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Factors affect stability of intertrochanteric fractures when elderly patients fall



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ABSTRACT

Background: Factors affecting the stability of intertrochanteric fractures when elderly patients fall are few to be reported. In this retrospective study, possible factors were investigated.

Methods: Two hundred and twenty-three consecutive elderly patients (≥ 65 years) with intertrochanteric fractures due to low energy injuries were studied. Patient age, gender, body mass index (BMI), body weight and height were compared between fractures with stable (AO/OTA type A₁, intact lesser trochanter, 80 patients) and unstable (AO/OTA types A₂, A₃, displaced lesser trochanter or reverse obliquity fractures, 143 patients) types. Statistical approaches with univariate and multivariate analyses were performed.

Results: There was no statistical difference in patient gender, age, body weight or height between patients with stable and unstable fractures in both univariate and multivariate analysis. However, BMI was statistically higher in patients with unstable fractures (22.7 vs 21.4, $p = 0.01$) in univariate analysis, but without a difference in multivariate analysis ($p = 0.07$).

Conclusions: Stability of intertrochanteric fractures may be not associated with gender, age, body weight and height or BMI when elderly patients fall. Bone mineral density or impact direction may be other possible contributing factors but requires further proofs.

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At a glance commentary

Scientific background on the subject

Factors affecting the stability of intertrochanteric fractures when elderly patients fall are few to be reported. No statistical difference in patient gender, age, and body weight or height was found in this study. However, bone mineral density or impact direction may be suggested to be possible contributing factors.

What this study adds to the field

The stability of intertrochanteric fractures, when elderly patients fall, can deeply affect the treatment outcomes. This study tried to find various factors which can decide the stability establishment. If favorable situations can be created, a success rate of treatment may be greatly improved.

Intertrochanteric fractures in elderly patients are common and generally caused by low-energy injuries, such as falls. The mortality and morbidity rates with conservative treatment for such patients are high and the favored treatment method

nowadays is a closed reduction of fractures with internal fixation using plate or nail systems [1–3]. However, despite operative treatment being aggressively pursued, a 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 severity of the osteoporosis, fracture types, fixator position, and patient compliance [6–10]. In the literature, intertrochanteric fractures are usually divided into a stable or unstable type depending on without or with displacement of the lesser trochanter or reverse obliquity fractures (AO/OTA classification) [1,11]. An unstable intertrochanteric fracture with displaced lesser trochanter or reverse obliquity fractures (AO/OTA types A₂, A₃) has a much higher failure rate of fixation than that of a stable fracture (AO/OTA type A₁) [Fig. 1] [1,6–10]. Conceptually, an unstable intertrochanteric fracture should be treated more carefully in order to lower the rate of treatment failure. In the literature, factors affecting the stability of intertrochanteric fractures when elderly patients fall have not been definitely clarified. Theoretically, bone strength, fall forces, and protective effects may affect the stability of fractures [Table 1] [11–17]. Normally, bone strength may be represented by bone mineral density (BMD) [5,18,19]. Fall forces are represented by body weight, height, body mass index (BMI), and the direction of impact [13,16,20]. The protective



Fig. 1 – (Upper panels) A stable left intertrochanteric fracture with the intact lesser trochanter was treated with a sliding compression screw. The fracture healed uneventfully within 3 months. (Lower panels) An unstable right intertrochanteric fracture with the displaced lesser trochanter was treated with a sliding compression screw. A cutout of the lag screw with nonunion occurred at 3 months.

Table 1 – Pathomechanism for factors affecting stability of intertrochanteric fractures when elderly patients fall.

Factor	Bone strength	Fall force	Protective effect
Body weight	–	+	+
Body height	–	+	–
Body mass index	–	+	+
Impact direction	–	+	–
Bone mineral density	+	–	–

+: Positive effect; –: No effect.

effect (or the cushion effect by soft tissue thickness over the greater trochanter) is represented by body weight and BMI [13,15,16]. The aim of this retrospective study was to investigate factors affecting the stability of intertrochanteric fractures when elderly patients fell. Then, methods of protection to lower the instability of fractures might be developed. Therefore, the treatment success rate of elderly patients with intertrochanteric fractures might be further increased.

