Utility of the Current Procedural Terminology Codes for Prophylactic Stabilization for Defining Metastatic Femur Disease

Abstract

Introduction: Cohorts from the electronic health record are often defined by the Current Procedural Terminology (CPT) codes. The error prevalence of CPT codes for patients receiving surgical treatment of metastatic disease of the femur has not been investigated, and the predictive value of coding ontologies to identify patients with metastatic disease of the femur has not been adequately discussed.

Methods: All surgical cases at a single academic tertiary institution from 2010 through 2015 involving prophylactic stabilization of the femur or fixation of a pathologic fracture of the femur were identified using the CPT and International Classification of Disease (ICD) codes. A detailed chart review was conducted to determine the procedure performed as documented in the surgical note and the patient diagnosis as documented in the pathology report, surgical note, and/or office visit notes.

Results: We identified 7 CPT code errors of 171 prophylactic operations (4.1%) and one error of 71 pathologic fracture fixation operations (1.4%). Of the 164 prophylactic operations that were coded correctly, 87 (53.0%) had metastatic disease. Of the 70 pathologic operations that were coded correctly, 41 (58%) had metastatic disease.

Discussion: The error prevalence was low in both prophylactic stabilization and pathologic fixation groups (4.1% and 1%, respectively). The structured data (CPT and ICD-9 codes) had a positive predictive value for patients having metastatic disease of 53% for patients in the prophylactic stabilization group and 58% for patients in the pathologic fixation group. The CPT codes and ICD codes assessed in this analysis do provide a useful tool for defining a population in which a moderate proportion of individuals have metastatic disease in the femur at an academic medical center. However, verification is necessary.
Anticipated benefits of the electronic health record (EHR) included the ability to use existing patient data to rapidly answer research questions and provide accurate quality metrics. Exposures and outcomes based on EHR data are often defined by administrative code data, such as the Current Procedural Terminology (CPT) codes and International Classification of Disease (ICD) codes. However, even with multiple available coding systems, identifying patients in a target cohort can be challenging. Difficulties can arise from the fact that administrative data are not collected for the purpose of defining research cohorts. Data integrity can further suffer from inaccuracy, incompleteness, and a lack of standardization across multiple providers and institutions.1,2

Previous research on the use of EHR data to identify patients of interest has largely focused on tracking the outcomes of surveillance significance, such as healthcare-associated infections.3,6 Although some studies have investigated the use of EHR data to identify patients with rare diseases, these studies have generally not included an analysis of the error prevalence of CPT coding, and thus far no studies have been published regarding the use of structured data to identify patients with bony metastases.7-9

Metastatic bone disease is relatively common, affecting an estimated 280,000 to 330,000 people in the United States.10,11 However, most studies on metastatic bone disease are small, single-center studies12-16 or use larger databases with limitations that stem from retrospective design, low granularity, and lack of statistical control.17 Some studies have used the CPT and ICD codes to define cohorts of patients with metastatic disease of the femur,17 whereas others do not explicitly state the criteria or methodology that were used to identify patient cohorts.12-16,18-20 Efforts to produce studies with larger sample sizes will likely rely on structured data to identify patient cohorts. A lack of understanding of the characteristics and accuracy of cohorts defined by ICD and CPT codes could lead to biased conclusions.

The CPT and ICD ontologies are candidates to identify patients requiring surgical treatment of metastatic disease of the femur. This study aimed to characterize the error prevalence and utility of the CPT and ICD codes in the identification of two cohorts of interest: patients who received prophylactic stabilization of the femur for metastatic disease and patients who underwent surgical fixation of completed pathologic femur fractures because of metastatic bone disease.

**Methods**

**Data Source and Study Design**

This is a cross-sectional study at a single academic medical center. The study design and methods for data collection were approved by the Institutional Review Board.

**Study Sample**

All surgical cases at a single academic tertiary institution from 2010 through 2015 involving prophylactic stabilization of the femur or fixation of a pathologic fracture of the femur were identified using the CPT and ICD codes as outlined in Table 1. The selected time frame was used to assess ICD-9 codes without the influence of the ICD-10 transition. Briefly, prophylactic stabilization cases were identified using CPT codes 27495 or 27187. Pathologic fixation cases were identified using CPT codes 27236, 27244, 27245, 27269, 27506, or 27511 plus ICD-9 codes 733.10, 733.14, or 733.15. A total of 171 prophylactic stabilization and 71 pathologic fracture cases were identified.

