Mechanism of Extremity Pathologic Fracture is Different from Osteoporotic Fracture

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Introduction: Prediction of fracture risk for patients with bone lesions due to metastatic carcinoma, myeloma, and lymphoma is of interest in order to more precisely define when prophylactic surgical stabilization is needed. X-ray analysis alone has proven to be inaccurate.3,5 Other available techniques include two CT based techniques: structural rigidity analysis (CTRA) and finite element modeling (FEM).1 One potential advantage of FEM over CTRA is the ability to evaluate risk of fracture for a variety of mechanisms of injury.2 CTRA is based purely upon cross sectional rigidity of the bone and is independent of patient function. In order to develop FEM techniques for accurate fracture risk prediction, a better understanding is needed of the mechanism of injury for pathologic fractures. Although most osteoporotic fractures occur due to a fall or injury, pathologic fractures through malignant bone lesions are notorious for fracturing without significant trauma.1,4 Surprisingly, there has been little documentation of the exact mechanisms of injury that lead to pathologic fractures and hence little basis to guide FEM for risk of fracture in these lesions. If FEM analysis can be tailored to specific activities, then it may be able to provide more specific and useful functional information to the patient with respect to risk of fracture and therefore need for prophylactic stabilization. Hence, the purpose of this study was to define the mechanism of injury for pathologic fractures of the extremity. We hypothesized that pathologic fractures due to disseminated malignancy occur due to other mechanisms than falls, including but not limited to walking, standing, and rising from a sitting position.
Methods: Patients of the senior researcher (TAD) that were seen between January 2000 and June 2014 were screened through CPT codes to yield a list of patients that could potentially be included in the study. The CPT codes included those for tumor excision or resection and those for all types of femur fractures. This search yielded a list of 556 patients that were then screened for two inclusion criteria: a) disseminated malignancy of the bone and b) pathologic fracture through one of these lesions. Additionally, a list of 47 patients was received from another researcher who was working on a study for FEM analysis. These patients were screened for the same inclusion criteria and a total of 48 patients were enrolled into this study. For patients that qualified for the study, demographic information including age at the time of fracture, date of fracture, weight, height, BMI, co-morbidities, the bone fractured, radiology of the lesion and fracture, history of pain in the region prior to the fracture, and irradiation history was noted. All information was collected directly from the patient charts. The mechanism of injury was noted exactly as it was stated in the patient chart. The categories included fall, standing, walking, twisting injury, moving from a seated to standing position, moving from a standing to seated position, generalized increase in pain, and stretching in bed. Additionally,
Results: Of the 48 patients that were entered into the study, 24 patients (50.0 %) had a pathologic fracture due to a mechanism other than a fall, 14 (29.2%) had a fracture due to a fall, and the mechanism of fracture was unknown for 10 (20.8%) patients (Table 1). Of the patients that fractured

from another method besides fall, the most common mechanisms were walking (4 patients), going from a sitting to standing position (5 patients), and generalized increase in pain without noted injury (9 patients). Patients with increased pain were not placed in the unknown category because their charts at least indicated they had increasing pain associated with the fracture. Conversely, the files for patients placed under the unknown category did not even note increased pain or stated a vague description of the cause of their fracture (ex. minor injury). Of the patients in the "fall" category, only one patient clearly stated that they experienced pain prior to the fall and the others fell either after slipping or tripping. Note that of the 48 patients, three developed a pathologic fracture post prophylactic stabilization, two in the fall category and one in the not fall category. Moreover, three other patients were believed to have developed post radiation fractures highlighted by the absence of a lesion at the location of fracture at the time of the fracture and a history of irradiation including the fracture field (again, two in the fall group and one in the not fall group).

Demographics were similar among the three groups. Most of these fractures occurred in the diaphysis, regardless of the category and the femur was most commonly fractured (Table 1). Likewise, metastatic breast carcinoma was the most common malignancy overall and within each of the three individual groups. Additionally, in all three groups there were more females with fractures than males and the average age of the patients in all three groups was in the mid- 50s (Table 1).

Discussion: In conclusion, the results of this study indicated that pathologic fractures associated with disseminated malignancy more frequently occur due to activities such as walking or standing up from a seated position rather than from a fall, the typical mechanism of injury for approximately 90% of osteoporotic hip fractures.1 Moreover, in a study conducted by Pakkari et. al, on the cause of hip fractures, 98% of them were due to a fall.4 Contrarily, half of the pathologic fractures entered in this study were due to mechanisms other than a fall. Such a high percentage warrants further prospective investigation of the mechanism of pathologic fractures with a larger patient population size. Moreover, it provides the basis for use of FEM to evaluate risk of fracture using mechanisms of injury other than direct lateral compression (the modeling technique for a direct fall), as has been used for osteoporotic fractures of the proximal femur. Regardless, the results of this study indicate that performing FEM analysis for activities including standing, walking, twisting, and moving from a seated to a standing position may help determine which patients may have a high risk for pathologic fractures and thus warrant prophylactic stabilization.

Significance: Knowing the most common mechanisms of pathologic fractures can be utilized to better apply FEM analysis to predict a patient's risk for pathologic fracture. Those that are predicted to have a high risk can then undergo prophylactic stabilization to strengthen the bone and prevent fractures.

Table 1: Half of the patients with pathologic fractures fractured due to a mechanism other than a fall.								
	Bone Fractured	Number of Patients	Total	Average Age of Patients	Female to Male Ratio	Number of Proximal Epiphyseal/ Metaphyseal Fractures	Number of Diaphyseal Fractures	Number of Distal Epiphyseal/ Metaphyseal Fractures
Fall	Humerus	1	14	56 (8-87)	12:2	4	9	1
	Radius	0						
	Femur	13						
	Fibula	0						
Not Fall	Humerus	3	24	58 (41-83)	15:9	9	14	1
	Radius	0						
	Femur	21						
	Fibula	0						
Unknown	Humerus	3	10	58 (12-81)	9:1	3	6	1
	Radius	1						
	Femur	5						
	Fibula	1						
Total	-	48	48	-	-	16	29	3

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