



# Failure after intramedullary nailing for geriatric trochanteric fracture: does quality of fracture reduction on the AP and lateral planes show the same results?

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## Abstract

**Purpose** This study aimed to investigate the failure of trochanteric fracture fixation according to the quality of fracture reduction on the anteroposterior (AP) and lateral views.

**Methods** Data from 340 female and 152 male patients  $\geq 60$  years of age who underwent intramedullary nailing for a trochanteric fracture between 2016 and 2020 were analysed retrospectively. The quality of fracture reduction was classified as type A, type E, and type I on the AP view and type N, type A, and type P on the lateral view according to the relative position of the proximal and distal fragments. The failure rate was evaluated and compared according to the quality of fracture reduction. The risk factors of the fixation failure were investigated by comparison of variables between patients with and without failure and by regression analysis.

**Results** Patients with poor reduction, type I and type P had higher failure rates. However, a statistically significant difference was found only for patients with poor reduction (type P) on the lateral view ( $p < 0.001$ ). Patients with failure showed significantly higher rates of poor reduction on the lateral view and AO/OTA type A3 fractures. The regression analysis also showed that poor reduction on the lateral view (odds ratio [OR] 12.70; 95% confidence interval [CI] 4.0–40.6;  $p < 0.001$ ) and AO/OTA type A3 fractures (OR 5.40; 95% CI 1.24–23.49,  $p = 0.025$ ) were risk factors for failure.

**Conclusion** Poor reduction such as type P reduction was associated with failure after intramedullary nailing for trochanteric fractures. Surgeons should check the quality of fracture reduction carefully with the proper fluoroscopic view to prevent failure in geriatric patients with trochanteric fractures.

**Keywords** Trochanteric fracture · Femur · Reduction quality · Intramedullary nailing · Cut-out · Failure

## Introduction

Femoral trochanteric (or pertrochanteric) fractures are known to have high mortality and morbidity rates in elderly patients [1]. Except for a limited number of patients, most geriatric trochanteric fractures can be successfully managed with surgical repair. Although some surgeons have attempted hip arthroplasty for trochanteric fractures and reported

satisfactory results [2, 3], osteosynthesis is still the standard treatment for trochanteric fractures regardless of the comminution status and degree of osteoporosis.

Intramedullary nailing (IMN) has gained popularity for the fixation of geriatric trochanteric fractures in the last decade [4]. Compared to extramedullary fixation devices, fixation by IMN has shown advantages, including a shorter operation time and lower blood loss volume, as well as early weight bearing through its advantageous biomechanics [5, 6]. Despite these advantages, meta-analysis has shown no evidence of a decreased rate of complications, including fixation failure, with IMN in geriatric trochanteric fractures [7, 8].

The quality of reduction and position of the implant within the femoral head have been shown to be surgeon-modifiable risk factors for fixation failure and nonunion [9, 10]. Previous studies have also reported that the fixation

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failure rate can be determined by the quality of fracture reduction in trochanteric fractures [11–13].

Regarding reduction quality, relative locations of proximal and distal fragments have been focused. Anatomic reduction or the relative position of cortices that can prevent sliding have been reported to yields postoperative stability and favourable results in unstable geriatric trochanteric fractures [12–16]. On the other hand, anteromedial cortex of the proximal fragment located lateral or posterior to that of the distal fragment, which cannot prevent excessive sliding, has been reported to be related with unfavourable outcome [12–16]. Our question was whether the results of poor reduction on the AP and lateral views has a similar impact on the failure of trochanteric fracture fixation. Therefore, we evaluated the fixation failure rate according to the quality of reduction in elderly patients with trochanteric fractures.

## Materials and methods

This study was approved by the institutional review board (IRB No. DFH2003-02-001) of the institution where the study was conducted. The requirement for informed consent was waived due to the retrospective design of the study.

A retrospective radiographic review of all patients aged  $\geq 60$  years treated with IMN for trochanteric fractures between 2016 and 2020 was conducted. Patients with hip fracture dislocation and those with fractures of adjacent areas such as the acetabulum, pelvic ring, and femoral shaft were not included in this study. Those with pathologic fractures caused by neoplasms were also excluded. After excluding the abovementioned patients, 660 femoral trochanteric fracture patients who underwent IMN during the study period were identified. Patients in whom bone union could be confirmed with radiographs obtained at the study institution were included in the analysis.

