

The influence of acetabular morphology on prediction of proximal femur fractures types in an elderly population

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ABSTRACT

Introduction: The role of proximal femur morphology to the development of certain proximal femur fracture types both femoral neck and trochanteric fractures has been observed. However, the relevance of acetabular morphology to the development of proximal femur fractures is not extensively questioned. Therefore the aim of the study was to determine whether there is a correlation between acetabular morphology and pathogenesis of 2 different hip fracture types after low energy trauma.

Methods: This retrospective study includes 60 cases (41 women, 19 men) with a proximal femoral fracture after a low energy trauma between July 2012 and December 2014. Acetabular depth and acetabular index were measured on pelvic radiographs. Neck shaft angle, hip axis length and cortical index were measured on pelvic computed tomography scans. All measurements were performed on the contralateral hip.

Results: Mean age was 77.56 ± 8.99 years (range 61-92 years). No statistically significant difference was found with regard to neck shaft angle, acetabular depth or cortical index measurements between patients with femoral neck fracture and patients with trochanteric femoral fractures ($p > 0.05$). Acetabular index measurement was higher ($p = 0.001$) and hip axis length measurement was lower ($p = 0.001$) in trochanteric fracture group as compared to femoral neck fracture.

Conclusions: The rate of trochanteric femur fractures is higher in patients with high acetabular index, whereas the rate of femoral neck fractures is higher in patients with increased hip axis length.

Keywords: Acetabular index, Hip axis length, Neck shaft angle, Proximal femoral fracture, Proximal femur morphology

Introduction

Proximal femoral fractures continue to be an important public health issue in older populations and are a well-established risk factor for morbidity and mortality (1). Proximal femoral fractures are divided into 2 main groups, which are referred to the neck and trochanteric regions (2). The treatment and prognosis can differ in these 2 types (3-6).

To date; age, gender, bone mineral density (BMD) (7-12) and the morphology of the proximal femur have been

suggested to be causative factors in proximal femur fractures. Additionally, their role in the development of different fracture types was investigated in many studies. A prospective study by Koval et al concluded that trochanteric fractures are more prevalent among older women compared to femoral neck fractures (12). Duboeuf et al (6) show that BMD was lower in the trochanteric fracture group than in controls. Faulkner et al (13) were the first, who demonstrated in their case-control study, hip axis length (HAL) was higher in both femoral neck fractures and trochanteric fracture compared to controls. Previous studies were able to detect that higher HAL values were associated only with femoral neck fractures (6, 9, 14-16). Many studies imply that large neck shaft angle (NSA) is associated with the increased risk of femoral neck fracture. Maeda Y et al (2) found that cortical index (CI) was decreased in trochanteric fractures but it was not statistically significant. Finally many studies about proximal femur morphology were performed (14, 17-20) but there is no consensus about the relationship between proximal femur morphology and fracture type, and also acetabular morphology.

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TABLE I - Comparison of the demographics of the study groups

	Trochanteric fracture	Femoral neck fracture	p value
Female/Male	32/5	9/14	0.001
Age (years)	79.22 ± 9.09	74.77 ± 8.29	0.036
BMI (kg/m ²)	23.4 ± 6.5 kg/m ²	22.3 ± 6.2 kg/m ²	0.233

BMI = body mass index.

In previous morphological studies, only proximal femoral morphology was assessed in terms of proximal femoral fracture pathogenesis. To our knowledge, this is the first article focusing on the association between acetabular morphology and the development of different proximal femoral fracture types. Therefore, we hypothesised that both acetabular morphology and proximal femur morphology could influence the development of different proximal femoral fracture types.

Patients and methods

The data of 84 patients who were admitted to our hospital due to hip fracture after a low energy trauma between July 2012 and December 2014 were retrospectively reviewed. The study protocol was approved by our Ethical Committee. In our emergency department, pelvic computerised tomography (CT) is requested in some hip fracture cases with low energy trauma to detect any additional pathology and delineate the fracture configuration. Patients with both pelvic CT and plain radiograph were included in this study.

Patients were excluded if they; sustained fractures after high energy trauma, having had a contralateral hip fracture, history of previous fractures, pathological fracture, paralysis, low extremity deformity, metabolic bone disease and history of surgery on the same extremity, were excluded from the study. According to these criteria, 24 patients were excluded from the study and 60 patients were included into the analysis. The demographic population characteristics were shown in Table I. The information was obtained from the ward records, emergency service records and the Picture archiving and communication system (PACS) system used in the Radiology Department.

To analyse proximal femoral morphology, HAL, NSA and CI values were measured. Acetabular morphology was investigated by using Sharp's acetabular index (AI) (21) and acetabular depth (AD).

