RADIOGRAPHIC RISK FACTORS FOR INTERPROSTHETIC FEMUR FRACTURES

Jason S Lipof, MD, Ari D Amitai, MD, Kyle T Judd, MS MD*, John T Gorczyca, MD

ABSTRACT

Purpose: Total hip arthroplasty (THA) and total knee arthroplasty (TKA) are among the most common orthopaedic procedures performed in the United States annually. As the number of patients undergoing these procedures increases so too does the incidence of periprosthetic femur fractures. A number of these periprosthetic fractures occur between two ipsilateral implants, so-called interprosthetic fractures. Recent biomechanical data has challenged the importance of these interprosthetic distances, relating that cortical width and osteoporotic bone are more closely correlated with fracture than interprosthetic distance. The purpose of the current study is to further define the presence of osteoporosis, cortical width (CW) and medullary diameter (MD) as potential predictive factors for interprosthetic femur fractures.

Methods: Current Procedural Terminology (CPT) codes were used to identify a cohort of patients undergoing operative treatment for periprosthetic femur fractures. A review of the medical records identified 23 patients (5 male / 18 female) with a femur fracture between two intramedullary implants. CPT codes were also used to identify a second cohort of 25 patients (8 male / 17 female) having undergone ipsilateral THA and TKA. The intact femoral isthmus was identified radiographically and the MD and CW (mm) were measured. A ratio of MD to CW was also determined. Chart review was undertaken and any diagnosis of osteoporosis was recorded. An independent sample T-test was performed comparing the mean MD, CW, and the ratio of MD:CW for these groups. Significance was set at p.

Keywords: trauma, periprosthetic, osteoporosis, femur fracture, interprosthetic

*Corresponding author
Kyle T Judd, MS MD
601 Elmwood Ave, Box 665
Rochester, NY 14642
kyle_judd@urmc.rochester.edu
585-275-5321

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INTRODUCTION

Total hip arthroplasty (THA) and total knee arthroplasty (TKA) are among the most common orthopaedic surgical procedures performed in the United States, with over 1 Million combined procedures performed each year.[1] The population of "baby boomers" continues to age and the incidence of symptomatic end stage arthritis requiring total joint arthroplasty increases in turn. As the average life span continues to increase, the number of years spent living with total joint arthroplasty also increases. A 2010 study by Kremers et al.[2] estimated about 7 million Americans or about 2% of the American population is currently living with either total hip or total knee replacement. An estimated 620,000 of these individuals have undergone both a THA and TKA.

With an increase in the elderly population, the number of fragility fractures is also expected to continue to increase. Of these fragility fractures, fractures of the hip are of the most common with over 300,000 patients greater than 65 years of age being hospitalized for hip fractures in the United States each year[3] Despite the relatively high incidence of native hip fracture, periprosthetic femur fractures seem to occur at relatively low rates, with THA periprosthetic factures occurring at a rate of 0.1%-6% and TKA periprosthetic fractures occurring at a rate of 0.3%-5.5% in those having undergone the respective procedure. Kenny et al.[4] estimated the incidence of interprosthetic femur fractures to be about 1.25%. (Figure 1)

Historically, risk factors associated with periprosthetic femur fractures have included osteoporosis, osteomalacia, chronic steroid use, rheumatic disease, loosening of implants, press-fit implants, distance between implants, angular malalignment and surgeon experience.[5,6] Several studies have sought to understand the biomechanics of intact bone when ipsilateral femoral implants are present. These studies have reported that cortical width and osteoporotic bone are more closely correlated with fracture risk than interprosthetic distance.[7,8] To date, there have been limited clinical evaluations aimed at further defining the relationship of cortical width, medullary diameter, and presence of osteoporosis to the risk of interprosthetic femur fractures.

The purpose of the current study is to further define the presence of osteoporosis, cortical width and