Overall, 492 of 660 patients were enrolled in the current study. Of the 492 patients, 152 and 340 were male and female, respectively. The average age at the time of surgery was  $79.1 \pm 8.1$  years (range 60.0–99.0 years). The average follow-up period was  $14.3 \pm 9.9$  months (range 6–54 months).

## Surgical technique

All patients were operated on by the first author. A proximal femoral nail antirotation II (PFNA II; Synthes, Oberdorf, Switzerland) implant with a length of 200 mm, caput-collum-diaphyseal (CCD) angle of  $125^\circ$ , and spiral blade was used for all cases. Patients were positioned in the supine position on the fracture table. Closed reduction was attempted with traction and rotation under fluoroscopic guidance. When closed reduction failed to achieve satisfactory

reduction, limited open reduction via a lateral stab incision was performed using a tonsil clamp.

After confirming the reduction, a guide pin was placed through the just medial to the tip of the greater trochanter on the AP view. The guide pin was positioned in line with the middle of the femoral neck on the lateral image. Then, reaming was performed, pushing the hammer from the lateral side to prevent “fish-mouth” deformity. The diameter and length of the nail were determined by intraoperative measurement using a ruler, and the values measured on radiographs of the contralateral femur were also considered. Then, the nail was inserted to an appropriate depth for blade placement. During blade fixation, we tried to place the blade tip in the middle of or slightly inferior the femoral head on the AP view and at the centre of the femoral head on the lateral view.

Sitting and wheelchair ambulation were encouraged immediately after surgery. Weight-bearing with aid was allowed when tolerable according to the patient’s general condition.

## Radiographic and clinical assessments

Two orthopaedic surgeons reviewed all radiographic images. The morphology of all fractures was classified according to the AO/OTA classification, which was revised in 2018 [17]. The fracture reduction status was classified as type A, type E, and type I on the AP view and as type N, type A, and type P on the lateral view according to the relative position of the proximal and distal fragments using intraoperative fluoroscopic images and immediate postoperative radiographs [12–14, 16].

On the AP view, the medial cortex was used as an index: the type A, the medial cortices of the proximal and distal fragments continued anatomically; the type E, the medial cortex of the proximal fragment was located extramedullary, medial to that of the distal fragment; and the type I, the medial cortex of the proximal fragment was located intramedullary, lateral to that of the distal fragment (Fig. 1a–c) [14].

For the lateral view, the anterior cortex was used as an index: the type N, the anterior cortices of the proximal and distal fragments continue anatomically; the type A, the anterior cortex of the proximal fragment is located extramedullary (anteriorly) to that of the distal fragment; the type P, the anterior cortex of the proximal fragment is located intramedullary (posteriorly) to that of the distal fragment (Fig. 1d–f) [14].

The tip–apex distance (TAD) was assessed by measuring the distance between the blade tip and the apex of the femoral head on both AP and lateral radiographs. To correct for magnification, the measured distance was multiplied by the ratio between the actual diameter and the measured diameter of the blade according to previous literature [10, 18].



**Fig. 1** Method for classifying the reduction state on the anteroposterior (AP) and lateral views. On the AP view: **a** in type A reduction, the medial cortices of the proximal and distal fragments continued anatomically; **b** in type E reduction, the medial cortex of the proximal fragment was located extramedullary, medial to that of the distal fragment; **c** in type I reduction, the medial cortex of the proximal fragment was located intramedullary, lateral to that of the distal fragment.

The Cleveland index, describing the position of the implant within the femoral head, was evaluated using the lateral view [19] and divided the position of the screw in the femoral head into safe zones (zones 5, 6, 8, and 9) and danger zones (zones 1, 2, 3, 4, and 7) [19].

Bone union was determined using the criteria suggested by Corrales et al., as follows: clinical absence of pain at the fracture site on both palpation and weight-bearing and

On the lateral view, the anterior cortex was used as an index: **d** in type N reduction, the anterior cortices of the proximal and distal fragments continued anatomically; **e** in type A reduction, the anterior cortex of the proximal fragment was located, anterior to that of the distal fragment; **f** in type P reduction, the anterior cortex of the proximal fragment was located posterior to that of the distal fragment

radiological evidence of bridging of 3 or more cortices on two different views [20]. Fixation failure was defined as cut-through or cut-out of spiral blade, and breakage of implant.

