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Review

Predictor of hip fracture type: a systematic review

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Abstract. *Background & Aim:* Proximal femoral fracture is one of the most common type of fracture in the elderly, with a high 1-year mortality rate. In literature, many risk factors have been related to proximal femur fracture in elderly, but most of the studies do not explore possible differences between the two main types of proximal femoral fractures: femoral neck fractures (FNF) and pertrochanteric fractures (PF). The aim of the paper is to review the current literature available on hip fractures in order to assess risk factors associated with a specific pattern of proximal femur fracture. *Methods:* Nineteen studies met the inclusion criteria and were taken into consideration in the review. Data reported from the included articles were age, gender of the patient, type of femoral fracture, BMI, height, weight, soft tissue composition, BMD, vitamin D levels, PTH levels, hip morphology and hip osteoarthritis. *Results:* Bone mineral density (BMD) of the intertochanteric region result significant lower in PF, while BMD in femoral neck regione was lower in FNF. Low levels of Vit D with high PTH are observed in TF whereas low levels of vit D and normal PTH in FNF. Hip osteoarthritis (HOA) is significant less present and less severe in FNF, while in PF is usually more frequent or higher grade. *Conclusions:* Patients with pertrochanteric fracture are older, with a low cortical thickness in the femoral isthmus, low BMD in the intertrochanteric region, severe HOA, low mean haemoglobin and albumin levels and hypovitaminosis D with a high PTH levels. Patients with FNF are younger, taller, with higher body fat mass, with lower BMD levels in femoral neck region, mild HOA, hypovitaminosis D without PTH response. (www.actabiomedica.it)

Key words: Hip fracture, Femoral Neck Fracture, Pertrochanteric fracture, Proximal femoral fracture, BMD, Vitamin D, PTH, Hip osteoarthritis

Background

Proximal femur fracture is one of the most common type of fracture in the elderly. It occurs in 18% of women and in 6% of men worldwide (1). It is caused by accidental falls in elderly patients, due to osteoporosis (2). The incidence of proximal femur fracture has raised worldwide in the last two decades along with the increase in the average age of the population and the global number of hip fractures is expected to increase from 1.26 million in 1990 to 4.5 million by the year 2050 (1).

The incidence of femoral neck fractures (FNF) is approximately equal to the incidence of pertrochanteric fractures (PF), in combination making up over 90% of all proximal femur fractures (3).

In Italy, hip fractures occurred in people over 65 years increased from 89,601 to 94,525 during the period from 2007 to 2014 (4). This leads to an increasing number of hospital admission and hospitalization costs (5). Most of the patients with hip fracture are elderly people and many of those already suffering from other major comorbidities (6). Furthermore, hip fractures affect the quality of life of patients (7). Approximately, half of the independent elderly patients become partly dependent and ultimately a third totally dependent

after the hip fracture. The 1- year mortality after hip fracture is reported varying from 13 to 36% with mean value 25% (8–15). The treatment options for the different fracture types can be grossly divided into osteosynthesis or hip replacement. For the undisplaced cervical fractures the method of choice is fixation by nailing or screwing. For a displaced cervical fracture the main treatment options are hemiarthroplasty or total hip replacement. Osteosynthesis can also be used for displaced cervical fractures, preferably if the patient is young (16); pediatric fracture have different surgical treatment. The most common surgical method for treating a trochanteric fracture is sliding hip screw and plate fixation, but over the years intramedullary nailing has shown to be an option (16). In literature, many risk factors have been related to proximal femur fracture in eldery, such as increased age, female gender, physical characteristics, white race, bone mineral density, endocrinological disorders, poor general health status, alcohol assumption, smoke, history of falls and low estrogens levels (17–21). However, most of the studies considered hip fractures as a single entity without exploring possible differences of the two main types of proximal femur fractures: femoral neck fractures and pertrochanteric fractures.

The aim of our study is to review the current literature available to assess the risk factors associated with the specific pattern of proximal femur fracture and investigate any connection between pre-existent comorbidities and proximal femur fracture pattern.