**Study Variables**

Patient date of birth, age at the time of surgery, sex, CPT codes, and ICD codes were abstracted as part of the database query. Manual chart review was conducted to determine body mass index, race, the American Society of Anesthesiologists score as documented in the anesthesia note, the procedure performed, and whether the patient had a diagnosis of metastatic cancer. There were two main outcome variables of interest. The first was the proportion in which the procedure outlined in the surgical operative note matched the CPT code. The second was the proportion in which the pathology report, surgical note, or office visit notes documented a diagnosis of metastatic cancer or myeloma in patients who were identified as such by the corresponding CPT and ICD codes as defined above.
Statistics

Proportions of patients with correct CPT codes are reported. Of patients with correct CPT codes, the proportion of patients who had metastatic disease on chart review are also reported. Correlations are analyzed using a two-sided chi-square tests or Fisher exact test. Analyses were pre-planned, and an alpha of 0.05 was taken as significant. All statistics were conducted in R version 3.6.1.

Results

Patient characteristics are shown in Table 2. The mean patient age in both the prophylactic and pathologic groups was approximately 55 years. The prophylactic group had a slight majority of women (54%), whereas in the pathologic group, women were a slight minority (48%). Patients in both groups were overwhelmingly Caucasian, which is consistent with the demographics of the area served by the study institution.

After comparison to the surgical reports, we identified seven CPT code errors of 171 (4.1%) prophylactic operations and one error of 71 (1.4%) pathologic fracture fixations (Table 3). Among cases incorrectly coded as prophylactic stabilization, three cases incorrectly applied a CPT of 27187 and four cases incorrectly applied a code of 27495. The incorrectly applied 27187 codes were applied to one case of hemiarthroplasty, one case of revision of hardware, and one case of a documented fracture. The incorrectly applied 27495 codes were applied to two cases of revisions of stabilization or fixation of osteotomies, one case of removal of an antibiotic spacer, and one case of an explant of a total knee arthroplasty (Table 4). For the single miscoded pathologic fixation case, a CPT code of 27506 was incorrectly applied for removal and replacement of screws in an existing femoral intramedullary nail.

Of the 164 prophylactic operations that were coded correctly, 87 (53.0%) had metastatic disease as verified by manual chart review (Table 5). Of the 70 pathologic operations that were coded correctly, 41 (58%) had metastatic disease as verified by manual chart review (Table 5). Thus, the CPT and ICD codes had a positive predictive value for patients having metastatic disease as determined by chart review of 53% for patients in the

| CPT Codes | CPT Codes | ICD Codes |
|-----------|-----------|-----------|
| 27495: prophylactic treatment (nailing, pinning, plating, or wiring) with or without methylmethacrylate and femur | 27236: open treatment of femoral fracture, proximal end, neck, internal fixation, or prosthetic replacement | 733.14: pathologic fracture neck of femur |
| 27187: prophylactic treatment (nailing, pinning, plating, or wiring) with or without methylmethacrylate, femoral neck, and proximal femur | 27244: treatment of intertrochanteric, pentrochanteric, or subtrochanteric femoral fracture, with plate/screw type implant, with or without cerclage | 733.15: pathologic fracture other part of femur |
| | 27245: treatment of intertrochanteric, pentrochanteric, or subtrochanteric femoral fracture, with intramedullary implant, with or without interlocking screws and/or cerclage | 733.10: pathologic fracture unspecified site |
| | 27269: open treatment of femoral fracture, proximal end, and head, includes internal fixation, when performed | |
| | 27506: open treatment of femoral shaft fracture, with or without external fixation, with insertion of intramedullary implant, with or without cerclage and/or locking screws | |
| | 27511: open treatment of femoral supracondylar or transcondylar fracture without intercondylar extension, includes internal fixation, when performed | |

