

Original Article

Comparison of elderly patients with and without intertrochanteric fractures and the factors affecting fracture severity

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ABSTRACT

Background: Intertrochanteric fractures in elderly patients are common and normally caused by low-energy injuries, such as falls. The favored treatment method is closed reduction with internal fixation using plate or nail systems. In general, the severity of an intertrochanteric fracture is one of key factors that affects the success rate of fixation. However, the factors that affect the severity of intertrochanteric fractures in elderly patients are rarely reported in the literature. In this prospective study, several possible factors were investigated.

Methods: The bone mineral densities (BMD) of 48 elderly patients (≥ 65 years) with intertrochanteric fractures due to low-energy injuries were compared with the BMDs of 48 elderly persons without hip fractures. Both groups were composed of people of similar ages and male-to-female ratios. Furthermore, in the patients with fractures, BMD, body mass index (BMI), body weight, and body height were compared between patients with nonsevere (intact lesser trochanter; 14 patients) and severe (displaced lesser trochanter or reverse obliquity fractures; 34 patients) intertrochanteric fractures.

Results: Patients with intertrochanteric fractures had significantly lower BMDs compared with persons without hip fractures to the lesser trochanter, total hip area, femoral neck, or greater trochanter ($p = 0.001, <0.001, <0.001, \text{ and } <0.001$, respectively). There was no statistical difference in terms of BMD, BMI, body weight, or body height between patients with nonsevere and severe fractures.

Conclusion: Elderly patients with intertrochanteric fractures have lower BMDs than persons without hip fractures. However, the severity of intertrochanteric fractures cannot be predicted by local BMD, BMI, body weight, or body height.

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1. Introduction

Intertrochanteric fractures in elderly patients are common and generally caused by low-energy injuries, such as falls. The mortality and morbidity rates following conservative treatment of such patients are high, and currently the favored treatment method is closed reduction of the fracture with internal fixation using plate or nail systems.^{1–3} However, despite the fact that operative treatment is usually aggressively pursued, the 1-year mortality rate may be as high as 10–20%.^{4,5}

The success of internal fixation of intertrochanteric fractures in elderly patients mainly depends on the severity of osteoporosis, the fracture type, the position of the fixator, and patient compliance.^{6–10} In the literature, intertrochanteric fractures are usually

classified as stable or unstable type depending on the displacement of the lesser trochanter and the presence of a reverse obliquity fracture.³ An unstable intertrochanteric fracture with displaced lesser trochanter or reverse obliquity fracture has a much higher rate of fixation failure than that of a stable fracture (Fig. 1).^{3,6–10} Conceptually, an unstable intertrochanteric fracture may be regarded as a severe type of fracture and should be treated more carefully in order to lower the rate of treatment failure. In the literature, the factors that affect the severity of intertrochanteric fractures that occur when elderly patients fall have not been definitely clarified. Theoretically, bone strength, the force of the fall, and protective effects may affect the severity of the fracture.^{11–17} Normally, bone strength is characterized by the bone mineral density (BMD).^{5,18,19} The force of the fall is represented by body weight, body mass index (BMI), body height, and the direction of impact.^{11,15,20} The protective effects (e.g., the cushioning provided by the soft tissue over the greater trochanter) are represented by body weight and BMI.^{11,15,16} The aim of this prospective study was to investigate the factors that affect the severity of intertrochanteric fractures when

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Fig. 1. (Case 1) A stable left intertrochanteric fracture with an intact lesser trochanter that was treated using a sliding compression screw. The fracture healed uneventfully within 3 months. (Case 2) An unstable right intertrochanteric fracture with a displaced lesser trochanter that was treated using a sliding compression screw. The cutout of the lag screw with nonunion was made at 3 months.

elderly patients fell. Accordingly, protective methods against low-severity fractures could be developed. Therefore, the treatment success rate of elderly patients with intertrochanteric fractures might be further increased.

2. Patients and methods

From September 2008 through October 2009, 181 consecutive patients with intertrochanteric fractures were surgically treated at Chang Gung Memorial Hospital, Chang Gung University, Taoyuan, Taiwan. To simplify the comparisons, the inclusion criteria of the present study included old age (≥ 65 years), the presence of a unilateral fracture, no history of fractures in the lower extremities, and intact walking ability before injury (i.e., no need for aids). The exclusion criteria included high-energy injuries (due to their low incidence of 3.2%), regular use of steroids or estrogen, history of ovarian or uterine surgeries or medical diseases related to secondary osteoporosis (e.g., rheumatoid arthritis, thyroid or parathyroid disorders, malabsorption syndrome, and chronic liver disorders).³ Finally, 48 intertrochanteric fractures were included in the present study. The patients in the study were aged between 67–93 years (average age: 79.9 years) with a male-to-female ratio of 1:2 (15 men and 33 women). All fractures were caused by low-energy injuries such as sliding or falling to the ground. No open fractures were included in this study. This investigation was approved by the hospital ethics committee, and informed consent was obtained from each patient.

