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Original Article

Z-effect after intramedullary nailing systems for trochanteric femur fractures

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Purpose: The aim of this study was to investigate the incidence of Z-effect after dual lag screw intramedullary nailing systems and risk factors contributing to this effect. We hypothesized that long nails provide more neck strength due to a longer lever than short nails and are therefore less likely to develop a misbalance of a higher head compressive strength than neck compressive strength.

Methods: In this retrospective cohort study 103 patients treated operatively with a dual lag screw intramedullary nailing device for (sub)trochanteric hip fracture were included. We analysed patient charts regarding patient and operation characteristics. Furthermore we conducted radiologic measurements within the 2-year follow-up period to investigate the quality of fracture fixation, implant failure and predictors for Z-effect. The re-operation risk was investigated with multivariate regression analysis.

Results: The incidence of (reversed) Z-effect in this study was 9% ($n = 80$); 6 out of 7 Z-effects occurred in the short nail group, which was not significant. Patients who were treated with a long nail had a significant larger number of complications in comparison with the short nail group (median 2 vs 0.5, $p = 0.001$). The long nail group received more often erythrocytes blood transfusions (82% vs 31%, $p < 0.01$) and had a longer hospital stay (13 vs 21 days, $p < 0.05$). Migration of lag screws ($p < 0.05$) and unstable fracture type ($p < 0.05$), were risk factors for re-operation. The re-operation rate within 2 year after surgery was 21%, of which one fourth was due to a Z-effect.

Conclusion: The nail length was not associated with the development of a Z-effect. Migration of lag screws after intramedullary nailing is common and a risk factor for re-operation.

Introduction

The worldwide incidence of geriatric hip fracture is increasing. This phenomenon can be explained largely through the extreme increase of incidence of hip fracture in most Asian countries in the last decades. It is expected that by 2050 more than 50% of all osteoporotic fractures will occur in Asia.[1,2] Ageing is one of the major contributors to this phenomenon, as well as the incidence of osteoporosis and the process of urbanization.[3] On the contrary in most developed parts of the world the incidence of hip fracture has decreased or developed a plateau in the age-adjusted rates in the last decades.[3–5]

Hip fracture is one of the most common orthopedic causes leading to hospital admission in the geriatric population and is associated with a high morbidity and mortality rate.[6–9] Surgical treatment options depend greatly on fracture type which can be divided into intracapsular fractures (femoral neck) and extracapsular fractures (trochanteric fractures). Extracapsular fractures can be stabilized by extramedullary and intramedullary implants. Intramedullary nailing devices allow load sharing with immediate mobilization and show less intraoperative blood loss, shorter operation time and lower postoperative complication rates. In unstable fracture patterns, intramedullary devices appear to have a biomechanical advantage over extramedullary devices, lowering the force imposed on the implant due to the shorter lever arm of the fixation.[10–12] The most common implant-related complication is lag screw migration with an incidence of 2%–13%.[13]

The dual lag screw intramedullary nail systems[14,15] were designed to improve the rotational stability and bony purchase within the femoral head, thus resisting cut-out and subsequent

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fixation failure.[16] The dual lag screw design provides equivalent rigidity and stability compared to an intramedullary nail with a single lag screw, and has a significantly higher failure strength.[16] This implant design also brings a new type of failure: the Z-effect phenomenon, which describes the appearance of a lateral migration of the inferior lag screw and medial migration of the superior lag screw during the weight bearing rehabilitation period.[10,17–20] The reversed Z-effect describes the opposite effect: migration of the inferior lag screw medially and the superior lag screw laterally. Most studies about intramedullary nailing report the incidence of (reversed) Z-effect but very few studies have studied this phenomenon specifically. The cause of the Z-effect is thought to be biomechanical, possibly due to a misbalance in head and neck compressive strength leading to varus collapse.[21] The precise etiology of the Z-effect requires further clarification.[20] Suggested explanations for the development of the Z-effect were medial migration due to lateral buttress deficiency, unstable medial cortex[21] and constant friction within the femoral head and axial loading in varus.[22] Another study[19] found that a cervicodiaphyseal angle of <125° of the postoperative X-rays was associated with the development of a Z-effect. An inadequate fracture reduction or entry point and osteoporotic bone might also be contributing factors, but convincing evidence lacks. We hypothesize that long nails provide more neck strength due to a longer lever than short nails and are therefore less likely to develop a Z-effect.