Materials And Method

This research was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

A systematic review of the literature indexed in PubMed, MEDLINE and Cochrane Library databases using the search key word: “TYPE”, “HIP FRACTURE”, “PROXIMAL FEMUR FRACTURE”, in any possible combination, using Boolean operator “AND” and “or” was performed. The reference lists of relevant studies were screened to identify other studies of interest. To minimize the number of missed studies, no filters were applied to the search strategy. The bibliography of the selected studies was accurately searched by hand, in order to identify further studies not found during our electronic search. No restrictions on the date of publication were applied. Only articles written in English language with available abstract were selected. The title of the journal, name of authors, or supporting institutions were not masked at any stage. No attempt to contact authors in order to obtain individual patient data was made. Abstracts and full texts were independently screened by two authors (MMR and DFA), if the article met the inclusion criteria, the full text was obtained and consequently reviewed. Any discordance was solved by consensus with a third author (SA). Data reported from the included articles were age, gender of the patient, type of femoral fracture, BMI, height, weight, soft tissue composition, intertrochanteric BMD, femoral neck BMD, vitamin D levels, PTH levels, hip morphology and hip osteoarthritis.

The methodological quality of the studies was assessed using the modified Coleman Methodology Score (mCMS). Each article was evaluated by two independent investigators (MMR, DFA); in cases with more than a five-point difference between their rating, the discrepancy was solved by consensus with a third author (SA). The mCMS ranges from 0 to 100 points, representing a well-designed study with no bias or confounding factors.

Results

The electronic search resulted in 107 records. Following the PRISMA flow chart (22), only nineteen studies met the inclusion criteria and were taken into consideration in the review (Table 1) (19,23–40). All of the selected studies were retrospectively analyzed. The target population consisted in 5175 patients with proximal femur fracture, divided into two groups according to the fracture pattern (2250 with pertrochanteric fracture and 2925 with femoral neck fracture).

According to the mCMS evaluation, the mean score of the studies reached was 35,5 points (23-47 points) showing a poor-mediocre result.

Age

Fifteen of the nineteen studies took in consideration reported patients’ age and divided them into two

Table 1. Antropometric data and modified Coleman Methodology Score

Study	Number of patient			Sex (Male/Female)			Age (y.o.)			mCMS
	FNF	PT	Total	FNF	PT	Total	FNF	PT	Total	
Zhuang et al	69	48		20/49	16/32		75.19.±60	78.19.±10		35
Di monaco et al 2008	23	15		6/17	8/7		77±7.6	81.3±8.8		35
Michaelsson et al	811	483				all female	72.9±6.8	72.1±6.7		38
Tanner et al			2150			1595/555				33
Fisher et al	444	317				191/570	81.7±8.2	83.1±9.5		46
Mautalen et al						all female				
Greenspan et al	53	59		14/39	13/46		87±10/84±8	88±6/85±8		35
Treece et al	55	44					77.8 5.7	77,5 5.7		47
Dreatkis et al	50	60				48/68	77.3 ± 8.4	87.1 ± 4.4	80.8 ± 8.5	43
Cauley et al	249	213				all female	73.95±5.3	75.75±6.15		32
Cho et al	162	167		47/115	49/118		78.53 ± 6.52	80.49 ± 6.37		34
Di Monaco et al	53	49				all female	79.6±8.2	80.1±7.5		26
Nakamura et al	53	53					79.0	82.3		33
Bruce et al			283			-			80±9	38
Maeda et al	22	18	40	5/17	4/14		76.8 ± 9.8	79.2 ± 8.7		23
Calderazzi etl	85	49		19/66	6/43		85.34	84.63		33
Maluta et al	166	154		48/118	47/107		84	85		25
Rotem et al	44	104								40

groups, based on the type of fracture (FNF or PF). The mean age of patients with pertrochanteric fracture is 78.99, while the mean age of those with femoral neck fracture is 75.95, with a difference of 3.04 years. Tanner et al. found an increasing tendency to PF in women with increasing age; the mean age of women with PF is significantly older than those with FNF (83.9 ± 8.03 SD vs. 81.1 ± 9.23 SD; p < .001). They also showed that men with PF were younger than those with FNF (77.5 ± 11.02 SD vs. 79.3 ± 9.99 SD; p = .05) (23).