After the general conditions of the patients were stabilized, the intertrochanteric fractures were surgically treated as soon as

possible. Sliding compressive screws (Synthes, Bettlach, Switzerland), with or without bone cement augmentation, were used depending on the type of intertrochanteric fracture. Within 48 hours post-operation, all patients underwent dual-energy X-ray absorptiometry (DXA) examination of the contralateral hip. In the present study, BMD is completely represented by the DXA values.¹⁸

The DXA machine (Delphi A; Hologic Inc., Bedford, MA, USA) was regularly maintained at our institution and the long-term precision and accuracy errors were within 1%.⁵ DXA was used as the standard procedure for each patient. Only the hip area was examined.

After the DXA examination was completed, the patients were allowed protected weight-bearing ambulation using walkers as early as possible. Hip and knee range-of-motion exercises were encouraged. Patients were discharged and received regular follow-up examination through the outpatient department at 4–6 week intervals.

For the control study, the participants consisted of 48 consecutive elderly persons (≥ 65 years) without hip fractures who were seen between March 2009 and December 2009. These persons underwent hip DXA for osteoporotic evaluation during a health survey, not for treatment purposes. Similar to the fracture group, persons using steroids or with metabolic diseases were excluded from this study. The ages of the patients in the control group ranged from 70–86 years (average age: 78.6 years) and the male-to-female ratio was 1:2.

DXA data from both groups of patients were analyzed and compared. Normally in DXA, the transcervical area is represented by the neck, the lateral part of the intertrochanter is represented by

the greater trochanter, and the medial part of the intertrochanter is represented by the lesser trochanter (Fig. 2).^{5,18} The DXA values at various areas were compared using the independent Student *t* test. Sex was compared using Chi-square test. Furthermore, $p < 0.05$ was used to indicate statistical significance.

Patients with intertrochanteric fractures were further divided into two subgroups according to the severity of the fracture pattern.²¹ The nonsevere group was defined by fractures without displacement of the lesser trochanter or without reverse obliquity fractures, and the severe group was defined by fractures that displaced the lesser trochanter or reverse obliquity fractures. The BMDs, BMIs,¹ body weights, and body heights of the patients in both subgroups were compared. Because of the small sample size in one subgroup, nonparametric statistical tests were used for comparisons. The Mann-Whitney U-test or Fisher exact test were also used, and $p < 0.05$ was used to indicate statistical significance.

3. Results

Complete hip DXA data were obtained from all 48 patients with intertrochanteric fractures and all 48 persons without hip fractures (Table 1).

The age difference between the patients with and without fractures were not significant (79.9 vs. 78.6 years; $p = 0.22$). The sex ratio of the patients with fractures was not significantly different in comparison with the sex ratio of the patients without fractures (15 men and 33 women vs. 17 men and 31 women; $p = 0.62$). The DXA values of the total hip area were significantly different between patients with and without fractures (0.58 vs. 0.67 g/cm²; $p < 0.001$; Fig. 3). The DXA values of the greater trochanter were significantly different between patients with and without fractures (0.41 vs. 0.48 g/cm²; $p < 0.001$). The DXA values of the lesser trochanter were significantly different between patients with and without

Table 1

Comparison of elderly patients with or without intertrochanteric fractures hip fractures in various areas ($n = 96$).

	Characteristic Intertrochanteric Fractures ($n = 48$)	Without Fractures ($n = 48$)	<i>p</i>
Age (y)	79.9 (6.2)	78.6 (4.0)	0.22
M/F ratio	15/33	17/31	0.62
BMD (g/cm ²)			
Total hip area	0.58 (0.10)	0.67 (0.12)	<0.001
Greater troch	0.41 (0.08)	0.48 (0.09)	<0.001
Lesser troch	0.69 (0.13)	0.78 (0.15)	0.001
Neck	0.51 (0.08)	0.60 (0.10)	<0.001

Parenthetical information indicates the standard deviation.

BMD, bone mineral density; M, male; F, female; troch, trochanter.

fractures (0.69 vs. 0.78 g/cm²; $p = 0.001$). The DXA values of the femoral neck were significantly different between patients with and without fractures (0.51 vs. 0.60 g/cm²; $p < 0.001$).

Among the patients with intertrochanteric fractures, comparisons were made between the two subgroups: the 14 patients with nonsevere (stable) fractures were compared with the 34 patients with severe (unstable) fractures (Table 2). The age difference was not statistically significant (78.0 vs. 80.6 years; $p = 0.21$). The sex ratios of these two groups was not significantly different (5 men and 9 women vs. 12 men and 22 women; $p = 0.69$). The BMD values of the various local areas were not statistically significant ($p = 0.71, 0.63, 0.83, 0.32$ for the total hip area, greater trochanter, lesser trochanter, and femoral neck, respectively). The BMI values of the patients were not statistically significant (21.5 vs. 22.6; $p = 0.64$). The body weights of the patients in both groups were not statistically significant (54.2 vs. 55.3 kg; $p = 0.89$). Body height was not significantly different between both groups (159 vs. 157 cm; $p = 0.57$).