Materials and methods

This retrospective study was conducted in the department of Trauma Surgery in the Maxima Medical Center in the Netherlands, a large rural teaching hospital. From the 1st January 2006 till 31st December 2007 all patients treated with a dual lag screw intramedullary nailing for trochanteric hip fracture were analysed. In this period two types of nails were used: the Recon nail (Stryker, USA) and the Trigen nail (Smiths & Nephews, UK). A follow-up period of 2 years was chosen for implant-related failures. We selected all patients who received surgery for hip fracture and excluded the polytrauma patients and other fixation types. Patients with a malignancy in their history or pathological fractures were not excluded. A protocolised treatment algorithm regarding hip fractures was used. Standard work-up after admission to the emergency department consisted of a detailed history, a complete physical examination, an electrocardiography and standard biochemical and hematologic tests.

All medical records were evaluated for patient and operation characteristics such as sex, age, American Society of Anesthesiologists (ASA) score, fracture type by the AO-classification system (Arbeitsgemeinschaft für Osteosynthesefragen, Switzerland), anesthesia type, delay to surgery, operation time and days of hospitalization. Furthermore we investigated postoperative complications and re-interventions during the 2-year follow-up.

Radiological analyses were performed to measure the position of the superior and inferior lag screw, the cervicodiaphyseal angle and the Tip Apex Distance (TAD). The TAD is a clinically useful way to describe the position of the lag screws by the sum of the distance from the tip of the lag screw to the apex of the femoral head on the anteroposterior radiograph and the same distance on the axial radiograph with correction for magnification.[23] The amount of radiographic magnification was determined by dividing the diameter of the projected shaft of the lag screw as seen on the radiograph by its known diameter.

By measuring the TAD over time we studied the incidence of (reversed) Z-effect. The maximum TAD (TAD^{max}) was measured during the follow-up period or before re-operation. To study migration of lag screws over time we calculated the TAD difference (TAD^{diff}), which describes the maximum TAD minus the immediate postoperative TAD.

The quality of the fracture reduction was based on the fracture alignment and the fracture displacement. This was judged by the cervicodiaphyseal angle, the degree of angulation and the displacement between fracture fragments and shortening. The fracture reduction status was subsequently scored as good (scored as: 2), acceptable (scored as: 1) and poor (scored as: 0).[24,25] The position of the inferior lag screw in the femoral head was determined and judged as correct when placed as inferior or centrally on the anteroposterior radiograph and central placement on the axial radiographs.[26] All radiological measurements are displayed in Fig. 1.

Statistical analysis

All analyses were performed with SPSS 16.0 statistical software (SPSS Inc., Chicago, Illinois, USA). $p < 0.05$ was considered to be statistically significant. Data were presented as mean for normally distributed or median for non-normally distributed variables. Percentages were used when appropriate. One-way ANOVA was used to compare normally distributed variables and the Mann Whitney *U* test for non-normally distributed continuous variables with Bonferroni correction for multiple testing. A Pearson's chi-square (χ^2) test was used to investigate whether distributions of categorical variables differ from one another. To investigate potential predictors for re-intervention we performed a multivariate logistic regression analysis. All theoretically important variables were entered in the model. Re-intervention was chosen as outcome of the model so that other implant-related complications like cut-out, cut-through and non-union could be included in the analysis.

