



Original article

Risk factors and involvement of radiological characteristics of the proximal femur in disassembly of the femoral neck triple screw in seniors

Facteurs de risque et implication des caractéristiques radiologiques du fémur proximal dans le démontage de la triple vis du col du fémur chez les personnes âgées

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Résumé

Objectif de l'étude : L'objectif est de prédire le démontage postopératoire de la fixation par triple vis du col fémoral à l'aide d'indices radiologiques du fémur proximal, afin d'améliorer la prise en charge.

Méthodologie : Il s'agit d'une étude de cohorte observationnelle rétrospective de 3 ans. Nous incluons les patients âgés de 65 ans ou plus présentant une fixation par triple vis du col du fémur dont l'indication opératoire a été classée comme Jardin 1 ou 2.

Résultats : Au total, 65 patients ont été opérés, dont 45/65 (69,2%) femmes, avec un sex-ratio de 2,2 F/M.

L'âge moyen était de $84,9 \pm 8,9$ ans. L'IMC moyen était de $23,4 \pm 5,04$ kg/m², la majorité (39/65, 60 %) avait un score ASA de 3, la fracture du jardin 1 étant plus représentée (50/65, 76,9 %). Nous avons identifié

11 cas (16,9 %) de retrait de vis postopératoire. Les échecs étaient plus fréquents chez les femmes (7/4) ($p = 0,045$), avec une force d'association 1,4 fois plus élevée [OR = 1,4 (0,3-5,2)]. Pour les scores ASA de 3 à 4 ($p = 0,019$), ce risque a été multiplié par 1,7 [OR = 1,7 (0,2-6,6)]. Les fractures du jardin

1 étaient moins sujettes à l'échec du traitement [OR = 0,7 (0,13-3,7)] que celles du jardin 2 ($p = 0,05$). L'indice moyen d'évasement canalaire (CFI) et l'indice d'épaisseur corticale (CTI) étaient de $4,02 \pm 0,9$ et $0,53 \pm 0,08$. Pour les cas d'échec thérapeutique, l'ICT était de $0,528 \pm 0,101$ ($p=0,218$) et l'ICC de $3,91 \pm 1,09$ ($p=0,168$), par rapport à un simple suivi opératoire. Conclusion : nous n'avons pas trouvé de corrélation entre le démontage postopératoire et les indices radiologiques. Le sexe féminin, le score élevé de l'ASA et le degré de déplacement initial du cou étaient associés au démantèlement postopératoire, mais n'étaient pas déterminants.

Mots-clés : Caractéristiques radiologiques, fracture du col du fémur, triple vissage.

Abstract

Aim of the study: The aim is to predict postoperative dismantling of triple screw fixation of the femoral neck using radiological indexes of the proximal femur, in order to improve management.

Methodology: This is a 3-year retrospective

observational cohort study. We including patients aged 65 or over with triple screw fixation of the femoral neck whose operative indication was classified as Garden 1 or 2.

Results: A total of 65 patients underwent surgery, including 45/65 (69.2%) women, with a sex ratio of 2.2 F/M. Mean age were 84.9 ± 8.9 years. Mean BMI was 23.4 ± 5.04 Kg/m², the majority (39/65, 60%) had an ASA score of 3, with Garden 1 fracture more represented (50/65, 76.9%). We identified 11 cases (16.9%) of postoperative screw removal. Failures were more common in women (7/4) ($p=0.045$), with a 1.4-fold higher strength of association [OR=1.4 (0.3-5.2)]. For ASA scores of 3 to 4 ($p=0.019$), this risk was multiplied by 1.7 [OR=1.7 (0.2-6.6)]. Garden 1 fractures were less prone to treatment failure [OR=0.7(0.13-3.7)] compared with Garden 2 ($p=0.05$). The mean canal flare index (CFI) and cortical thickness index (CTI) were 4.02 ± 0.9 and 0.53 ± 0.08 . For cases of therapeutic failure, the CTI was 0.528 ± 0.101 ($p=0.218$) and the CFI 3.91 ± 1.09 ($p=0.168$), compared with simple operative follow-up.

Conclusion: we did not find any correlation between postoperative disassembly and radiological indices. Female gender, high ASA score and degree of initial neck displacement were associated with postoperative dismantling but were not determinant.

Keywords: Radiological characteristics, femoral neck fracture, triple screwing.

Introduction

The problem Fractures of the proximal femur in elderly patients (over 65 years of age) are generally the consequence of a fall from its height, or may occur spontaneously as a result of the state of the bone, weakened by a medical condition. They are subdivided into intra-capsular fractures (capital, sub-capital and trans-cervical) and extra-capsular fractures (basi-cervical and trochanteric mass) [1, 2]. Intracapsular fractures are those in which the

fracture line is located in the joint capsule, with a risk of cephalic necrosis and secondary displacement that varies according to the initial displacement of the femoral head (assessed by the Garden score) and the orientation of the fracture line, reflecting fracture stability (assessed by the Pauwels score) in the case of true cervical fractures [2]. The treatment of these fractures and the prevention of these risk factors in the elderly represent a major challenge for orthopaedic surgeons, geriatricians, rheumatologists and physiotherapists. Collegial management is therefore essential to ensure patient autonomy and limit the complications associated with prolonged bed rest [3]. For intracapsular fractures, the recommendations of the French National Authority for Health are as follows:

- Before age 65, osteosynthesis for all fracture types.
- After age 65, osteosynthesis for Garden 1 and 2 fractures, and hip arthroplasty for Garden 3 and 4 fractures [4].