Demographic data, including age, sex, and body mass index (BMI), were reviewed. The general condition of the patients was assessed using the American Society of Anesthesiologists (ASA) classification and the Charlson Comorbidity Index (CCI) [21, 22]. Bone mineral density (BMD)

was measured in the lumbar spine and hip regions with dual-energy X-ray absorptiometry (DXA, DPX-NT; GE Medical Systems Lunar, Madison, WI, USA). Among the measured T scores of the lumbar spine, femoral neck, and total hip, the lowest T score was used for the analysis. Clinical data, including demographics, are presented in Table 1.

## Statistical analysis

Fixation failure rates were compared according to the reduction quality. To evaluate factors affecting fixation failure, a comparison of variables was performed between patients with and those without fixation failure. The comparison was performed using a t test for continuous variables. For categorical variables, a comparative analysis was performed using the Chi-square or Fisher's exact test when  $\geq 1$  of the cells had an expected frequency of  $\leq 5$ .

Binary logistic regression models were generated to identify risk factors for fixation failure. The regression model included radiologic factors known as risk factors of fixation failure including A3 type of AO/OTA classification, blade tip located at danger zones according to the Cleveland index, TAD, poor reduction on AP view (type I reduction), and poor reduction on lateral view (type P reduction). To exclude the effect from patient characteristics, age, sex, BMI, and presence of osteoporosis was adjusted for the model. TAD, age, and BMI were incorporated as continuous variables for the model. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated. Statistical significance was accepted if the  $p$  value was  $< 0.05$ . Data analysis was performed using SPSS version 21.0 (SPSS, Inc., Chicago, IL, USA).

## Results

Bone union was not achieved in 15 out of 492 patients (3%). The failure rates according to the reduction status on the AP view were as follows: 2.7% with type A reduction, 2.4% with type E reduction, and 8.6% with type I reduction ( $p = 0.140$ ). The failure rates according to the reduction on the lateral view were as follows: 1.1% with type N, 2.4% with type A, and 11.8% with type P reduction ( $p < 0.001$ , Fig. 2). Twelve out of 113 (10.6%) patients with poor quality of reduction (type I or type p reduction) showed failure, while failure occurred in only three out of 379 (0.8%) patients without poor reduction on both AP and lateral view (Fig. 2). The difference of failure rate between patients with poor reduction and those without poor reduction was statistically significant ( $p < 0.001$ ). Considering the combined reduction status on the AP and lateral views, the highest failure rate was observed with type I-type P (AP-lateral) and type I-type A reduction, followed by type A-type P reduction. There

were no cases of failure with type A-type A or type E-type A reduction (Fig. 2).

Comparison of variables between patients with and without fixation failure showed that there was no significant difference in the TAD, reduction quality on the AP plane, and Cleveland index. The reduction state on the lateral view and the proportions of AO/OTA fracture types significantly differed between the two groups (Table 2).

Similarly, the regression analysis showed that poor reduction on the lateral view (type P reduction; OR = 12.70; 95% CI = 3.97–40.65,  $p < 0.001$ ) and AO/OTA type A3 fractures (OR = 5.40; 95% CI = 1.24–23.49,  $p = 0.025$ ) were significantly associated with failure (Table 3).

The mode of failure was as follows: cut-through in three cases, cut-out in five cases, and nail breakage in seven cases (Fig. 3). Conversion to hip arthroplasty was performed in nine patients, and osteosynthesis was performed in four patients. Two patients refused further surgical management due to general medical conditions.

## Discussion

In our study, quality of reduction was significantly associated with failure after IMN in fragility trochanteric fractures. Especially, type P reduction on lateral view showed significant correlation with fixation failure. AO/OTA type A3 fractures were also related to failure.

Five major factors have been reported to be related to the outcome of femoral trochanteric fracture treatment, including bone quality, fragment geometry, reduction quality, implant choice, and implant placement in the femoral head [9, 20, 23, 24]. Among these, the factors that the surgeon can control are reduction quality, implant choice, and implant placement.