Results

During the study period of 2006–2007, 224 patients were operatively treated for trochanteric hip fracture. Of these patients 103 received an intramedullary nail system with dual lag screws. In 23/103 (22%) patients there was only one X-ray control postoperatively. These patients were regarded as loss to follow-up. In these 23 patients there were no signs of a Z-effect during hospitalization. The remaining 80 patients enrolled in this study had data of 2-year follow-up.

Table 1 shows the baseline data and operation characteristics. There were significantly more unstable fracture types (A2.2, A2.3 A3.3) and A3 fracture types treated with a long nail ($p < 0.001$). There were no other differences in baseline or operation characteristics between patients who received a short nail or long nail. The long nail group patients had a significant longer hospital stay (13 vs 21 days, $p < 0.05$).

Table 2 lists the radiological measurements displayed and classified by nail length. The TAD, TAD^{max}, TAD^{diff} were not significantly different between the short nail group and the long nail group. The quality of the fracture reduction, expressed by a score (0–2), was significantly worse in the long nail group ($p < 0.05$). Furthermore, the inferior lag screw was inserted at a larger angle in the long nail group in comparison with the short nail group ($p < 0.05$). The correct position of the inferior lag screw in the femoral head was not different between both groups. Furthermore there were no differences in the collodiaphyseal angle or average screw migration between both groups.

Seven patients developed a (reversed) Z-effect, leading to an incidence of 9%. Six of them were treated with a short nail, which did not reach significance in comparison with the long nail group. Radiological measurements displayed and classified by the presence of (reversed) Z-effect are summarized in Table 3. The TAD^{diff} of the inferior lag screw was significantly different between the Z-