Methods

From September 2008 to April 2010, 223 consecutive patients with intertrochanteric fractures were surgically treated at the authors' institution and included in the present study. To simplify the comparison, the inclusion criteria in the present study were old age (≥ 65 years), a unilateral fracture, and intact walking ability (no need for aids) before this injury. The exclusion criteria were high-energy injuries (due to their low incidence), regular use of steroids or estrogen, history of ovarian or uterine surgeries or medical diseases related to secondary osteoporosis (rheumatoid arthritis, thyroid or parathyroid disorders, malabsorption syndrome, and chronic liver disorders) [19]. All fractures were caused by low-energy injuries such as sliding or falling to the ground. There were no open fractures. This study was approved by the Institutional Review Board of the authors' institution (no.102-05678).

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 or trochanter stabilizing plates (Synthes, Bettlach, Switzerland) were used depending on the types of intertrochanteric fractures. All surgical procedures were performed under the guidance of an image intensifier.

Postoperatively, patients were allowed to ambulate with protected weight bearing, using walkers as early as possible. Hip and knee range of motion exercises were encouraged. Patients were discharged and followed up at the outpatient department regularly at 4–6 week intervals.

For the present study, patients with intertrochanteric fractures were divided into two groups according to the AO/OTA classification [1,11]. Type A₁ fractures were classified into a stable group and types A₂ and A₃ fractures were included in an unstable group. Patient age, gender, body weight, height, and BMI (body weight/body height²) from patients of both groups were compared.

Statistical analysis

Statistical analysis was performed using the SPSS 11.0 software package (SPSS Inc, Chicago, Illinois, USA). Chi-square test or unpaired Student's t-test was used for univariate comparison. The multi-factor comparison was made by logistic regression analysis. A $p < 0.05$ indicated statistical significance.

Results

Eighty patients with stable fractures and 143 patients with unstable fractures were included in the present study [Table 2].

In univariate analysis

Patients with stable fractures were aged from 65 to 92 years (average, 76.4 years) while patients with unstable fractures were aged from 65 to 94 years (average, 75.1 years, $p = 0.55$).

Patients with stable fractures included 37 men and 43 women while patients with unstable fractures included 52 men and 91 women ($p = 0.14$).

The average body weight in patients with stable fractures was 54.9 (9.0) kg. The value in the parenthesis indicated the standard deviation. The average body weight in patients with unstable fractures was 55.8 (7.6) kg ($p = 0.42$).

The average body height in patients with stable fractures was 158.2 (0.1) cm while the average body height in patients with unstable fractures was 156.4 (0.1) cm ($p = 0.06$).

The average BMI in patients with stable fractures was 21.4 (4.9) while the average BMI in patients with unstable fractures was 22.7 (2.9) ($p = 0.01$).

Among the 223 patients, 89 patients were men and 134 patients were women (a male to female ratio of 2:3). Among 89

Table 2 – Comparison of elderly patients with intertrochanteric fractures for stable and unstable fractures (n = 223).

Characteristics	Stable fractures (n = 80)	Unstable fractures (n = 143)	p value	
			univariate	multivariate
Age (years)	76.4 (15.6)	75.1 (15.6)	0.55	0.71
Male/Female ratio	37/43	52/91	0.14	0.14
Body weight (kg)	54.9 (9.0)	55.8 (7.6)	0.42	0.57
Body height (cm)	158.2 (0.1)	156.4 (0.1)	0.06	0.06
BMI (kg/cm ²)	21.4 (4.9)	22.7 (2.9)	0.01 ^a	0.07

Abbreviations: BMI: body mass index; SD: Standard deviation.

^a Statistical significance. Average (SD).

male patients, 37 fractures were a stable type and 52 fractures were an unstable type. There was no statistical difference for patient age, body weight, height or BMI between the two groups. Among 134 female patients, 43 fractures were a stable type and 91 fractures were an unstable type. There was no statistical difference for patient age, body weight, height or BMI between the two groups.

In multivariate analysis

There was no statistical significance in patient gender ($p = 0.14$), age ($p = 0.71$), body weight ($p = 0.57$), body height ($p = 0.06$) and BMI ($p = 0.07$).