CPT = Current Procedural Terminology, ICD = International Classification of Disease
prophylactic stabilization group and 58% for patients in the pathologic fixation group. The proportion of patients with metastatic disease in the group of patients with correct CPT codes did not differ significantly between the prophylactic fixation and prophylactic stabilization groups ($\chi^2 = 0.69789$, df = 1, $P = 0.4035$). In both the prophylactic stabilization and pathologic fixation cohorts without metastatic bone disease, the most common diagnosis was a benign lesion (69% and 52%, respectively). The second most common diagnosis for prophylactic stabilization patients without metastatic disease was soft-tissue sarcoma (25%); these patients underwent prophylactic stabilization because of the use of radiation and periosteal stripping during their operations. For pathologic fixation patients without metastatic disease, the next most common diagnoses were soft-tissue sarcoma and primary bone cancer (14% each). For the primary bone tumors, in addition to resection, these patients underwent reconstructions which met the inclusion criteria by used CPT codes.

Diagnoses for patients who did not have metastatic disease included severe osteoporosis, previously radiated soft-tissue sarcomas, benign bone lesions, and metabolic diseases affecting the bone.

### Discussion

#### Key Findings

Over the study period, the data suggest there was a CPT code error prevalence of 4% for patients in the prophylactic stabilization group and 1% in the pathologic fracture group, although these were not necessarily for metastatic disease. This low error prevalence is likely related to the importance of accurate coding at academic institutions for appropriate billing.

The structured data used (CPT and ICD-9 codes) had a positive predictive value for patients having metastatic disease of 53% for patients in the prophylactic stabilization group and 58% for patients in the

### Table 2

| Patient Characteristics by Procedure Type | Prophylactic Stabilization (n = 171) | Pathologic Fixation (n = 71) |
|------------------------------------------|-------------------------------------|-------------------------------|
| Age, mean (SD)                           | 55.17 (19.69)                      | 55.19 (21.97)                 |
| Sex, n (%)                               |                                     |                               |
| Male                                     | 78 (46)                             | 37 (52)                       |
| Female                                   | 93 (54)                             | 34 (48)                       |
| BMI category n (%)                       |                                     |                               |
| Underweight                              | 4 (2)                               | 5 (7)                         |
| Normal weight                            | 61 (36)                             | 27 (38)                       |
| Overweight                               | 38 (22)                             | 20 (28)                       |
| Class I obesity                          | 40 (23)                             | 11 (16)                       |
| Class II obesity                         | 15 (9)                              | 4 (6)                         |
| Class III obesity                        | 13 (8)                              | 4 (6)                         |
| Race and ethnicity, n (%)                |                                     |                               |
| Caucasian                                | 148 (87)                            | 61 (86)                       |
| Black                                    | 4 (2)                               | 0 (0)                         |
| Hispanic                                 | 6 (4)                               | 5 (7)                         |
| Asian                                    | 6 (4)                               | 1 (1)                         |
| American Indian or Alaskan Native        | 2 (1)                               | 0 (0)                         |
| Native Hawaiian or Pacific Islander      | 0 (0)                               | 1 (1)                         |
| Other/multiracial                        | 3 (2)                               | 2 (3)                         |
| ASA, n (%)                               |                                     |                               |
| 1                                        | 14 (8)                              | 5 (7)                         |
| 2                                        | 57 (33)                             | 20 (28)                       |
| 3                                        | 84 (49)                             | 38 (54)                       |
| 4                                        | 14 (8)                              | 7 (10)                        |

ASA = American Society of Anesthesiologists, BMI = body mass index

### Table 3

| CPT Code Error Counts by Procedure Type | Total | Correct CPT | Incorrect CPT |
|----------------------------------------|-------|-------------|---------------|
| Prophylactic stabilization, n (%)      | 171   | 164 (96)    | 7 (4)         |
| Pathologic fixation, n (%)             | 71    | 70 (99)     | 1 (1)         |

CPT = Current Procedural Terminology
CPT errors were not associated with procedure type (two-sided Fisher exact test, $P = 0.44$).
pathologic fixation group. This low positive predictive value may be due to an unusually high number of patients with soft-tissue sarcomas, primary bone lesions, and other unusual surgical diagnoses (including osteogenesis imperfecta and severe osteoporosis for example) at this tertiary academic center. The positive predictive value may be higher at other institutions.