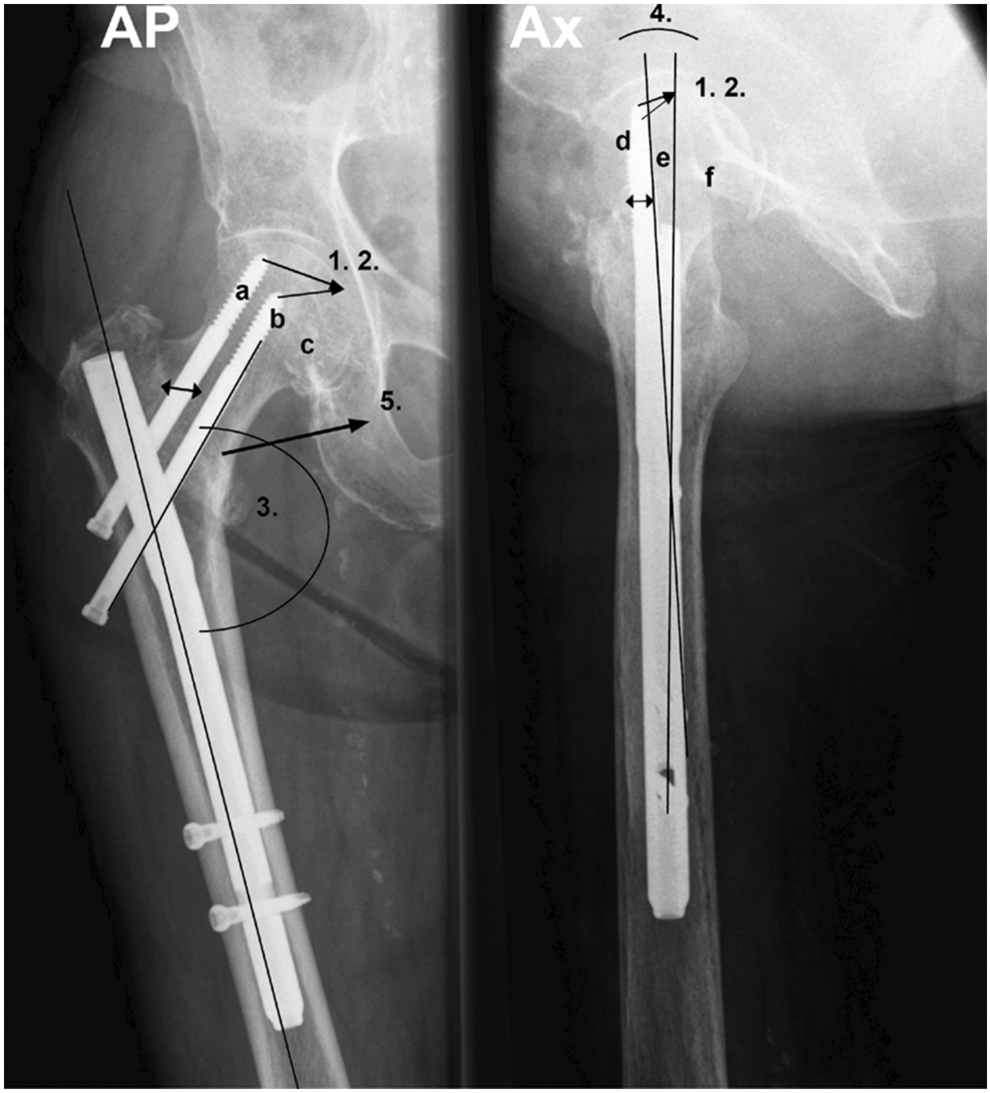

Fig. 1. Detailed radiological measurements. 1. Tip Apex Distance (TAD) of the superior screw, 2. Tip Apex Distance (TAD) of the inferior screw, 3. Collodiaphyseal angle (Anterior posterior view), 4. Angulation of the inferior lag screw (<20% on the Axial view), 5. Fracture dislocation (>80% overlapping in both planes AP and Ax; <5 mm of shortening), a–f represent the zones in which the inferior lag screw can be placed in the femoral head.

Table 1
Baseline data and operation characteristics.

Variables	Short nail ($n = 58$)	Long nail ($n = 22$)	p
Age (years)	76 (SD 14)	78 (SD 18)	0.8
Male sex [n (%)]	14 (24)	8 (36)	0.3
ASA score			
ASA (average)	2.2 (SD 0.7)	2.4 (SD 0.9)	0.2
ASA 1 [n (%)]	7 (12)	2 (9)	0.7
ASA 2 [n (%)]	31 (53)	10 (46)	0.5
ASA 3 [n (%)]	19 (33)	8 (36)	0.8
ASA 4 [n (%)]	1 (2)	2 (9)	0.1
AO classification [n (%)]			
A1.1 − A1.3	14 (24)	2 (9)	0.1
A2.1 − A2.3	33 (57)	3 (14)	0.001
A3.1 − A3.3	11 (19)	17 (77)	<0.001
Spinal anesthesia [n (%)]	43/51 (84)	14/19 (74)	0.3
General anesthesia [n (%)]	8/51 (16)	5/19 (26)	0.3
Delay to surgery (h)	10 (IQR 13)	6 (IQR 13)	0.6
Operation time (min)	71 (SD 31)	103 (SD 26)	0.6
Number of patient days	13 (IQR 11)	21 (IQR 29)	<0.05

Note: Data are presented as mean when normally distributed and as median when non-normally distributed.
SD = Standard deviation; IQR = Interquartile range; ASA score = American Society of Anesthesiologists score.

effect group vs no Z-effect group ($p = 0.001$). Table 4 shows the radiological measurements classified by implant failure (cut-out, cut-through and Z-effect). Significant displacement occurred of the superior and inferior lag screw over time in the implant failure group vs no implant failure ($p < 0.001$ and $p = 0.003$ respectively). Four patients needed a re-operation because of the presence of a (reversed) Z-effect. A reversed Z-effect occurred in 2 patients (1 in short nail group, 1 in long nail group) and was always a reason for re-operation. Patients who were treated with a long nail had a significant larger number of complications in comparison with the short nail group (median 2 vs 0.5, $p = 0.001$). The long nail group received more often erythrocytes blood transfusions (82% vs 31%, $p < 0.001$) (Table 5).