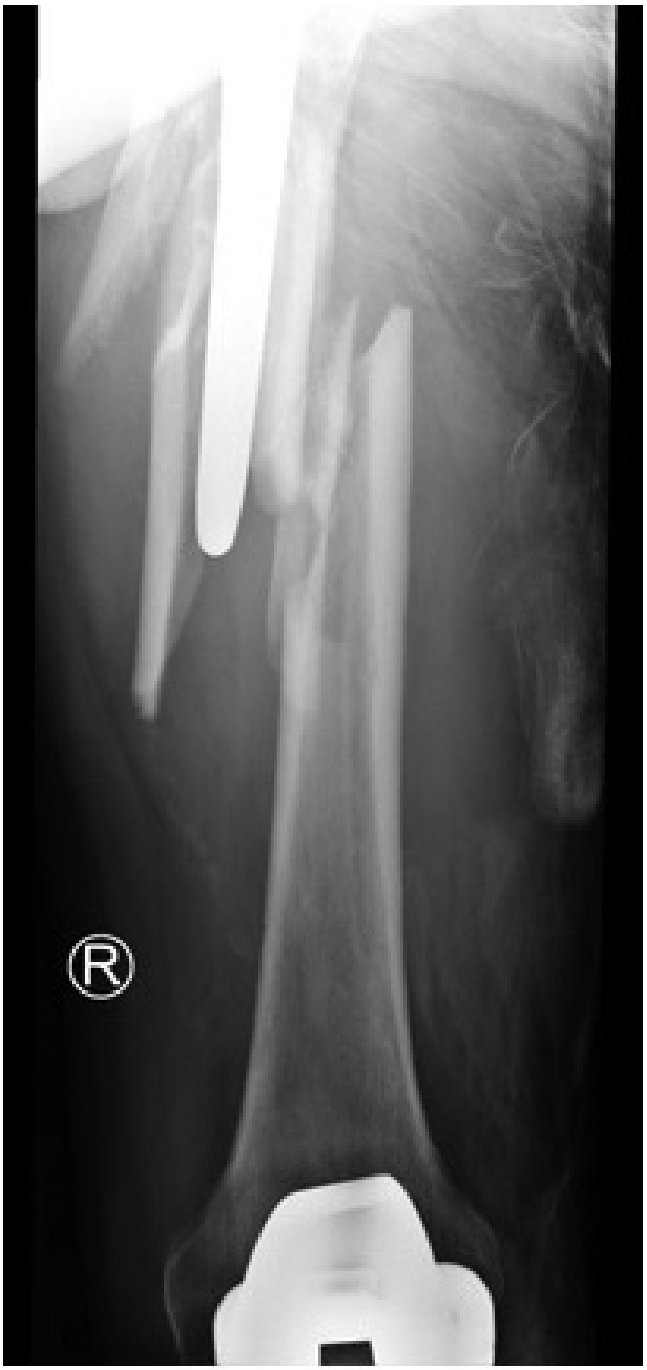

Figure 1. Example of an interprosthetic femur fracture – a fracture that occurs between two ipsilateral intramedullary implants

medullary diameter as potential predictive factors for interprosthetic femur fractures in patients with ipsilateral intramedullary implants.

Our hypothesis is that smaller cortical width and larger medullary diameter are risk factors for interprosthetic femur fractures.

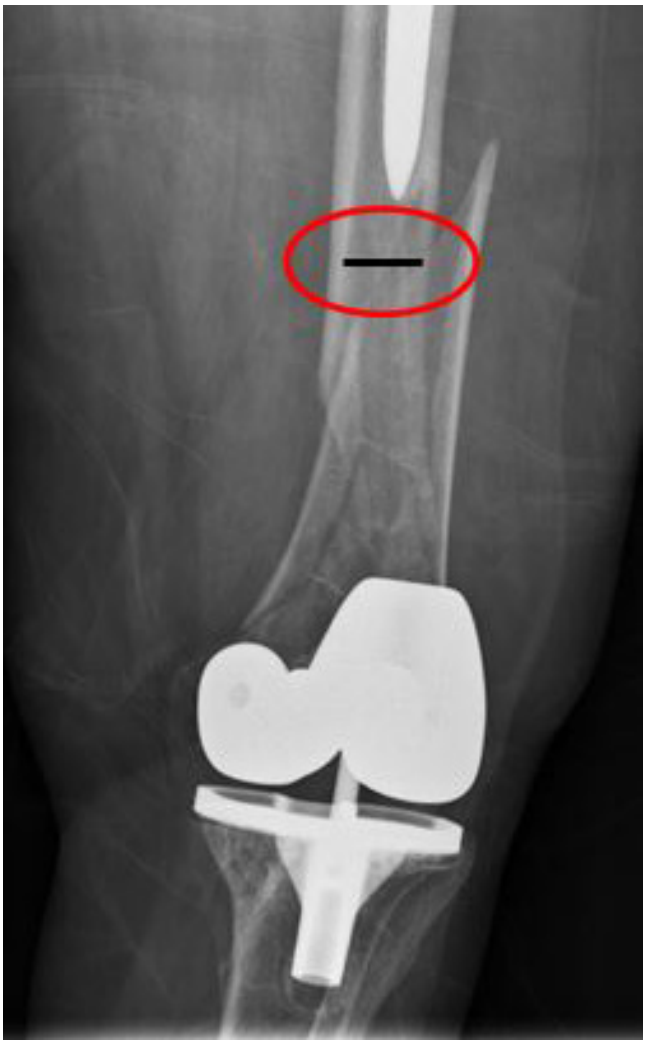

Figure 2. Identification of the femoral isthmus and measurement of the medullary diameter in millimeters, utilizing the PACS system