**Strengths and Limitations**

The strength of this study design was the use of manual chart review for several key unstructured fields. Review of individual surgical notes, pathology notes, and office visit notes was critical to determine the primary and secondary outcomes in this study. In contrast to many previous studies, an estimate of CPT coding error prevalence is presented. It is important to establish coding error prevalence because a high error rate would certainly confound attempts to accurately

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**Table 4**

List of All Miscoded Procedures by Procedure Type

| Prophylactic Cases | CPT Code | Reason-Deemed Miscode | Pathologic Cases | CPT Code | Reason-Deemed Miscode |
|--------------------|----------|-----------------------|------------------|----------|-----------------------|
| Prophylactic      |          |                       | Pathologic Cases |          |                       |
| Miscode Case      |          |                       | CPT Code         |          | Reason-Deemed Miscode |
| 1                  | 27187a   | Operation was right hip hemiarthroplasty | 1 | 27506b | Procedure was removing and replacing screws in existing femoral intramedullary nail |
| 2                  | 27187a   | Operation was revision of hardware of the left proximal femur | 3 | 27187a | Patient had a fracture documented by the surgeon; treatment was not prophylactic |
| 3                  | 27495c   | Operation was exchange of antibiotic spacer, right distal femur arthroplasty | 5 | 27495c | Operation was revision of stabilization of left femur osteotomy |
| 4                  | 27495c   | Operation was exchange of antibiotic spacer, right distal femur arthroplasty | 6 | 27495c | Operation was revision of fixation right femoral osteotomies with plates and screws |
| 7                  | 27495c   | Operation was explant of right total knee arthroplasty |

CPT = Current Procedural Terminology

a Prophylactic treatment (nailing, pinning, plating, or wiring) with or without methyl methacrylate, femoral neck, and proximal femur.

b Open treatment of femoral shaft fracture, with or without external fixation, with insertion of intramedullary implant, with or without cerclage and/or locking screws.

c Prophylactic treatment (nailing, pinning, plating, or wiring) with or without methyl methacrylate, femur. The CPT code that was applied and the reason the case was considered a miscode are shown.

**Table 5**

The Number of Patients With Correct CPT Codes Who Had Metastatic Disease of the Femur on Chart Review Versus Did Not Have Metastatic Disease of the Femur on Chart Review by Procedure Type ($\chi^2 = 0.69789$, df = 1, $P = 0.4035$)

| Procedure Type                        | Total | Presence of Metastatic Disease | Absence of Metastatic Disease |
|---------------------------------------|-------|--------------------------------|-------------------------------|
|                                      |       | to the Femur on Chart Review   |                               |
| Prophylactic stabilization, n (%)     | 164   | 87 (53)                        | 77 (47)                       |
| Pathologic fixation, n (%)            | 70    | 41 (58)                        | 28 (42)                       |

CPT = Current Procedural Terminology
identify a cohort of patients with metastatic disease to the femur using administrative code data. Because the study cohorts were defined a priori using the CPT and ICD codes, not all patients receiving prophylactic stabilization or pathologic fixation for metastatic disease of the femur were necessarily captured, given the inherent CPT error prevalence for this method described in this study. A manual chart review of all femoral stabilization and arthroplasty procedures to confirm whether a pathologic fracture existed is rarely practical. We can therefore not speak to the true sensitivity, specificity, or negative predictive value of this ontology.

In addition, the predictive value of the ICD and CPT codes may have changed with the transition to ICD-10 codes. However, this depends on accurately identifying cohorts of interest. Our results suggest that the CPT codes for prophylactic femur stabilization and fixation of pathologic femur fractures are rarely miscoded but are inadequate to define a cohort of patients with metastatic disease. This suggests a major limitation in the use of administrative databases for research on this patient population without additional means of identifying metastatic disease. The wide variety of primary ICD codes associated with the procedures also limits the utility of simply combining the CPT with ICD codes.