There were 17 re-operations performed within two years after primary surgery: 4/17 (23%) of cases due to a (reversed) Z-effect and 13/17 (76%) of cases due to a screw-related implant failure. All reasons for re-operation are mentioned in Table 6. There were significantly more deep infections in the long nail group ($p < 0.05$).

All possible predictors for re-operation were entered in a logistic regression analysis (Table 7). Migration of the superior/inferior lag screw over time and unstable fracture type were the predicting

Table 2
Radiological results classified by nail length.

Variables	Short nail ($n = 58$)	Long nail ($n = 22$)	p
Superior screw TAD (mm)	26 (IQR 16)	25 (IQR 16)	0.9
Superior screw TAD^{max} (mm)	28 (IQR 17)	27 (IQR 16)	0.7
Superior screw TAD^{diff} (mm)	4 (IQR 5)	2 (IQR 8)	0.3
Inferior screw TAD (mm)	24 (IQR 16)	26 (IQR 13)	0.5
Inferior screw TAD^{max} (mm)	27 (IQR 21)	25 (IQR 14)	0.9
Inferior screw TAD^{diff} (mm)	3 (IQR 7)	4 (IQR 6)	0.8
Quality fracture reduction (score 0−2)	2 (IQR 1)	1.5 (IQR 2)	<0.05
Angle inferior lag screw (Ax, °)	4 (IQR 9)	9 (IQR 12)	<0.05
Collodiaphyseal angle (AP, °)	134 (IQR 12)	133 (IQR 8)	0.7
Correct placement inferior lag screw in femoral head[a] [n (%)]	37 (64)	12 (55)	0.4

Note: Data are presented as mean when normally distributed and as median when non-normally distributed.
TAD^{diff} = Tip Apex Distance difference of TAD^{max} (maximal measured TAD distance over time) minus the TAD (first postoperative measured TAD). AP = anteroposterior view, Ax = axial view.
[a] Correct placement established as inferior or centrally placement of the lag screw on the anteroposterior radiograph and central placement on the axial radiographs.

Table 3
Radiological results classified by the presence of a (reversed) Z-effect.

Variables	Z-effect* ($n = 7$)	No Z-effect ($n = 73$)	p
AO classification [n (%)]			
A1.1 − A1.3	2 (29)	14 (19)	0.5
A2.1 − A2.3	4 (57)	32 (44)	0.5
A3.1 − A3.3	1 (14)	27 (37)	0.2
Superior screw TAD (mm)	21 (IQR 17)	26 (IQR 17)	0.5
Superior screw TAD^{max} (mm)	26 (IQR 41)	28 (IQR 15)	0.9
Superior screw TAD^{diff} (mm)	6 (IQR 7)	3 (IQR 5)	0.2
Inferior screw TAD (mm)	24 (IQR 14)	25 (IQR 15)	0.6
Inferior screw TAD^{max} (mm)	26 (SD 41)	28 (SD 15)	0.4
Inferior screw TAD^{diff} (mm)	13 (SD 66)	3 (SD 5)	0.001
Quality fracture reduction (score 0−2)	2.0 (IQR 1.0)	2.0 (IQR 1.0)	0.8
Angle inferior lag screw (Ax, °)	9 (SD 8)	7 (SD 9)	0.7
Collodiaphyseal angle (AP, °)	131 (SD 8)	133 (SD 8)	0.6
Correct placement inferior lag screw in femoral head[a] [n (%)]	4 (57)	46 (63)	0.3

Note: Data are presented as mean when normally distributed and as median when non-normally distributed.
SD = Standard deviation; IQR = Interquartile range; ASA score = American Society of Anesthesiologists score. TAD^{diff} = Tip Apex Distance difference of TAD^{max} (maximal measured TAD distance over time) minus the TAD (first post-operative measured TAD). AP = anteroposterior view, Ax = axial view.
[a] Correct placement established as inferior or centrally placement of the lag screw on the anteroposterior radiograph and central placement on the axial radiographs.
* Z-effect or reversed Z-effect.