The pelvic radiographs were performed by a DirectView CR850 system (Carestream Health) routinely after trauma at our hospital were taken approximately 100 cm above the supine patient, symphysis pubis being at the center and both hips being approximately 15°-30° internally rotated. To confirm standardisation of the anteroposterior (AP) pelvis radiographs, the obturator foramen index was used as a reference parameter. The pelvic CT (Somatom Emotion 16, Siemens Healthcare Systems) was performed showing the area from iliac crest to shaft of femur. AI and AD were measured on AP radiographs. HAL, NSA and CI were measured on pelvic CT at the mid-coronal plane. The measurements were performed digitally by using the measurement program 0206 mme

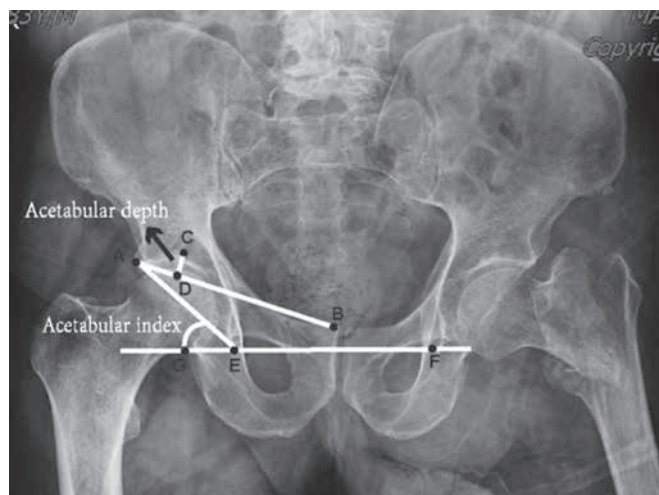


Fig. 1 - Measurement of acetabular morphology. AB = the line drawn from the furthest lateral edge of acetabulum to the upper edge of the symphysis pubis junction; AE = the line drawn from furthest lateral edge of acetabulum to lower edge of the teardrop figure; EF = the line connecting the lower edges of both teardrop figure; CD (acetabular depth) = the distance from the deepest part of the acetabular margin (C point) to AB line; AI (acetabular index) = the AEG angle.

of the PACS system. All these measurements were done at different times by 2 orthopaedic physicians working in the same clinic. They are blinded to the study, and the average of 2 measurements made by these 2 physicians were calculated. AD and AI was measured on pelvic radiographs (Fig. 1) (19, 21, 22). HAL, NSA and CI were performed at mid-coronal plane on the pelvic CTs (Fig. 2) (2, 23).

Statistical analysis

NCSS (Number Cruncher Statistical System) 2007 & PASS (Power Analysis and Sample Size) 2008 Statistical Software were used for the statistical analysis. As well as defining statistical methods (mean, standard deviation), Mann-Whitney U-test ($p < 0.05$ significant) was also used for the 2 groups comparison of the parameters that do not show normal distribution. Yates Continuity Correction test (Yates correction chi-square) ($p < 0.01$ significant) was used for the comparison of the demographic values. p value < 0.05 was considered statistically significant.

Results

60 patients (41 female, 19 male) having eligibility criteria with a mean age of 77.56 ± 8.99 years (range 61-92 years) were assessed. 37 patients (5 male, 32 female), mean age: 79.22 ± 9.09 years (range 61-92 years) with trochanteric fracture were found. Mean BMI of these patients was 23.4 ± 6.5 kg/m². 23 patients (14 male, 9 female), mean age: 74.77 ± 8.29 years (range 62-86 years) had femoral neck fracture. Mean BMI of these patients was 22.3 ± 6.2 kg/m². No statistically significant difference was found between the 2 groups in terms of BMI.

The age of the patients having trochanteric fracture was significantly higher than the patients having femoral neck



Fig. 2 - Measurement of proximal femoral morphology. KM (hip axis length [HAL]) = the length along the femoral neck axis from the lateral aspect of the greater trochanter to the inner pelvic rim; PR = width of the intramedullary canal of femur; ST = femur diaphysis diameter; KLO (neck shaft angle [NSA]) = the angle between femur mid-cervical axis and mid-shaft axis; PR/ST (cortical index [CI]) = the ratio of the intramedullary canal diameter measured around 2 cm below minor trochanter to the femoral diaphyseal diameter.

TABLE II - Comparison of the radiological measurements of 2 groups

	Trochanteric fracture	Neck of femur fracture	p value
NSA	132.24 ± 16.71	128.74 ± 3.39	0.271
AD	11.38 ± 1.77	11.43 ± 1.95	0.975
AI	37.95 ± 2.35	32.57 ± 4.02	0.001
HAL	97.00 ± 6.5	104.52 ± 6.69	0.001
CI	0.43 ± 0.06	0.44 ± 0.06	0.222

AD = acetabular depth, AI = acetabular index, CI = cortical index, HAL = hip axis length, NSA = neck shaft angle.

fracture ($p = 0.036$) (Tab. I). No statistically significant differences were detected in NSA, AD or CI measurements between the 2 fracture types ($p > 0.05$). The AI of the patients having trochanteric fracture was significantly higher than the patients having femoral neck fracture ($p = 0.001$) (Tab. II). The HAL of the patients having trochanteric fracture was significantly lower than the patients having femoral neck fracture ($p = 0.001$) (Tab. II).

