograph to advanced imaging. This group represents the ability of radiographs alone at determining an underlying lesion. Sixty-three patients had radiographs obtained at the time of fracture but were undergoing surveillance imaging and had advanced imaging scans prior to the fracture. The purpose of the groupings is to determine the utilization of multiple advanced imaging techniques to identify an underlying lesion.

The group of 54 patients with non-pathologic fractures were analyzed as cohort to determine if osteosynthesis (CRPP) is an appropriate technique in the management of non-displaced femoral neck fractures in the oncologic setting. This cohort was divided according to the two fixation methods: CRPP (n=18) and HA (n=36). The primary endpoint was revision surgery or death. Variables included demographic information, cancer diagnosis, extent of disease, previous therapies, previous radiation therapy, ASA classification, fracture classification (Garden I and II: non-displaced; Garden III and IV: displaced), perioperative complications, mobility status, imaging obtained and timing, and histologic diagnosis.

Surgical Techniques

CRPP involved positioning the patient on a radiolucent table with care taken to avoid displacement of the fracture. Orthogonal radiographic imaging was utilized intra-operatively to place three cannulated screws, either 6.5 mm or 7.3 mm per surgeon's preference, in an inverted triangle or diamond configuration.

A posterolateral approach was utilized for PMMA cemented hemiarthroplasty in all cases. The choice of implant manufacturer was at the surgeons' discretion. Postoperatively, all patients were weight bearing as tolerated and evaluated by physical therapy on postoperative day 1. Systemic cancer therapy was delayed for 2 weeks or until wound healing occurred.

Statistical Analysis

The changes in the patient demographics were qualified by statistical analysis. The imaging studies were assessed by accuracy, as defined by true the sum of positive and true negative divided by the total number of groups, sensitivity, specificity, NPV, and PPV. Utilizing SAS version 25 (SAS, Gary, NC) a chi-squared test was performed to compare the durability of the two fixation methods. A two-sided p value <0.05 was considered statistically significant for all analyses.

Results

Advanced imaging improves accuracy, sensitivity, specificity, positive predictive value and negative predictive value

Analysis of radiographic imaging for all 109 patients undergoing HA demonstrated that radiographs alone were accurate 74% of the time with sensitivity of 0.76 and specificity of 0.70 in predicting an underlying pathological cause of the fracture. The addition of any advanced imaging study improved the results to 90%, 0.97, and 0.74, respectively. Individually, CT scan demonstrated results of 91%, 0.96, and 0.79, respectively. MRI demonstrated results of 86%, 1.00, 0.70, respectively. PET scan demonstrated results of 95%, 1.00, and 0.75, respectively. Bone scan demonstrated results of 88%, 0.95, and 0.50, respectively. Utilizing multiple modalities of advanced imaging resulted in accuracy 91%, sensitivity of 0.97, and specificity of 0.76. Technetium 99 bone scans and PET scans had 100% NPV. Combining PET scan with any other advanced imaging technique improved the accuracy, sensitivity, specificity, PPV, and NPV to 100% (Table 2).

CRPP and HA offer durable reconstructive options

Revision surgery was required for 1 patient that had a mechanical fall within 1 month of CRPP. At the time of analysis, 1 patient in the CRPP series was alive and 17 patients had died without requiring revision surgery at an average follow-up of 11.3 months. Pathologic analysis showed that HA was performed on 36 patients with non-pathologic fractures. No revision surgeries were required in the HA non-pathologic cohort, of which 9 patients were alive and 27 patients died without requiring revision surgery at an average follow-up of 34.7 months. Patients who underwent CRPP had a different primary cancer distribution and were more likely to be non-displaced fractures than HA patients. There were no significant differences in age, extent of disease, mobility status, advanced imaging obtained, ASA classification, and postoperative complications. Of interest, a greater percentage of patients had better or the same mobility after CRPP versus HA, but this difference did not reach statistical significance (Table 3).