Regarding the quality of reduction, it has been suggested that contact between the anteromedial cortex of the proximal fragment and that of distal fragment is crucial for maintain the bone-implant construct against the loading [12–15]. When the anteromedial cortex of the proximal fragment locating anteriorly (type A) and medially (type E) to that of the distal fragment, excessive sliding can be prevented [13, 17]. Reduction status that the relative position of the proximal and distal fragments which cannot prevent excessive sliding, type I on the AP view and type P on the lateral view, has been reported to yield unfavourable results in geriatric trochanteric fractures [12–14]. Recent biomechanical study also showed that the fracture reduction without the anteromedial cortical contact (type I and type P reduction in this study) showed a greater sliding compared to those with the anteromedial cortical contact (type E and type A in this study) [16]. Regarding of which planar reduction quality is more critical for the stability, Chang et al. suggested that

**Table 1** Demographics according to the reduction status

	Total	Type A/N (n=258)	Type E/N (n=86)	Type A/P (n=51)	Type E/P (n=27)	Type A/A (n=21)	Type I/N (n=21)	Type E/A (n=14)	Type I/A (n=7)	Type I/P (n=7)	p
<b>Sex</b>											
Male	152	74	31	20	11	7	1	3	3	2	0.135
Female	340	184	55	31	16	14	20	11	4	5	
<b>Age</b>	79.1 ± 8.1	79.5 ± 8.1	79.7 ± 7.7	76.7 ± 8.5	79.6 ± 7.3	78.2 ± 8.3	79.7 ± 7.6	76.2 ± 8.3	78.0 ± 11.3	79.6 ± 8.5	0.432
<b>BMD (T-score)</b>	- 3.0 ± 1.1	- 3.1 ± 1.0	- 3.0 ± 1.2	- 2.7 ± 1.2	- 2.8 ± 1.0	- 3.0 ± 1.0	- 3.2 ± 1.0	- 2.9 ± 1.2	- 2.9 ± 1.0	- 3.0 ± 1.1	0.481
<b>BMI (kg/m<sup>2</sup>)</b>	21.8 ± 3.3	21.6 ± 3.2	22.2 ± 4.0	21.2 ± 3.0	22.7 ± 2.7	21.7 ± 3.7	21.5 ± 3.1	21.6 ± 3.7	23.1 ± 4.7	22.6 ± 2.9	0.493
<b>ASA classification</b>											
1	19 (3.9)	9 (3.5)	4 (4.7)	5 (9.8)	1 (3.7)	0	0	0	0	0	0.078
2	185 (37.6)	103 (39.9)	20 (23.3)	26 (51.0)	7 (25.9)	7 (33.3)	11 (52.4)	4 (28.6)	4 (57.1)	3 (42.9)	
3	266 (54.1)	133 (51.6)	60 (69.8)	17 (33.3)	17 (63.0)	13 (61.9)	10 (47.6)	10 (71.4)	2 (28.6)	4 (57.1)	
4	22 (4.5)	13 (5.0)	2 (2.3)	3 (5.9)	2 (7.4)	1 (4.8)	0	0	1 (14.3)	0	
<b>CCI</b>	5.1 ± 1.9	5.3 ± 1.9	5.0 ± 1.9	4.5 ± 2.2	5.4 ± 1.8	4.5 ± 1.8	5.1 ± 1.6	4.5 ± 1.7	4.3 ± 2.2	5.1 ± 1.3	0.142
<b>AO/OTA classification</b>											
A1	45 (9.1)	35 (13.6)	1 (1.2)	4 (7.8)	3 (11.1)	2 (9.5)	0	0	0	0	<0.001
A2	408 (82.9)	209 (81.0)	81 (94.2)	43 (84.3)	22 (81.5)	15 (71.4)	19 (90.5)	11 (78.6)	2 (28.6)	6 (82.9)	
A3	39 (7.9)	14 (5.4)	4 (4.7)	4 (7.8)	2 (7.4)	4 (19.0)	2 (9.5)	3 (21.4)	5 (71.4)	1 (7.9)	

The order of reduction status is AP and lateral plane. Type A/N means type A reduction in AP and type N reduction in lateral plane. Continuous values are presented as the mean and the standard deviation, while categorical variables are presented as frequencies (percentages) p value < 0.05: considered significant

BMD bone mineral density, BMI body mass index, ASA American Society of Anesthesiologists, CCI Charlson comorbidity index