Table 4
Radiological results classified by the presence of implant failure (cut-out, cut-through or the presence of a Z-effect or reverse Z-effect).

Variables	Implant complication ($n = 17$)	No implant complication ($n = 63$)	p
AO classification [n (%)]			
A1.1 − A1.3	2 (12)	14 (22)	0.4
A2.1 − A2.3	11 (65)	25 (40)	0.1
A3.1 − A3.3	4 (24)	24 (38)	0.3
Superior screw TAD (mm)	21 (IQR 25)	26 (IQR 15)	0.8
Superior screw TAD^{max} (mm)	26 (IQR 43)	28 (IQR 14)	0.7
Superior screw TAD^{diff} (mm)	10 (IQR 43)	3 (IQR 4)	<0.001
Inferior screw TAD (mm)	22 (IQR 12)	25 (IQR 16)	0.3
Inferior screw TAD^{max} (mm)	23 (IQR 51)	25 (IQR 18)	0.2
Inferior screw TAD^{diff} (mm)	13 (SD 51)	3 (IQR 5)	0.003
Quality fracture reduction (score 0−2)	2.0 (IQR 1.0)	2.0 IQR 1.0	0.5
Angle inferior lag screw (Ax, °)	7 (SD 6)	8 (SD 8)	0.7
Collodiaphyseal angle (AP, °)	131 (SD 8)	134 (SD 8)	0.3
Correct placement inferior lag screw in femoral head[a] [n (%)]	11 (65)	38 (60)	0.7

Note: Data are presented as mean when normally distributed and as median when non-normally distributed.
SD = Standard deviation; IQR = Interquartile range; ASA score = American Society of Anesthesiologists score. TAD^{diff} = Tip Apex Distance difference of TAD^{max} (maximal measured TAD distance over time) minus the TAD (first post-operative measured TAD). AP = anteroposterior view, Ax = axial view.
[a] Correct placement established as inferior or centrally placement of the lag screw on the anteroposterior radiograph and central placement on the axial radiographs.

variables for re-operation. All other radiological variables used in this study were not associated with re-operation.

Discussion

The incidence of Z-effect in this study was 9%. The length of the nail was not associated with the development of a Z-effect. Migration of lag screws after intramedullary nailing is common, and a risk factor for re-operation. The re-operation rate within two years after surgery was 21%, of which one fourth was due to a Z-effect. Unstable fracture type was a predictor for re-operation.

We hypothesized that long nails provides more neck strength due to a longer lever and are therefore less likely to develop a misbalance of a higher head compressive strength than neck compressive strength, contributing to the Z-effect. In this study we did not find any convincing evidence for this hypothesis. There was

Table 5
Postoperative complications.

Complications	Short nail ($n = 58$)	Long nail ($n = 22$)	p
Number of complications*	0.5 (IQR 1)	2.0 (IQR 2)	0.001
Cardiac complications	3 (5)	1 (5)	0.9
Pulmonary complications	3 (5)	2 (9)	0.5
Blood transfusion	18 (31)	18 (82)	<0.001
Urinary tract infections	13 (22)	12 (55)	0.006
Z-effect	5 (9)	0 (0)	0.2
Reversed Z-effect	1 (2)	1 (5)	0.5
Re-operation	11 (19)	6 (27)	0.4
Cut-out	1 (2)	1 (5)	0.5
Cut-through	8 (14)	3 (14)	1.0
Non-union	1 (2)[a]	2 (9)[b]	0.1

Note: Data are presented as mean when normally distributed and as median when non-normally distributed.
Data are listed as n (%) except*.
[a] Nonunion due to avascular necrosis of the femoral head.
[b] nonunion due to deep infection.