Discussion

The management of femoral neck fractures in patients with cancer is not well-defined. Patients may still require systemic therapy for their oncologic disease burden. Therefore, determining the appropriate course of management for the femoral neck fracture is a priority. There are two decision points within in the algorithm that this study sought to answer: (1) What is the appropriate imaging to determine if the fracture is pathologic? (2) Is CRPP an appropriate technique in the management of non-displaced femoral neck fractures in patients with cancer? Analysis demonstrated that radiographs without advanced imaging for comparison are incorrect 26% of the time to predict a pathologic femoral neck fracture. CT imaging improves the accuracy to 91%. If results are still equivocal, then a PET scan can improve the accuracy to 100%. With regard to the method of fixation, CRPP was found to offer a durable reconstructive option in non-displaced, non-pathologic fractures in patients with metastatic disease. HA provides a durable reconstructive option in displaced fractures in this same cohort.

Table 2. The breakdown of accuracy, sensitivity, specificity, Positive Predictive Value (PPV), and Negative Predictive Value (NPV). The results are divided by the modalities of the imaging obtained.

Imaging	n	Accuracy	Sensitivity	Specificity	PPV	NPV
All hemiarthroplasties	109	0.81	0.82	0.78	0.88	0.68
XR only	11	0.82	0.67	1.00	1.00	0.71
XR only or XR before AI	46	0.74	0.76	0.71	0.81	0.63
XR after AI	63	0.86	0.86	0.84	0.93	0.73
Advanced imaging	98	0.90	0.97	0.74	0.89	0.92
CT+XR	65	0.91	0.96	0.79	0.92	0.88
MRI+XR	21	0.86	1.00	0.70	0.79	1.00
PET scan+XR	21	0.95	1.00	0.75	0.94	1.00
Bone scan+XR	25	0.88	0.95	0.50	0.91	0.67
CT+AI[a]	28	0.89	0.96	0.60	0.92	0.75
MRI+AI[b]	12	0.83	1.00	0.60	0.78	1.00
PET scan+AI[c]	10	1.00	1.00	1.00	1.00	1.00
Bone scan+AI[d]	17	0.94	0.94	1.00	1.00	0.50

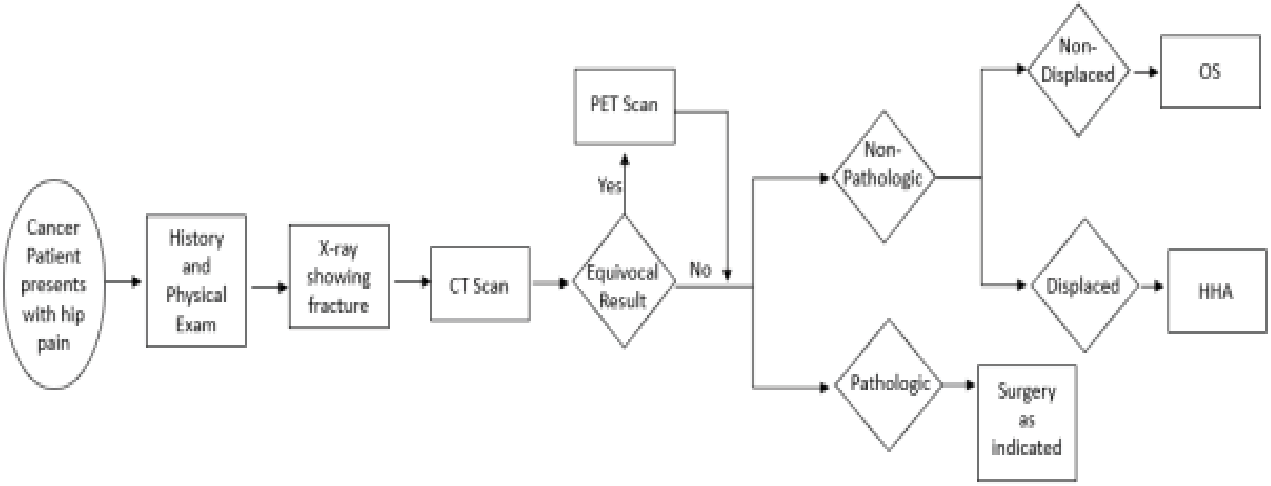
Note: NPV=Negative Predictive Value; PPV=Positive Predictive Value.
a. 'CT+AI' (n=28) includes patients with CT scans and other advanced imaging.
b. 'MRI+AI' (n=28) includes patients with MRI scans and other advanced imaging.
c. 'PET scan+AI' (n=28) includes patients with PET scans and other advanced imaging.
d. 'Bone scan+AI' (n=28) includes patients with technetium-99 bone scan and other advanced imaging.

Table 3. Disease and treatment data for non-pathologic femoral neck fractures (stratified by type of fixation).