Lateral view anteroposterior view	Type N	Type A	Type P (poor reduction quality)	
Type A	2/258 (0.8%)	0/21 (0%)	7/51 (13.7%)	9/330 (2.7%)
<b>Combinations of good reduction type</b>				
Type E	1/86 (1.2%)	0/14 (0%)	2/27 (7.4%)	3/127 (2.4%)
Type I (poor reduction quality)	1/21 (4.8%)	1/7 (14.3%)	1/7 (14.3%)	<b>3/35 (8.6%)</b>
	4/365 (1.1%)	1/42 (2.4%)	<b>10/85 (11.8%)</b>	

**Fig. 2** Radiographs of a patient with a failure after nailing. **a** A 78-year-old woman presented with a trochanteric fracture after a ground-level fall. Postoperative radiographs showed type A reduction on the anteroposterior (AP) view (**a**) but type P reduction on the

lateral view (**c**). **d** Fourteen months later, the nail was broken. **e** The fracture was healed after revisional osteosynthesis using the blade plate

**Table 2** Radiographic characteristics between patients with fracture union and those with mechanical failure in trochanteric femur fractures

	Total (n = 492)	Fracture union (n = 477)	Fixation failure (n = 15)	p
TAD		19.8 ± 5.3	21.0 ± 4.0	0.366
Reduction quality				
AP				
Type A	330 (67.1)	321 (67.3)	9 (60.0)	0.140
Type E	127 (25.8)	124 (26.0)	3 (20.0)	
Type I	35 (7.1)	32 (6.7)	3 (20.0)	
Lateral				
Type N	365 (74.2)	361 (75.7)	4 (26.7)	<0.001
Type A	42 (8.5)	41 (8.6)	1 (6.7)	
Type P	85 (17.3)	75 (15.7)	10 (66.7)	
Cleveland index (x <sup>2</sup> )				
1, 2, 3, 4, 7 (danger zone)	210 (42.7)	203 (42.6)	7 (46.7)	0.751
5, 6, 8, 9 (safe zone)	282 (57.3)	274 (57.4)	8 (53.3)	
AO/OTA classification				
A1	45 (9.1)	45 (9.4)	0 (0.0)	0.015
A2	408 (82.9)	397 (83.2)	11 (73.3)	
A3	39 (7.9)	35 (7.3)	4 (26.7)	

Continuous values are presented as the mean and the standard deviation, while categorical variables are presented as frequencies (percentages)

p value < 0.05: considered significant

TAD tip-apex distance, AP anteroposterior

considering the direction of sliding, reduction quality on the AP view may be more effective to prevent excessive sliding [13]. However, the difference in the effect of poor fracture reduction of the AP view and that of the lateral view has not been investigated deeply. Thus, we investigated whether the

effect of type I reduction on the AP and type P on lateral views is the same in terms of failure.

We found that the failure rate was higher with type I reduction than type A or type E reduction on the AP view, but the difference was not statistically significant. On the

**Table 3** Multivariate logistic regression analysis for the risk factors of fixation failure after nailing in trochanteric fractures

Variables	Odds ratio (95% CI)	<i>p</i> value
Type I reduction on the AP view	3.72 (0.78–17.74)	0.100
Type P reduction on the lateral view	12.70 (3.97–40.65)	<0.001
AO/OTA A3 type fracture	5.40 (1.24–23.49)	0.025
TAD (mm)	1.11 (0.99–1.24)	0.086
Danger zone (zone 1, 2, 3, 4 and 7) of Cleveland index	2.17 (0.60–7.87)	0.240
Age (years)	1.02 (0.96–1.08)	0.560
Sex (female)	0.84 (0.19–3.70)	0.822
Body mass index (kg/m <sup>2</sup> )	1.06 (0.88–1.27)	0.565
Osteoporosis	1.09 (0.24–4.85)	0.914