Table 6
Reasons for re-operation classified by nail length [n (%)].

Risk factors for re-operation	Short nail ($n = 58$)	Long nail ($n = 22$)	p
Z-effect	2 (3)	0 (0)	0.4
Reversed Z-effect	1 (2)	1 (5)	0.5
Cut-out	1 (2)	0 (0)	0.5
Cut-through	5 (9)	1 (5)	0.5
Deep infection	0 (0)	2 (9)	<0.05
Avascular necrosis of the femoral head (AVN)	1 (2)	0	0.5
Pain from screws/breakage of screws	0 (0)	2 (9)	0.1
Periprosthetic fracture or break-out nail	1 (2)	0 (0)	0.5

no association between nail length and the development of a Z-effect, although 6 out of 7 Z-effects occurred in the short nail group. These findings suggest that other variables are responsible for the occurrence of a Z-effect. More unstable fracture types and more high-energy trauma in the long nail group could explain the difference in quality of the osteosynthesis. This might also be the reason for the higher incidence of blood transfusion in the long nail group. The operation time was also longer in the long nail group but did not reach significance.

The overall incidence of Z-effect in this study was 9%, which is in line with other studies that report an incidence of 7.1%–13% after the proximal femoral nail fixation with antirotation screw (PFNa, dual screw device).[18,19,27] The migration of lag screws in the Z-effect group (Table 3) is probably underestimated because Z-effect ($n = 5$) and reversed Z-effect ($n = 2$) occur in the opposite direction. Therefor all patients with implant failure (cut-out, cut-through and Z-effect) were grouped to study migration of lag screws more closely (Table 4). Patients with implant failure did not have worse baseline characteristics of the primary placed dual lag screw system regarding fracture type, fracture reduction, collodiaphyseal angle or position of the lag screws in the femoral head. Significant migration of superior and inferior lag screws occurred over time in the case of implant failure ($p < 0.001$ and $p = 0.003$ respectively); the maximum migration for the superior lag screw was 82 mm, and for the inferior lag screw was 97 mm.

In 5 cases screw migration occurred with perforation of the acetabulum. Among them, 4 were due to cut-through and one developed a reversed Z-effect. The cause of this phenomenon is multifactorial. Osteoporotic bone and unstable fracture types have been previously mentioned to be risk factors.[28–30]

The principles behind the second or antirotation screw are clear, but strong clinical evidence for advantages lacks. In a randomized controlled trial the Dynamic Hip Screw (DHS) was compared to the PFNa, but no statistically significant differences were found regarding implant failure.[31] Another study compared PFNa with conventional gamma nails and concluded no difference in clinical outcome. However, the PFNa demonstrated better results biomechanically in terms of less sliding of lag screw, less change of neck shaft angle, and less complications for the treatment of reverse obliquity intertrochanteric fractures.[32] A previous study reported that the PFNa did not improve the position of the implant in the femoral head compared with the PFN without anti-rotation screw.[33] This suggests that due to the use of a dual screw system, there might be an increased risk for suboptimal placement. If the inferior lag screw is placed centrally, it may result in an unavoidable cranially placed superior lag screw.[34] The key to prevent Z-effects might be a optimal position of the lag screws in the head by inserting the inferior lag screw over the calcar of the femoral neck in order to achieve better bony anchoring, thus preventing screw cut-out. Strauss et al[21] suggested in their biomechanical study that in cases of intertrochanteric hip fractures with significant medial cortical comminution, surgeons may wish to avoid the use of a dual lag screw intramedullary nail.