Variables	OS (%)	HHA (%)	p value
Extent of Disease			
No metastatic disease	7 (39%)	10 (29%)	0.87
Isolated metastatic lesion	5 (28%)	4 (11%)	
Osseous metastases	6 (33%)	14 (39%)	
Visceral metastases	--	8 (22%)	
Chemotherapy			
None	3 (17%)	5 (14%)	0.17
Preoperative	2 (11%)	12 (33%)	
Postoperative	1 (6%)	5 (14%)	
Preoperative and postoperative	12 (67%)	14 (39%)	
ASA Classification			
2	2 (11%)	4 (11%)	0.236
3	10 (56%)	27 (75%)	
4	6 (33%)	5 (14%)	
Fracture			
Nondisplaced fracture	18 (100%)	14 (39%)	<0.01
Displaced fracture	--	22 (61%)	
Imaging Obtained			
X-ray	18 (100%)	36 (100%)	N/A
CT	10 (56%)	19 (53%)	0.847
MRI	3 (17%)	10 (28%)	0.368
Bone scan	3 (17%)	4 (11%)	0.567
PET scan	2 (11%)	4 (11%)	1
Postoperative Mobility			
Better after surgery	2 (11%)	2 (6%)	0.627
Same after surgery	10 (55%)	18 (50%)	
Worse after surgery	6 (33%)	16 (44%)	
Complications			
Delay in systemic treatment	3 (17%)	6 (17%)	1
Blood transfusion	10 (56%)	25 (69%)	0.314
DVT	0 (0%)	5 (14%)	0.097
PE	2 (11%)	2 (6%)	0.308
Pneumonia	0 (0%)	11 (31%)	0.115
Infection	0 (0%)	0 (0%)	--

Note: The comparison of the results of the non-pathologic femoral neck fractures. Groups are divided by the type of fixation utilized.

Figure 1 provides an algorithm to help guide surgical decision making for patients with cancer who present with femoral neck fractures. If a diagnosis of femoral neck fracture is supported by the history, physical exam, and radiographic imaging, the next recommended step is a CT scan, which can improve diagnostic accuracy by 15%. It is readily available in most Emergency Departments and is cost-



Note: CRPP: Closed Reduction and Percutaneous Pinning; HA: Hip Hemiarthroplasty.

Figure 1. An algorithm for evaluating cancer patients presenting with femoral neck fractures.

effective. If the CT results are equivocal, then a PET scan can improve the accuracy to 100% but may not readily available. Based on these results, a patient can be correctly placed into the appropriate femoral neck fracture category: non-displaced non-pathologic; displaced non-pathologic; and pathologic. Non-displaced non-pathologic fractures can be treated with CRPP. A displaced fracture can be treated with HA. Pathologic fractures should be referred to an orthopedic oncologist to optimize their functional and oncologic outcomes. The algorithm is presented in Figure 1.

In the cohort of 18 patients that underwent percutaneous pinning for non-pathologic fracture, one patient required revision to a hemiarthroplasty. This is less than the 10% rate of revisions noted by Kahlenberg et al. in their cohort of patients treated with percutaneous pining among non-cancer patients [12]. The one revision surgery was necessary after a mechanical fall and was not related to her oncologic diagnosis or any disease progression.

This study has limitations. It was a retrospective review of patients presenting with femoral neck fractures and a history of cancer. Based on the analysis of the results, an algorithm was created to help guide the management of this population. However, prospective validation of the algorithm is needed. Another limitation is the number of patients utilized to validate the algorithm. Over a 15-year period, only 18 patients underwent percutaneous pinning for hip fractures at our institution. In a study by Alvi and Damron, 11 of 96 patients with femur lesions experienced local bony disease progression of disease, but only 1 of 96 patients developed progression from an unknown metastatic lesion [11]. Based on these estimates, our study is underpowered to detect progression from an unknown metastatic lesion.

Conclusion

The difficulty in patients with cancer presenting with femoral fractures is ruling out pathologic fractures and identify which patients may benefit from a referral to an orthopedic oncologist. Radiographs without advanced imaging for comparison are incorrect 26% of the time. Advanced imaging improves the accuracy significantly. The algorithm presented can assist in the management of patients with a history of cancer presenting with a femoral neck fracture. However, additional studies are required to prospectively validate the algorithm.

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