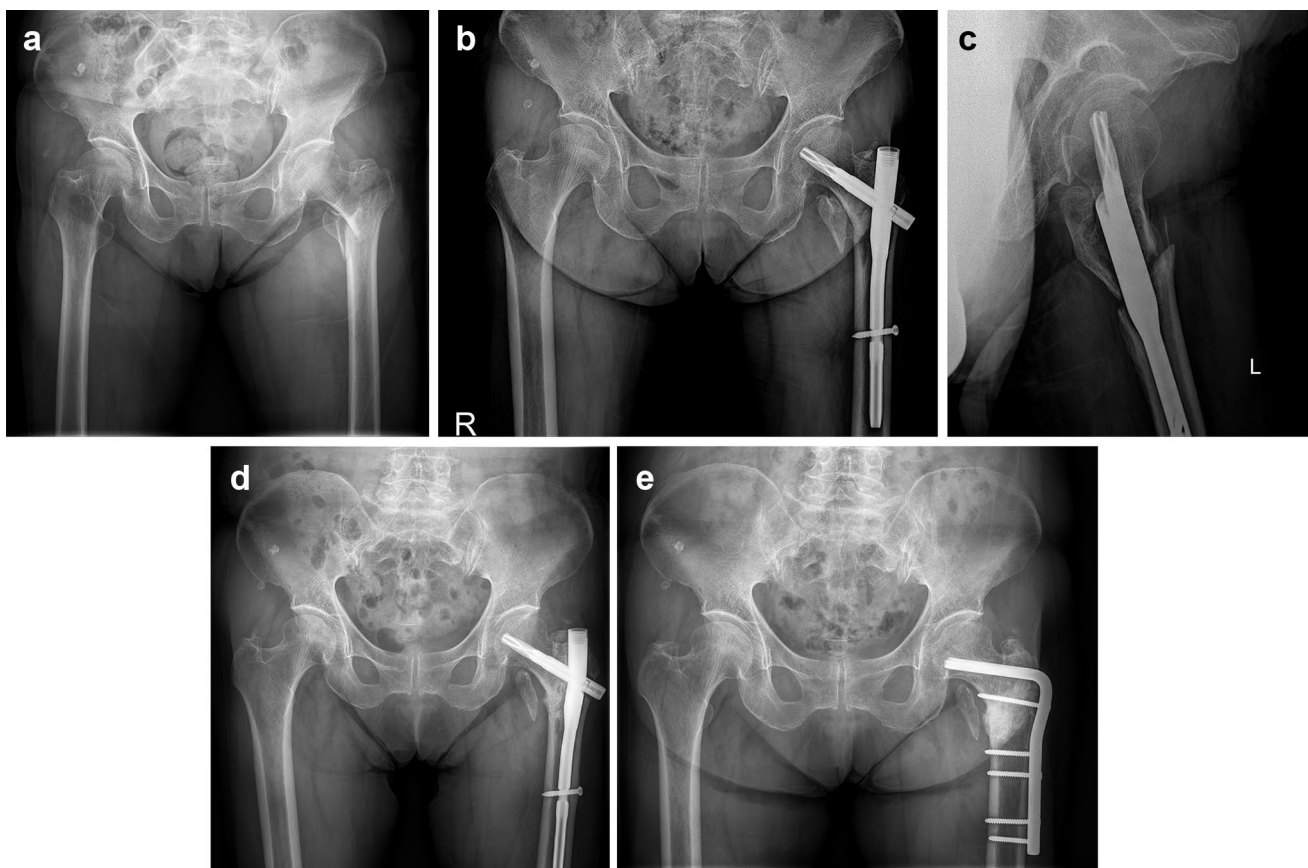
Data are presented as the odds ratio with the confidence interval in parenthesis

*CI* confidence interval, *TAD* tip–apex index

other hand, on the lateral view, the failure rate was significantly higher with type P reduction than with type N and type A reduction ( $p < 0.001$ ). Regression analysis also

confirmed that only the poor reduction on the lateral view (type P reduction) was associated with failure. These findings are in line with previous report on sliding distance according to the reduction quality. Ito et al. showed that excessive sliding was more evident with type P reduction and suggested that the contact form of the anteromedial cortex between fragments in the lateral view reflects the stability of the bone-implant construct [24]. However, the importance of the reduction status on the AP plane should not be overlooked. The reduction status on the AP plane have been shown to be significantly associated with radiologic and functional outcome in previous studies [13, 14]. Insignificant association between reduction status on the AP plane and fixation failure in this study might have been resulted from the relatively small number of patients with poor reduction on the AP plane.

In this study, the number of patients with poor reduction on the lateral view (type P reduction) was 2.4 times greater than that on the AP view (type I reduction). A tendency towards posterior angulation or sagging with a supine position on the fracture table may be responsible for the type P



**Fig. 3** Diagram showing failure rate according to reduction quality in AP and lateral plane. Type I and type P showed 8.6 and 11.8% of failure rate respectively. On the other hand, other types of reduction

showed less than 3% of failure rate. Combinations of good reduction type showed 0–1.2% of failure rate

reduction on the lateral view. In addition, difficulty in confirming the reduction state on the lateral view can also be a reason for this result. Therefore, an effort to obtain an appropriate lateral view with fluoroscopy should be made intraoperatively.