We acknowledge a few limitations for interpreting the results of our study. Of 23 patients there was a limited follow-up available; therefore an underestimation of the results could be made. The loss to follow-up could be explained by early death or when no further radiologic follow-up was performed. Most patients loss to follow-up were suffering from dementia and discharged to a nursing home. Furthermore selection bias cannot be excluded because of the retrospective study design. Although this is one of very few studies that specifically report about Z-effect after intramedullary nailing, the number of patients is relatively small, making the risk of type II error higher. The measured TAD depends on the angle the X-rays are shot, which makes it difficult to compare accurately, but we did use all available X-rays in the follow-up and corrected for radiographic magnification. There exists an overall difficulty of comparing long and short nails with another as well as A1 fractures with A2 or A3 fractures. We corrected our analysis for the presence of unstable fracture types.

In our study we did not only report implant-related complications but also looked at predictors for re-operation. Unstable fracture type was a predictor for re-operation as well as migration of the superior or inferior lag screw over time. The contributing effect of osteoporosis to implant failure was not included in our analysis. To prevent re-operations after intramedullary nailing, a stabile implant resistant to migration of lag screws is needed, even more in

Table 7
Regression analyses for re-operation.

Variables	p value	B	Std. error
Sex	0.4	−0.002	0.003
Age	0.6	0.09	0.1
ASA	0.7	0.03	0.07
Nail length	0.6	0.05	0.1
Unstable fracture type[a]	<0.05	0.2	0.1
Superior screw TAD^{diff}	0.009	0.009	0.003
Inferior screw TAD^{diff}	0.007	0.007	0.003
Quality fracture reduction (score 0–2)	0.9	0.013	0.07
Angle inferior lag screw (Ax)	0.7	−0.003	0.006
Collodiaphyseal angle (AP)	0.5	−0.004	0.005

Variables entered in Logistic regression analysis. $p < 0.05$ means significant difference.
ASA score = American Society of Anesthesiologists score, TAD^{diff} = Tip Apex Distance difference of TAD^{max} (maximal measured TAD distance over time) minus the TAD (first post-operative measured TAD).
[a] Unstable fracture types: A2.2, A2.3 A3.3 (AO-classification). AP = anteroposterior view, Ax = axial view.

unstable comminuted trochanteric fractures. Dual lag screw systems have improved over the years. Henschel et al[35] found that the stresses were distributed more equally between the two cephalic screws in the bone and the implant if a longer inferior screw was used. The Targon nail® (B. Braun, Aesculap) interlocking nail system was developed on the same biomechanical principle. In a randomized trial the Targon nail seems to be superior to the sliding hip screw (SHS) in the case of unstable A3 trochanteric fractures.[36] Fractures treated with SHS were more likely to show >50% medicalization compared with the Targon nail in A3 fractures (38.1% vs 3.8%, $p = 0.006$). Medialization >50% was a predictor for revision surgery.

Another dual lag screw nail was reintroduced (Trigen Intertan, Smith-Nephew) and designed with two integrated lag screws to overcome Z-effect complications, and provides immediate intraoperative linear compression and rotational stability. Several studies have shown reliable outcome without the presence of Z-effect.[34,37,38] A prospective randomized comparative study of the Endovis® Cephalomedullary dual lag screw nail vs DHS showed comparable outcome, with implant failure rates of 9% and 11% respectively.[39] Lag screw migrations only occurred in patients with unstable trochanteric fractures with comminution of the medial cortex. Finally, a recent prospective, randomized, multicenter clinical trial compared the Trigen Intertan nail (Smith-Nephew) with DHS. This study showed that most patients with intertrochanteric femur fractures could expect similar functional results whether treated with an intramedullary or extramedullary device. Sub-group analysis showed that active and functional patients with unstable trochanteric fractures have better outcome regarding less shortening, better Functional Independence Measure (FIM) and Timed Up and Go test (TUG) after one year follow-up when the Trigen Intertan nail is used.[40] More prospective randomized comparative studies of recent dual lag screw systems with other fixation types are warranted to conclude what osteosynthesis is preferable in unstable trochanteric fractures.

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