Our findings are most directly relevant to database studies and other studies using CPT and ICD codes to identify patients without verification by chart review. Such use of administrative databases for orthopaedic clinical research is rising steadily. Our data suggest identification of patients requiring surgical treatment of metastatic bone disease of the femur using structured data alone is likely to produce biased results. The cohorts we identified in this way contained a high proportion of patients without metastatic disease. In the study by Phillipp et al, for example, we expect their estimates of survival are probably overestimates.

Table 6

| Types of Lesions for Patients With Metastatic Disease to the Femur (Top) and Without Metastatic Disease of the Femur (Bottom) by Surgery Type | Prophylactic Stabilization | Pathologic Fixation |
|---|---|---|
| Presence of metastatic disease to the femur on chart review | 87 | 41 |
| Metastasis from carcinoma | 67 (77) | 29 (71) |
| Metastasis from hematologic cancer | 16 (18) | 9 (22) |
| Metastasis from melanoma | 2 (2) | 3 (7) |
| Metastasis from primary bone tumor | 2 (2) | 0 (0) |
| Absence of metastatic disease to the femur on chart review | 77 | 29 |
| Benign lesion | 53 (69) | 15 (52) |
| Aneurysmal bone cyst | 3 | 3 |
| Brown tumor | 2 | 0 |
| Chondroblastoma | 3 | 0 |
| Low-grade chondroid neoplasm | 8 | 0 |
| Desmoplastic fibroma | 1 | 0 |
| Fibrous dysplasia | 12 | 2 |
| Giant cell tumor | 4 | 0 |
| Osteochondroma | 4 | 1 |
| Pigmented villonodular synovitis | 1 | 0 |
| Unicameral bone cyst | 8 | 1 |
| Nonneoplastic, no specific pathologic diagnosis | 7 | 8 |
| Infection | 1 (1) | 2 (7) |
| Nonmetastatic primary bone cancer | 0 (0) | 4 (14) |
| Soft-tissue sarcoma | 20 (26) | 4 (14) |
| Radiation-induced lesion | 0 (0) | 1 (3) |
| Other | 3 (4) | 3 (10) |

Percentages that do not add to 100 are because of rounding error. Data are presented as n (%).
These findings also highlight the importance of explicitly stating the process by which patients are identified in retrospective cohort studies for metastatic bone disease, considering that CPT coding errors would lead to the inclusion of patients outside a given target cohort. In several of the small cohort studies on metastatic bone disease of the femur we reviewed, the methods suggested that a chart review for data abstraction took place, but it was unclear if or how the chart review contributed to the definition of eligible patients.12-16,18-20,25

The CPT codes assessed in this analysis do provide a useful tool for defining a population in which a moderate proportion of individuals have metastatic disease in the femur at an academic medical center. However, verification is necessary, and individual verification by chart review is time consuming. Algorithms based on structured and unstructured EHR data may facilitate this process, although even algorithms with good sensitivity and specificity have poor positive predictive value for rare diseases.6,9

Our results suggest that structured data may be useful to screen in a population of individuals with a higher prevalence of a rare disease, which would allow algorithms based on further structured and unstructured data to better identify patients in the cohort of interest. Because most our diagnosis verification was performed via review of surgical and pathology reports, we propose that a patient identification algorithm based on natural language processing may facilitate verification.