METHODS

This study was approved by our local Institutional Review Board (IRB). Billing records were reviewed for Current Procedural Terminology (CPT) codes to identify patients who had undergone operative treatment of femur fractures over a ten year period from 2005 to 2015. A chart review was then conducted to identify a cohort of patients that had sustained interprosthetic femur fractures. Inclusion criteria were operative treatment of a periprosthetic femur fracture occurring between two ipsilateral femoral implants and sufficient perioperative radiographic studies. A total of 23 patients (5 male and 18 female) met inclusion criteria. CPT codes were then used to identify a second cohort of 25 patients, 8 male and 17 female, who had undergone ipsilateral THA and TKA who had not sustained a femur fracture.

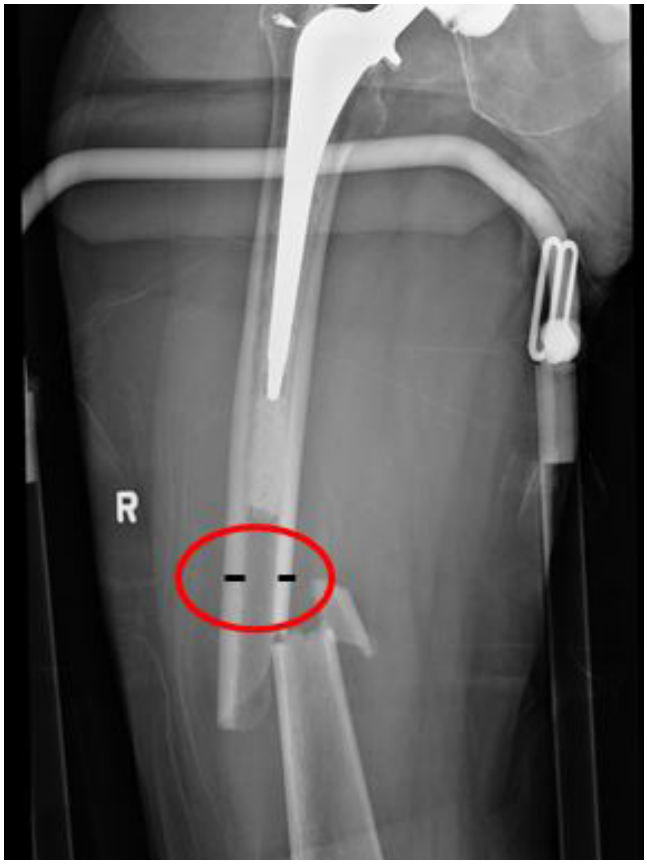

Figure 3. Identification of the femoral isthmus and measurement of the cortical width in millimeters, utilizing the PACS system

Radiographic measurement consisted of identification of the intact femoral isthmus on anteroposterior radiographs and measurement of the medullary diameter (mm) (Figure 2) and cortical width (mm) (Figure 3) utilizing the Picture Archiving and Communication System (PACS) measurement tool. A ratio of medullary diameter (MD) to cortical width (CW) was also determined for each patient at the point of measurement.

Further chart review was also undertaken to determine demographic information, presence of pre-existing diagnosis of osteoporosis and prior DEXA results if available. An independent sample T-test was performed, comparing the mean MD, CW, and the ratio of MD-to-CW for the two cohorts. Statistical significance was set at $P<0.05$ and confidence interval of 95%.