4. Discussion

The mechanism of fracture can be clearly expressed using a force-deformation curve. An object that is sustaining a force will deform and break once the force exceeds its strength.^{19,22} The mechanism of hip fracture following a fall in elderly patients has been intensively studied, and the sideways fall has been reported as the most common type of fall that results in hip fractures.^{11,12,15,16,20} The greater trochanter impacts the ground, causing a fracture. However, the direction of the impact may be angulated with respect to the greater trochanter; consequently, either femoral neck or intertrochanteric fractures can result.^{14,20} Theories explaining the mechanisms of both fractures vary and are controversial.^{5,23–25} Until now, none of the explanations for these fractures have been absolutely convincing. Clinically, randomized studies that test these explanations cannot be implemented because of their disregard for medical ethics.

When an elderly person falls and the greater trochanter impacts the ground, some factors are believed to affect the occurrence of a fracture.^{11,12,15,16} Normally, healthy bone is strong enough to resist fracture from low-energy injuries. However, osteoporosis is the most common disorder in elderly patients and this weakens the bone.^{5,14,18} In the present study, the BMD of patients with fractures was significantly lower than that of persons without fractures. The differences were located at the femoral neck, the greater trochanter, and the lesser trochanter. However, once intertrochanteric fractures occur, BMD does not affect fracture severity. Lotz et al used quantitative computed tomography to estimate the risk of hip fracture in a cadaveric study.²⁶ They suggested that the energy absorbed during the fall and impact, rather than bone

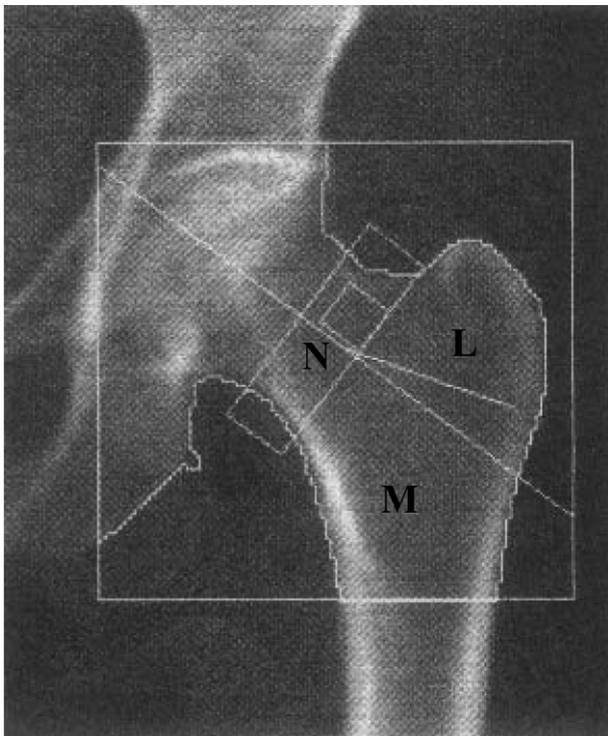


Fig. 2. Regions in the hip that were selected for bone mineral density (BMD) measurement using dual-energy X-ray absorptiometry (DXA). L, greater trochanter; M, lesser trochanter; N, femoral neck.

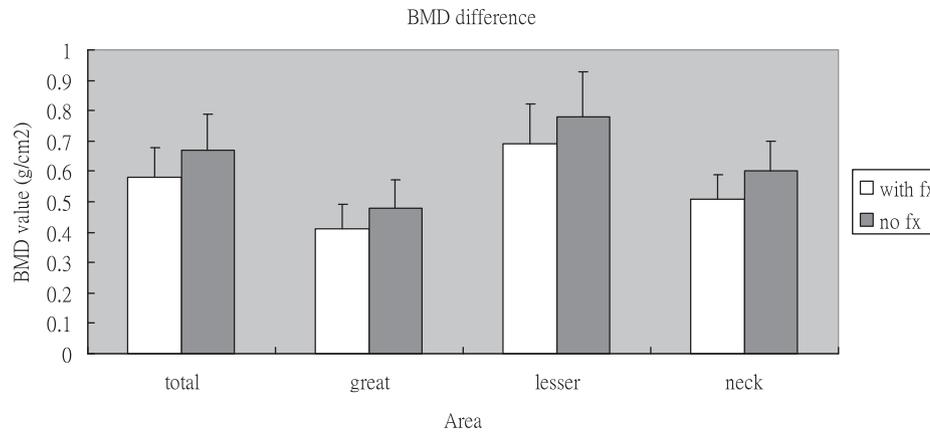


Fig. 3. Bone mineral density (BMD) values of various areas of the proximal femur were statistically different between elderly people with and without intertrochanteric fractures (bars indicate standard deviation, $p < 0.05$).

strength, may be the dominant factor in the biomechanics of hip fracture. The present study seems to verify their observations.