Height, weight, BMI

Anthropometric features, such as average height, weight and BMI were reported in most of the studies analyzed (Table 2). In almost all the articles considered there was no statistically significant difference in BMI, height and weight. Michaëlsson et al found that patients with FNF were significantly taller than subjects with PF (p = 0.001), with an odds ratio that increased 23% per 5 cm height (95% CI 15–32%) (30). Mautalen et al. summarized studies evaluating hip fractures, founding that the average weight of subjects with PF was less compared to those with FNF, with a difference between the two groups of approximately 3.2 kg. They also showed that the mean height of women with PF was less than that of FNF, with a difference of 2 cm (29).

Soft tissue composition

Di Monaco et al. observed, in a sample of elderly women, that fat body mass and the percentage of body fat were significantly lower in the patients with trochanteric fractures than in those with cervical fractures of the hip (25). Body fat mass in women with trochanteric fracture was 15.71±7.30 kg whereas in patients with FNF was 18.56±6.73 kg (difference between groups: 2.86 kg; 95% CI 0.10–5.61 kg; p=0.042) (25).

Bone Mineral Density

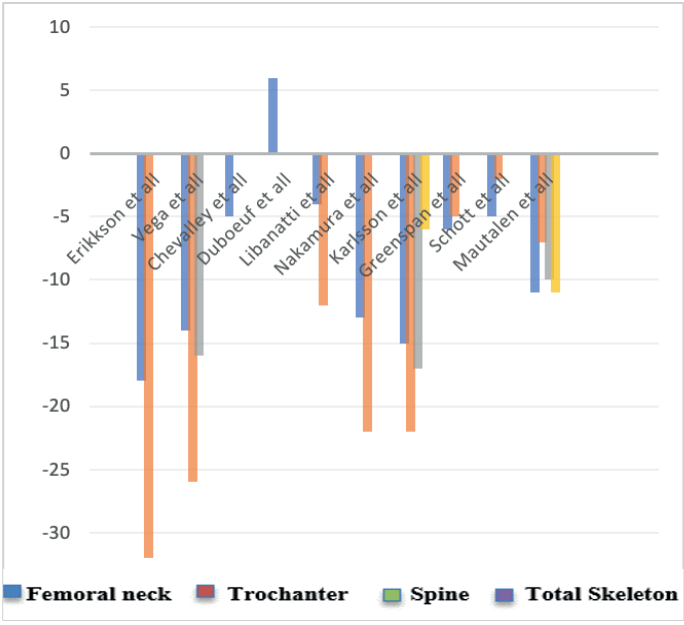
Bone Mineral Density (BMD) was studied in 8

Table 2. Data were reported as absolute value and in brackets SD.

Study	Weight (Kg)			Height (meters)			BMI		
	FNF	PT	p	FNF	PT	p	FNF	PT	p
Zhuang et al	54.5±1.5	55.3±14.0	>0.05	1.58±0.08	1.59±08	>0.05	21.4±4.30	21.6±4.10	>0.05
Di Monaco et al 2008							21.1±4.6	21.6±4	>0.05
Michaelsson et al	60.5±11.7	61.5±10.7	>0.05	163.3±6.8	164±6.4	<0.05	22.6±4.0	22.7±3.6	>0.05
Mautalen et al	55.6	58.8		157.4	160.0	<0.001			
Greenspan et al	61.5±12	62±*11.5*		1.65±*0.1*	1.6±*0.1*		24±*4.5*	23±*4*	
Treece et al	77.8±11.4	82.3±14.1		174.1±6.0	174.4±6.5				
Dreatkis et al									
Cauley et al	63.75 ± 12.25	63.25 ± 10.7		157.2 ± 6.4	159.05± 6.65				
Cho et al							22.27 ± 3.89	22.34 ± 3.44	>0.05
Di Monaco et al 2003	53.2±10.5	55.5±9.4		157.5±5.1	159.1±6.1				
Maeda et al	46.4 ± 5.8	51.2 ± 8.9		150.2 ± 7.3	154.0 ± 8.1		20.6 ± 2.4	21.5 ± 2.9	