RESULTS

Of the 23 patients comprising the interprosthetic femur fracture group, 21 patients had undergone THA and 2 patients had non-arthroplasty intramedullary implants. Six of the 21 THA prostheses (26%) were cemented and 15 were press-fit implants. The two remaining implants were cephalomedullary devices. Seven patients (30%) in the fracture group carried a formal diagnosis of osteoporosis. Of the 25 patients comprising the control group that did not sustain a fracture, all had undergone press-fit THA, with the exception of one femoral implant which was cemented. Six patients (24%) in the control group carried a formal diagnosis of osteoporosis. (Table 1)

Table I. Demographic data of the Fracture and Intact cohorts

	Interprosthetic Fractures (n=23)	Intact Cohort (n=25)
Age	82	72
Sex	Female 18 Male 5	Female 17 Male 8
Cemented Implant	6 (26%)	1 (4%)
Diagnosis of Osteoporosis	7 (30%)	6 (24%)

Those patients sustaining an interprosthetic femur fracture were found to have significantly narrower cortices at the isthmus with a mean of 12.2mm compared to a mean of 16.7mm in the control group ($P<0.0001$). These patients were also found to have, on average, significantly wider medullary canals measuring 21.3mm compared to 14.8mm ($P<0.0001$) in the intact group. The significance of these variables were maintained when standardizing between patient radiographs using the ratio of medullary diameter to cortical width with a mean ratio of 1.86 compared to 0.96 in the intact group ($P<0.0001$) (Table 2). Intraclass correlation was evaluated between two experienced surgeons for measurement of both cortical width and medullary diameter. The intraclass correlation coefficient was calculated and demonstrated good-to-excellent agreement between the two surgeons (Table 3).

DISCUSSION

Total joint arthroplasty and intramedullary fracture fixation have become increasingly common over the past several decades. As the average life span continues to increase the portion of the population living with ipsilateral intramedullary implants is also likely to increase. The incidence of periprosthetic and interprosthetic fractures is projected to increase as the prevalence of ipsilateral intramedullary fracture fixation implants and total joint arthroplasty increase.[5,6] As a consequence, orthopaedic surgeons will be tasked with treating these complex fractures with increasing frequency.[10]

In the current study patients sustaining interprosthetic femur fractures were found to have significantly narrower femoral cortices at the isthmus compared to those with

Table II. Cortical Width, Medullary Diameter and MD:CW ratio for Fracture and Intact cohorts

Measurement	Interprosthetic Fractures (n=23)		Intact Cohort (n=25)		Statistical Significance	
	Mean	SD	Mean	SD	P-value	95% of difference
Cortical Width (mm)	12.26	2.55	16.74	3.9	<0.0001	(-6.42, -2.55)
Medullary Diameter (mm)	21.3	4.15	14.81	3.19	<0.0001	(4.34, 8.62)
MD:CW	1.86	0.76	0.96	0.41	<0.0001	(0.55, 1.25)

Table III. Intraclass Correlation Coefficient – assessment of intraobserver reliability

	CW Intraclass Correlation	95% Confidence Interval		MD Intraclass Correlation	95% Confidence Interval	
		Lower Bound	Upper Bound		Lower Bound	Upper Bound
Single Measures	.669	0.362	0.845	.871	0.721	0.943
Average Measures	.801	0.532	0.916	.931	0.838	0.971

ipsilateral implants and intact femurs (P<0.0001). Those sustaining interprosthetic fractures were also found to have significantly wider femoral medullary diameters at the isthmus (P<0.0001) compared to their uninjured counterparts. An increased medullary diameter to cortical width ratio was also found to be statistically significant (P<0.0001) demonstrating that this significance is maintained when standardizing for magnification.

These findings confirm our hypothesis and correlate with previous biomechanical data suggesting decrease in bone strength with narrowing of the cortical width and increase in medullary diameter. These simple radiographic markers of bone strength should be considered when indicating patients for either THA or TKA in the presence of a pre-existing ipsilateral femoral implant. Those with radiographically decreased cortical width, increased medullary diameter, and increased medullary diameter to cortical width ratio may be at increased risk of interprosthetic fracture as these findings may be indicative of an overall decrease in the strength of the remaining intact femur. The prevalence of osteoporosis may be underappreciated in patients sustaining interprosthetic femur fractures as highlighted by the fact that despite significantly narrower cortices and wider medullary diameters, the presence of a formal diagnosis of osteoporosis was similar between the two groups. Given the radiographic findings described in the fracture group, the presence of osteoporosis would likely be much higher than the rate at which it had been documented. These findings underscore the heightened need for metabolic bone screening in this at risk population, as this group of patients is likely undertreated for osteoporosis.

Limitations of this study include inability to effectively measure interprosthetic distance, as medical center radiographic imaging does not routinely obtain full limb-segment films. The radiographs were not electronically calibrated, and variation between them may exist. As this study was a retrospective review, the authors were limited by information available at the time of review and reliant on the accuracy of the medical record at the time of data collection.

CONCLUSION

Decreased cortical width and increased medullary diameter may be predictive of interprosthetic fracture as significant differences between fracture patients and those with intact femora exist.

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