References

1. Drees M, Gerber JS, Morgan DJ, Lee GM: Research methods in healthcare epidemiology and antimicrobial stewardship: Use of administrative and surveillance databases. Infect Control Hosp Epidemiol 2016;37:1278-1287.
2. Cohen B, Vawdrey DK, Liu J, et al: Challenges associated with using large data sets for quality assessment and research in clinical settings. Policy Polit Nurs Pract 2015;16:117-124.
3. Colborn KI, Bronsert M, Amioka E, Hammermeister K, Henderson WG, Meguid R: Identification of surgical site infections using electronic health record data. Am J Infect Control 2018;46:1230-1235.
4. Colborn KI, Bronsert M, Hammermeister K, Henderson WG, Singh AB, Meguid RA: Identification of urinary tract infections using electronic health record data. Am J Infect Control 2019;47:371-375.
5. Gundlapalli AV, Divita G, Redd A, et al: Detecting the presence of an indwelling urinary catheter and urinary symptoms in hospitalized patients using natural language processing. J Biomed Inform 2017;71: S39-S45.
6. Goto M, Ohl ME, Schweizer ML, Perencevich EN: Accuracy of administrative code data for the surveillance of healthcare-associated infections: A systematic review and meta-analysis. Clin Infect Dis 2014;58:688-696.
7. Anaya DA, Becker NS, Richardson P, Abraham NS: Use of administrative data to identify colorectal liver metastasis. J Surg Res 2012;176:141-146.
8. Hanauer DA, Gardner M, Sandberg DE: Unbiased identification of patients with disorders of sex development. PLoS One 2014;9:e108702.
9. Walsh JA, Pei S, Pennetsa GK, et al: Cohort identification of axial spondyloarthritis in a large healthcare dataset: Current and future methods. BMC Musculoskelet Disord 2018;19:317.
10. Hernandez RK, Adhia A, Wade SW, et al: Prevalence of bone metastases and bone-targeting agent use among solid tumor patients in the United States. Clin Epidemiol 2015;7:335-345.
11. Li S, Peng Y, Weinhandl ED, et al: Estimated number of prevalent cases of metastatic bone disease in the US adult population. Clin Epidemiol 2012;4:87-93.
12. Arvinius C, Parra JL, Mateo IS, Maroto RG, Borrego AF, Stern LI: Benefits of early intramedullary nailing in femoral metastases. Int Orthop 2014;38:129-132.
13. Blank AT, Lerman DM, Patel NM, Rapp TB: Is prophylactic intervention more cost-effective than the treatment of pathologic fractures in metastatic bone disease? Clin Orthop Relat Res 2016;474:1563-1570.
14. Kotian RN, Puvanesarajah V, Rao S, El Abiad JM, Morris CD, Levin AS: Predictors of survival after intramedullary nail fixation of completed or impending pathologic femur fractures from metastatic disease. Surg Oncol 2018;27:462-467.
15. Guzik G: Oncological and functional results after surgical treatment of bone metastases at the proximal femur. BMC Surg 2018;18:5.
16. Piccoli A, Rossi B, Scaramuzza L, Spinelli MS, Yang Z, Masciauro G: Intramedullary nailing for treatment of pathologic femoral fractures due to metastases. Injury 2014;45:412-417.
17. Philipp TC, Mikula JD, Douc YC, Gundle KR: Is there an association between prophylactic femur stabilization and survival in patients with metastatic bone disease? Clin Orthop Relat Res 2020;478:540-546.
18. Chafey DH, Lewis VO, Satcher RL, Moon BS, Lin PP: Is a cephalomedullary nail durable treatment for patients with metastatic peritrochanteric disease? Clin Orthop Relat Res 2018;476:2392-2401.
19. Meares C, Badran A, Dewar D: Prediction of survival after surgical management of femoral metastatic bone disease: A comparison of prognostic models. J Bone Oncol 2019;15:100225.
20. Peterson JR, Declevvey AP, O’Connor IT, Golubić J, Witting 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;475:745-756.
21. R Core Team. R: A language and environment for statistical computing. Vienna, Austria, R Foundation for Statistical Computing, 2019. https://www.R-project.org/. Accessed September 20, 2020.
22. Patel AA, Singh K, Nunley RM, Minhas SV: Administrative databases in orthopaedic research: Pearls and pitfalls of big data. J Am Acad Orthop Surg 2016;24:172-179.
23. Karlson NW, Nezwek TA, Menendez ME, Tybor D, Salzler MJ: Increased utilization of American Administrative Databases and large-scale clinical registries in orthopaedic research, 1996 to 2016. J Am Acad Orthop Surg Glob Res Rev 2018;2:e076.
24. Gendi K, Hennessy D, Heiner J: The burden of metastatic disease of the femur on the Medicare system. Springerplus 2016;5:1916.
25. Willeumier JJ, Kaynak M, van der Zwaal P, et al: What factors are associated with implant breakage and revision after intramedullary nailing for femoral metastases? Clin Orthop Relat Res 2018;476:1823.