Because of the anatomical features of the hip joint, a varus deformation force on the coronal plane and a force for posterior angulation on the sagittal plane are applied. Moreover, a combination of these forces can cause rotational deformation, especially in cases of fractures of the proximal femur. In addition, modern devices for the fixation of trochanteric fractures allow sliding at the fracture site. Therefore, the fracture reduction state immediately after surgery would not be maintained during the follow-up period due to these anatomical and biomechanical characteristics. Excessive movement (sliding, bending, or rotation) of the proximal fragment or fixation failure could be prevented by achieving type A or type E reduction on the AP view and type A or type N on the lateral view.

In the current study, the implant position in the femoral head, as indicated by the TAD and Cleveland index, was not associated with failure. Notably, the mean TAD, even in patients with failure, was only 21 mm in this study. Considering that a TAD exceeding 25 mm is regarded as risky [18], the TAD in most patients of our cohort was in the safe range. Therefore, the low TAD value in our cohort might be why the TAD did not significantly impact failure in this study. Regarding the nonsignificant difference in the Cleveland index, the result can be interpreted as follows: even if the blade is in a danger zone, it may not fail if the reduction state is feasible and other factors, such as the TAD, are appropriate.

In our study, bone union was achieved in all cases of stable (A1) fractures, whereas all cases of failure occurred in patients with unstable (A2 and A3) fractures. Regression analysis also showed a significant association of type A3 fractures with failure. This finding indicates that the AO/OTA classification can help predict outcomes after fracture treatment. Noteworthy, the reduction status was significantly different according to the distribution of AO/OTA classification. It seems like that more severe fracture types are more frequently associated with poor quality of reduction resulting in fixation failure. Therefore, the results of the current study should be interpreted carefully.

Though, there is no case fixed with cement augmentation included in the analysis, it is a valuable method to add stability to bone-implant construct and to avoid mechanical failures such as cut-out and cut-through. Recent meta-analysis on the cement augmentation in trochanteric fractures showed that it could lead to fewer complications, reoperations, and shorter hospital stay [25]. Therefore, the authors think it is a viable option to prevent fixation failure especially in patients with severe osteoporosis.

Our study has several limitations. First, the number of patients with type I reduction and type P reduction was relatively small compared to the number of patients with other reduction types since the authors tried to avoid poor reduction on both the AP and lateral views intraoperatively. It may have affected the results. Second, the case–control and retrospective design of this study and the relatively small sample size did not allow for the detection of causal relationships. Finally, only radiologic outcomes were evaluated, and functional outcomes could not be analysed due to the study design. Further studies investigating the association between reduction status and functional results are necessary.

Despite these limitations, our study is the first to report the failure rate according to the reduction status on the AP and lateral views and the plane in which poor reduction has a greater effect on fixation failure. Another strength of this study is that we analysed nearly 500 geriatric trochanteric fractures that were fixed by a single surgeon using a single implant with the same length and CCD angle. Therefore, bias originating from differences in surgical skills and fixators could be excluded from our study.

In conclusion, poor reduction status such as type P reduction was associated with the risk of failure. Surgeons should check the quality of fracture reduction carefully with the proper fluoroscopic view to prevent failure in geriatric patients with trochanteric fractures.

**Supplementary Information** The online version contains supplementary material available at <https://doi.org/10.1007/s00402-023-05176-3>.

**Author contributions** All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Y-HC, SK and JK. The first draft of the manuscript was written by Y-HC and S-EB and all authors commented on previous version of the manuscript. The final editing was done by S-EB. All authors read and approved the final manuscript.

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**Data availability** My manuscript has data included as electrical supplementary material.

**Code availability** Not applicable.

## Declarations

**Conflict of interest** The authors have no relevant financial or non-financial interests to disclose.

**Ethics approval** This retrospective chart review study involving human participants was in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The institutional review board (IRB) of Daegu Fatima Hospital approved this study (IRB No. DFH2003-02-001).

**Consent to participate** Informed consent was waived due to the retrospective design of the study.



**Consent for publication** Not applicable.

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