BMI or body weight may have two contradictory effects on fracture occurrence.¹⁵ An elderly person with a high BMI value or body weight may indicate that the person is obese.^{11,15} When this type of person falls, the impact forces and stresses are generally larger compared with that of a slim person. On the contrary, an obese person may have thicker soft tissues over the greater trochanter, resulting in greater protective effects.^{11,15} Although Bouxsein et al suggested that a high BMI is a strong determinant of the risk of hip fracture, the present study found that neither BMI nor body weight is related to fracture severity.

Body height is normally proportional to the length of the lower extremities. When an elderly person falls and the greater trochanter impacts the ground, a higher altitude introduces a larger impact.^{15,17} Therefore, impact forces are larger and the fracture is consequently more severe. Although body height does not always sufficiently represent the length of the lower extremities, the present study did not find that fracture severity was associated with height.

In the DXA study, the greater trochanter possessed the lowest BMD value in all patients, both those with and without intertrochanteric fractures. Normally, DXA is considered the most reliable tool for evaluating BMD.^{5,18} Therefore, the weakest area in the proximal femur is the greater trochanter. When elderly persons fall with a sideways pattern, the fracture mostly likely initiates in this area.^{5,12}

Clinically, the impact force and impact velocity of the greater trochanter in elderly patients with intertrochanteric fractures

during sideways falls cannot be directly measured. However, using cadavers in biomechanical studies, the energy absorbed during the fall and impact was found to be the dominant factor that affects hip fracture rather than bone strength.^{11,26} In the literature, three-dimensional finite element modeling has been used to simulate falls.^{16,20} Soft tissue protection is believed to lower the incidence of fracture. Thus, lowering the impact force by using trochanteric protectors (such as pads) may be more useful than increasing BMD (e.g., ultrasound stimulation) for the prevention of intertrochanteric fractures.

Most notably, the impact direction on the greater trochanter has been suggested to maximize the impact force.^{14,20} Posterolateral impact can produce maximum damage to the intertrochanteric area.^{14,20} This viewpoint can also be used to explain the biomechanical concept. Normally, the ratio between the femoral basicervical and intertrochanteric diameter is 4:7. The area moment of inertia of the former is one-eighth that of the latter. Moreover, the polar moment of inertia of the former is one-sixteenth that of the latter.⁵ Because the femoral neck is 10–15° of anteversion in the frontal plane of the body, impact to the posterolateral aspect of the greater trochanter can transfer force to the femoral neck.^{14,20,25} The translation between intertrochanteric and femoral basicervical areas may create a huge stress-concentration effect, which may introduce a fracture. However, this viewpoint can only be theoretically deduced; clinically, it is very difficult to verify this viewpoint by eliciting realistic falls.¹³

The limitations of the present study include its relatively small size and inability to exactly clarify the impact direction when an elderly patient falls. Multivariate analysis could not be performed, and the factors that have been suggested by various basic studies cannot be verified.^{5,14,15} Many basic studies are often contradictory and the clinical evidence is critically important. However, this limitation could not be overcome because this study lacked additional funding. In addition, medical ethics cannot be disregarded in order to perform a clinical experiment.

In conclusion, elderly patients with intertrochanteric fractures have lower BMDs in comparison with persons without hip fractures. However, the severity of intertrochanteric fractures cannot be predicted by measuring local BMD, BMI, body weight, or body height.

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Table 2

Comparison of patients with severe and nonsevere types of intertrochanteric fractures ($n = 48$).

Characteristic	Severe type ($n = 34$)	Nonsevere type ($n = 14$)	p
Age (y)	80.6 (5.3)	78.0 (4.8)	0.21
M/F ratio	12/22	5/9	0.69
BMD (g/cm^2)			
Total hip	0.58 (0.10)	0.57 (0.12)	0.71
Greater troch	0.42 (0.08)	0.41 (0.09)	0.63
Lesser troch	0.69 (0.13)	0.68 (0.15)	0.83
Neck	0.52 (0.08)	0.50 (0.10)	0.32
BMI	22.6 (3.2)	21.5 (3.8)	0.64
Body weight (kg)	55.3 (6.2)	54.2 (5.4)	0.89
Body height (cm)	157 (12)	159 (14)	0.57

Parentetical information indicates the standard deviation.

BMD, bone mineral density; BMI, body mass index; M, male; F, female; troch, trochanter.

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