of all studies included in this review (Fig. 1)(Table 3) (19,24,26,29,31,33,34,36). Two studies did not find any statistical difference in BMD of intertrochanteric and femoral neck region between the two groups (31,33). Studies conducted by Cauley et al. and Mautalen et al. show that there were site-specific differences in BMD for both femoral neck and intertrochanteric hip fractures: BMD of the intertrochanteric region was lower in patient with trochanteric fracture while BMD of femoral neck region was lower in those with femoral neck fracture (19,29). Cauley et al. also found that lower hip BMD is associated with less severe FNF and PF. Cho et al. and Greenspan et al. found that both BMD levels of the intertrochanteric region and femoral neck region were lower in patients with intertrochanteric fractures (24,34).

Mautalen et al. also found that a previous vertebral fracture increases the risk of a PF more than a



	Femoral neck	Trochanter	Spine	Total Skeleton
Erikkson et al	-18%	-32%	x	x
Vega et al	-14%	-26%	-16%	x
Chevalley et al	-5%	X	x	x
Duboeuf et al	6%	x	x	x
Libanatti et al	-4%	-12%	x	x
Nakamura et all	-13%	-22%	x	x
Karlsson et al	-15%	-22%	-17%	-6%
Greenspan et al	-6%	-5%	x	x
Schott et al	-5%	-2%	x	x
Mautalen et al	-11%	-7%	-10%	-11%

Figure 1. Percentage difference in bone mineral density of women with hip fractures. Data representation for BMD density of women with hip fracture. X is for missing data.

Table 3. Bone Mineral Density in different type of fracture and in different proximal femur region. Data were reported as absolute value and in brackets SD.

Study	Bone Mineral Density (g\cm2) PT			Bone Mineral Density (g\cm2) FCF		
	Neck Femoral Area	Trochateric Area	p	Neck Femoral Area	Trochateric Area	p
Zhuang. et al	0.506±0.098	0.469±0.085	>0.05			>0.05
Greenspan et al	0.821±0196/0.673±0.146	0.751±0.144/ 0.638±0.234	<0.05			>0.05
Cauley et al	0.79±0.13)	0.775± 0.14	<0.05	0.57 ± 0.08	0.575± 0.10	<0.05
Cho et al	0.808 ± 0.147	0.735 ± 0.164	<0.05	0.542 ± 0.106	0.489 ± 0.123	>0.05
Nakamura et al	0.428± 0.107	0.351±0.048	>0.05	0.497± 0.141	0.439± 0.054	>0.05
Maeda et al	0.599 ± 0.271	0.443 ± 0.252	>0.05	0.888 ± 0.451	0.847 ± 0.591	>0.05

FNF (relative risk (RR) 2.3 vs. 1.3; p = 0.07). Likewise, one standard deviation decreased bone density of the spine is more strongly related to PF than to FNF (RR 2.2 vs. 1.3) (29). Di Monaco et al. analyzed if there was any difference in BMD between patients with Parkinson Disease (PD) with PF or FNF and patient with only PF or FNF. They found that there were no significantly differences between the two groups (26).

Cortical thickness

Zhuang et al also examined cortical thickness, which is lower in PF. The cortical bone index in the femoral isthmus of PF was lower than femoral neck fractures (2.85±0.77 in patient with FNF versus 2.48±0.76 in patients with PF; P = 0.013) (33).

Cortical Bone Mapping

Graham et al. also used cortical bone mapping (CBM) to predict fracture pattern. The authors showed that adding CBM to DXA-based BMD leads to a small but significant improvement in model prediction for any fracture. In particular, in proximal femoral fracture they observed that there is a clear patch at the superolateral side of the trochanter associated with trochanteric fracture, and an even clearer patch at the superior femoral neck associated with neck fracture (32).