Discussion

The mechanism of fractures can be clearly expressed by a force–deformation curve. An object sustaining forces will deform and break once the force exceeds its strength [18,21]. The mechanism of falls with hip fractures in elderly patients has been intensively studied and sideways fall is reported to be the most common type of fall resulting in hip fractures [13,15–17,20]. The greater trochanter impacts the ground causing a fracture. However, the direction of impact may be angulated with respect to the greater trochanter; consequently, either femoral neck or intertrochanteric fractures can be introduced [20,22]. Theories explaining the mechanism 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 to 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 considered to affect the occurrence of a fracture [13,15–17]. Normally, the healthy bone is strong enough to resist fracture occurrence in low-energy injuries. However, osteoporosis is the most common disorder and weakens the bone in elderly patients [5,13,19]. Lotz et al. used quantitative computed tomography to estimate risks of hip fractures in a cadaveric study [26]. They suggested energy absorbed during the fall and impact, rather than bone strength, may be the dominant factor in the biomechanics of hip fractures. Järvinen et al. had a similar viewpoint and advocated falls to be a more important factor as compared to osteoporosis to affect hip fractures [27]. The present study did not involve osteoporosis evaluation and could not find any clinical difference about body height, body weight, and BMI between both groups.

BMI or body weight may have two opposite effects on fracture occurrence [16]. An elderly person with a large BMI value or body weight may indicate an obese person [13,16]. When they fall, impact forces or stresses are generally larger as compared to that of a slim person. On the contrary, an obese person may have thick soft tissues over the greater trochanter and the protective effect is better [13,16]. Bouxsein et al. suggested that BMI was a strong determinant of hip fracture risk, and a low BMI greatly increased the fracture possibility [13]. Therefore, their viewpoints more support the protective effect

on affecting fracture production. The present study did not find the relation between BMI or body weight and fracture stability.

Body height is normally proportional to the lower extremity length. When an elderly person falls and the greater trochanter impacts the ground, a high altitude may introduce a larger extent of the impact [12,16]. Therefore, theoretically impact forces are larger and the fracture is consequently more unstable. However, Opatowsky et al. advocated that body height is not always convincing to sufficiently represent the lower extremity length [12]. Moreover, larger body height can contrarily lower the BMI value and lower the impact force. In the present study, no difference was found between both groups. Therefore, our findings cannot support or object studies by Opatowsky et al. [12].

Clinically, the impact force and impact velocity on the greater trochanter in elderly patients with intertrochanteric fractures during sideways falls cannot be measured directly. However, using cadaver for a biomechanical study, energy absorbed during the fall and impact is the dominant factor for hip fractures rather than bone strength [13,26]. In the literature, a three-dimensional finite element model is used to simulate the fall [15,20]. Soft tissue protection is believed to be helpful to lower a fracture incidence. Therefore, hip protectors may be used to lower the fracture instability although our study has no positive findings.

Impact direction on the greater trochanter has been especially suggested to maximize impact forces [20,22]. The posterolateral impact can produce the maximum damage in the intertrochanteric area [20,22]. Although clinically elderly patients with intertrochanteric fractures in sideways falls cannot be prospectively detected, studies of finite element models have supported this viewpoint. Therefore, impact direction may affect the stability of intertrochanteric fractures.

Although fracture risk assessment tool (FRAX) is used by the World Health Organization to predict a fracture risk in elderly patients, the BMD is considered not absolutely necessary to become one of 12 FRAX factors [28–30]. Combined with 11 factors except the BMD may still be able to achieve a useful conclusion. However, the BMD is the most convincing data to represent the bone strength [5,18,19]. The fracture stability may be closely related to the BMD and requires a long-term observation.

The limitations of the present study may include: (1) No BMD or impact direction is evaluated. Checking BMD requires a large number of funds and performed at admission. This is a retrospective study. BMD was not checked at that time. Checking impact direction is clinically difficult and uncertain. Therefore, both factors are inferred from the literature [5,13,15,20,22,27]. To our knowledge, no articles have reported such studies to predict the fracture stability. Theoretically, BMD or impact direction may affect the fracture stability when elderly patients fall; (2) The present study shows that no factors can be demonstrated to affect fracture stability. Therefore, techniques to improve the treatment cannot be developed. Beside BMD and impact direction, other possible factors may be necessary to investigate continuously. Enlarging sample size may let body height ($p = 0.06$) and BMI ($p = 0.07$) become statistically significant. Otherwise, treatment of intertrochanteric fractures in elderly patients is difficult to achieve far advancement. (3) This is a retrospective study. Most of the data for FRAX calculation (12 items) are lack and cannot be utilized. Thus, risks for fractures cannot be thoroughly studied.

Conclusion

The stability of intertrochanteric fractures cannot be predicted by patient age, gender, body weight, body height, and BMI when elderly patients fall. Impact direction on the greater trochanter or BMD may affect fracture stability but both require further proofs.

Source of support

Nil.

Conflict of interest

There are no conflicts of interest in this study.

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