Discussion

The aetiology, treatment and prognosis of trochanteric femur fractures show differences when compared to femoral neck fractures in older age groups. There are studies in the literature comparing these 2 types of fractures with regard to bone quality, age, and proximal femoral morphology. Many studies evaluated the proximal femoral morphology as

a known risk factor for these fractures (19, 20), but there is no consensus about how proximal femoral morphology is related to the occurrence of different proximal femoral fracture types. In this study, we assessed the effects of both proximal femoral and acetabular morphology on trochanteric and femoral neck fractures.

The proximal femoral bone quality, which is considered 1 of the morphological features, related to proximal femoral fracture, was previously assessed by plain radiography and pelvic CT. The relation to hip fracture was evaluated (2, 23, 24). Feola et al (24) found that the risk of hip fracture was increased in patients with low CI (24). Maeda et al (2) in their study, found no statistically significant difference when they compared the CI measured in the femur isthmus on CT scans of trochanteric fracture and neck of femur fracture. In our study, to eliminate the effect of bone mineral density, we compared the CI in patients with neck of femur fracture and trochanteric fractures, as we had no dual-energy x-ray absorptiometry (DEXA) scan values in our retrospective study group. No statistically significant difference was found between the 2 groups in terms of CI values.

The mean age of the patients with trochanteric fracture was significantly higher than patients with neck of femur fracture in our study, consistent with the literature. In a review including 14 studies, by Mautalen et al (3), the mean age of trochanteric fracture cases were found to be statistically higher than femoral neck fractures in all studies except in 1 study. It has been shown in many studies that wider NSA is associated with increased risk of neck of femur fractures (9, 15, 16, 25). It is also known that NSA decreases with aging (25-27). This supports the opinion about the positive correlation between risk of trochanteric fracture and age (9, 12). In our study group, NSA in trochanteric fractures was found to be less than in femoral neck fractures but there was no statistically significant difference.

Using the HAL, which was defined for the first time by Faulkner et al (13), he reported that increased values of HAL were associated with the risk of both trochanteric and neck of femur fractures. Later in a study of Gnudi et al (9), HAL has been showed to be more related to femoral neck fractures, but having no relationship with trochanteric fractures. An increased HAL represents a prolonged distance between the center of the hip and femur. It is supposed to increase the load on the neck of femur (28). Contrarily, Im and Lim (10) stated that increased HAL and NSA were associated with increased risk of trochanteric fracture. In our study, HAL was found to be statistically higher in patients with femoral neck fracture. An explanation for these different findings would be the potential of underlying multifactorial reasons such as the measurement techniques, position of the patient, presence of additional diseases, ethnic and anatomic differences. Additionally, suggested by 1 study, genetics was found to play a role in proximal femur morphology (29).

In our current study, acetabular morphology was evaluated by measuring AI, also known as the acetabular angle, first described by Sharp (21). In our study, we found that the risk of trochanteric fracture is increased in cases with high AI. We could not find an explanation in our literature search about

how this could happen. It can be assumed that increase in AI could increase the distance between the center of gravity of the body and rotation center of femoral head, resulting in shorter abductor arm level. Shortening of the abductor arm increases the load on the trochanteric area, as calculated by the law of the lever which was suggested by Archimedes with the formula "load $\times$ load arm = force $\times$ force arm". Anatomical and biomechanical studies should be conducted on the relation between the acetabular morphology and the fracture type.

Our literature search revealed no evidence about the relationship between acetabular depth and proximal femoral fracture, including only studies focusing on the relevance between acetabular depth and dysplasia/osteoarthritis. Most reports consider that Acetabular depth is more related with acetabular dysplasia and osteoarthritis (30, 31). In this study there was no statistically significantly found between acetabular depth and proximal femur fracture type.

Additionally, we cannot exclude the possible effect of differences in acetabular depth, which is affected by many factors including age and joint architecture disturbed as a result of osteoarthritis.

The limitations of this study were that it was retrospective in nature, which makes it unable to exclude confounding variables such as age, gender and bone mineral density. Secondly, this study group has a small sample size, which could lead to the possibility of a type 2 error.

Conclusion

Despite limitations, this study underlines the role of proximal femoral and acetabular morphology in development of the different proximal femoral fracture types. Increased HAL can be associated with increased risk of femoral neck fractures. Additionally higher AI is associated with increased risk of trochanteric fractures. All these findings are important for future studies in an effort to suggest the importance of acetabular morphology in proximal femoral fracture mechanism.

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