Vitamin D and PTH levels

Three of the studies considered Vitamin D and PTH levels, finding that most of the patients with hip fracture had vitamin D deficiency, which is also associated with increased falls (Table 4) (27,28,35). All three studies agreed that patients with hip fracture present hypovitaminosis D, while PTH levels were high in subjects with trochanteric fracture and normal in those with cervical fractures. In Dretakis et al. study it was further shown that individuals with blunted PTH response to vitamin D deficiency sustained less falls (p = 0.021), and suffered mostly from subcapital fractures (p = 0.05), as compared to patients with normal PTH response (hyperparathyroidism) to vitamin D deficiency. Interestingly, in patients without vitamin D deficiency, the presence or absence of elevated PTH levels was shown to be significantly related to trochanteric or subcapital fractures (p = 0.03), respectively (27).

Table 4. Other clinical features. Data were reported as absolute value and in brackets SD.

Study	PTH (pmol/L)			Vitamin D (nmol/L)			Menopause age (y.o.)			Body Fat Mass (kg)		
	FNF	PT	p	FNF	PT	p	FNF	PT	p	FNF	PT	p
Michaelsson et al							49.1±4.9	49.8±4.6	*<0.05*			
Fisher et al	8±6.9	5.9±3.6		37.6±	36.9±18.7							
Dreatkis et al	8.6.1 ±17.3	7.8 ±16.2		16.2 ± 7.7	19.6 ± 7.7							
Di Monaco et al 2003										5.71±7.30	18.56±6.73	*<0.05*

Other clinical features

Fisher et al. analyzed other laboratory characteristics, finding that mean haemoglobin levels (12.8±1.6 g/dl in patients with FNF versus 12.1±1.6 in PF; p=0.001) and albumin levels were lower in patients with PF (26). Furthermore, Bruce et al also considered renal function, showing that creatinine levels were higher in patients with cervical fracture (35). Michaëlsson et al. demonstrated that a short duration of menstrual cycling (i.e. the period of time between menarche and menopause) is related to an increased risk of PF, whereas almost the opposite association was found for FNF (30).

Hip Osteoarthritis and Hip and femoral morphology

Three study analyzed the correlation between hip osteoarthritis (HOA) and proximal femoral fracture pattern (37–39). They found that HOA was significantly ($p<0.01$) less represented in FNF than in PF. This correspondence become even more manifest in most severe grades of HOA. Rotem et al. evaluated hip morphology, that was determined by alpha angle, lateral central edge angle, acetabular index, neck-shaft angle, hip axis length, femoral neck diameter, Tönnis classification for hip osteoarthritis (OA) and the presence of a crossover sign. It was demonstrated that PF had significant higher neck-shaft angle, a shorter hip axis length, a narrower femoral neck diameter and a higher grade of Tönnis classification of HOA ($p = 0.045$, 0.046, 0.031, 0.022 respectively). Acetabular coverage and the proximal femoral head neck

junction, which were evaluated by lateral centre-edge angle, acetabular index and the presence of a crossover sign, did not correlate with fracture type (40).

Conclusion

Proximal femoral fractures in the elderly population are a major public health problem given the known associations with increased mortality, morbidity, and healthcare costs. Understanding the etiology and finding predictable factors of different types of hip fracture (femoral neck and trochanteric) can help with prevention and management. In the literature only few studies have been published. Nevertheless, we found that laboratory data, such as vitamin D and PTH levels, and BMD measurement of the intertrochanteric, femoral neck can suggest the fracture pattern.

The data emerged from the studies analyzed in this review showed that a patient with pertrochanteric fracture was older, with a low cortical thickness in the in the femoral isthmus, low BMD in the intertrochanteric region, severe HOA, low mean haemoglobin and albumin levels and hypovitaminosis D with a normal PTH response. On the other hand, a patient with FNF was younger, taller, with higher body fat mass, with lower BMD levels in femoral neck region, mild HOA, hypovitaminosis D without PTH response and low creatinine levels.

Conflicts of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

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