Several types of osteosynthesis are available, including double, triple or screw-plate fixation. They all ensure reduction of the fracture site, but the durability of the materials depends on the mechanical quality of the bone capital, which may deteriorate as a result of a pathological or physiological process [1, 5]. In our institution, we apply the recommendations of the Haute Autorité de Santé in the management of Garden 1 and 2 fractures in patients aged 65 or over. Despite this, 10% of Garden 1 and 2 neck fractures treated by osteosynthesis become displaced postoperatively [6]. The aim of this study is to determine risk factors and predict post-operative disassembly of triple screw fixation of the femoral neck using radiological characteristics of the proximal femur in patients aged at least 65 years.

Identify cases of triple femoral neck screw fixation failure in the study population;

Methodology

- *Study design and sitting:*

This is a 3-year retrospective observational cohort study, carried out in the orthopaedic surgery and traumatology department of CH EMILE-ROUX / Puy en Velay from May, 2020 to April, 2023.

- *Study participants:*

We including patients aged 65 or over with triple screw fixation of the femoral neck whose operative indication was classified as Garden 1 or 2 and whose clinical and radiological parameters of interest were clearly established in their digital file.

- *Data sources, study variables and measurement*

The clinical and radiological data were collected using a form, and the following variables were collected:

- Socio-demographic characteristics: marital status, age at osteosynthesis;
- circumstances of fracture occurrence
- Clinical characteristics: body mass index, ASA score (American Society of Anesthesiology), fracture type according to Garden (1 and 2), follow-up time in days (time from day of surgery to last appointment), occurrence of complications.

All our patients were followed for 3 months and the failure of triple screw fixation (complication) was defined by disassembly of the material. In the event of a complication, the patient was managed correctly according to the recommendations of the french society of orthopédic and trauma surgery in force [5]. We studied preoperative radiographs of the front pelvis in order to detect cases of disassembly, relating it to clinical data. We measured the following parameters on the contralateral femur [7, 8]:

- Do: outside diameter (outside diameter of the diaphysis at 10 cm below the lesser trochanter) ;
- Di: inner diameter (inner diameter of the shaft at 10 cm below the lesser trochanter, measured at the same level as Do);
- CW: canal width (canal width measured 2 cm above line a);
- Line a: a line drawn perpendicular to the femoral shaft through the midpoint of the lesser trochanter;

- Line b: a line parallel to the diaphysis, used as a reference for drawing line a;
- Line c: a 10 cm line drawn perpendicular to line a, used to identify the interior and Do measurement levels of the shaft.

We calculated the following indices on each patient's preoperative face radiographs (using Telemis software 4.96), currently recognized as a predictive factor for the risk of proximal femur fracture [9] (Figure 1) :

The proximal femoral cortical thickness index (CTI) knowing that :

$$CTI = (Do - Di) / Do$$

The proximal femoral canal flare index (CFI) knowing that :

$$CFI = CW / Di$$

- *Biais*

Radiological measurements were carried out using Telemis software 4.96, by an orthopaedic surgeon, but without counter-expertise.

- *Study size*

During our study period, we reviewed 77 records of patients operated on in the operating theatre of the Centre Hospitalier Emile Roux by triple screw fixation of the femoral neck, of whom we excluded 4 because their radiological records were not very informative and 8 others because they were less than 65 years old.

- *Statistical analysis*

Data were entered on the computer using Microsoft Office Excel 2010 and all statistical calculations were performed using SPSS software version 21.0 for Windows. For statistical analysis, a value of $p < 0.05$ was taken as significant for the interpretation of results. Qualitative data were compared with qualitative data using ANOVA followed by Student's paired test, qualitative data were studied using Pearson's Chi-square test.

- *Ethical considerations*

This study was carried out anonymously and in compliance with medical ethics. We certify that no human experimentation took place during the course of this work. We have collected data from our patients' medical records with strict respect for anonymity and with the consent of the person concerned.

Results

Our sample consisted of 65 patients who had undergone triple screwing of the femoral neck, the majority of whom were female, with a number of 45/65 (69,2%) and males were represented at 20/65 (30,8%). The sex ratio was 2,2 F/M. The mean age of our study population was 84.9 ± 8.9 years, with a predominance of people over 75 (52/65 ; 80%) (Table 1). In our study population, 28 patients had a normal BMI, with a mean of 23.4 ± 5.04 kg/m², the majority (39 patients, 60%) had an ASA 3 score, Garden 1 fracture was more common, with 50/65 (76.9%), and 55.4% (36/65) involved on the right side. Most patients had a fall from height as the mechanism of injury (51/65 ; 78.4%) (Table 2). The average of CFI and CTI varied respectfully from $4,02 \pm 0,9$ and $0,53 \pm 0,08$ (Table 3).

We identified 11 cas of dismantling of aequipment post-operatively, or 16,9% (Table 4).

Therapeutic failure was more frequent in female subjects (7 f/ 4 h), with a statistically significant difference ($p=0.045$) and a strength of association with therapeutic failure calculated at 1.4 times greater than in men in univariate analysis: [OR=1.4 (0.3-5.2)]. For patients with an ASA score of 3 and 4 ($p=0.019$), the risk of failure was multiplied by 1.7 [OR=1.7 (0.2-6.6)]. On the other hand, patients with a Garden 1 score [OR=0.7 (0.13-3.7)] were at much lower risk of treatment failure than Garden 2 patients, with a borderline p-value in univariate analysis ($p=0.05$). In multivariate analysis, no variable was retained (Table 5).

The table 6 provides information on the different patient averages according to operative outcome. The mean CTI for patients with therapeutic failure was 0.528 ± 0.101 and the mean CFI was 3.91 ± 1.09 , with no statistically significant difference when compared to patients with uncomplicated operative sequelae.

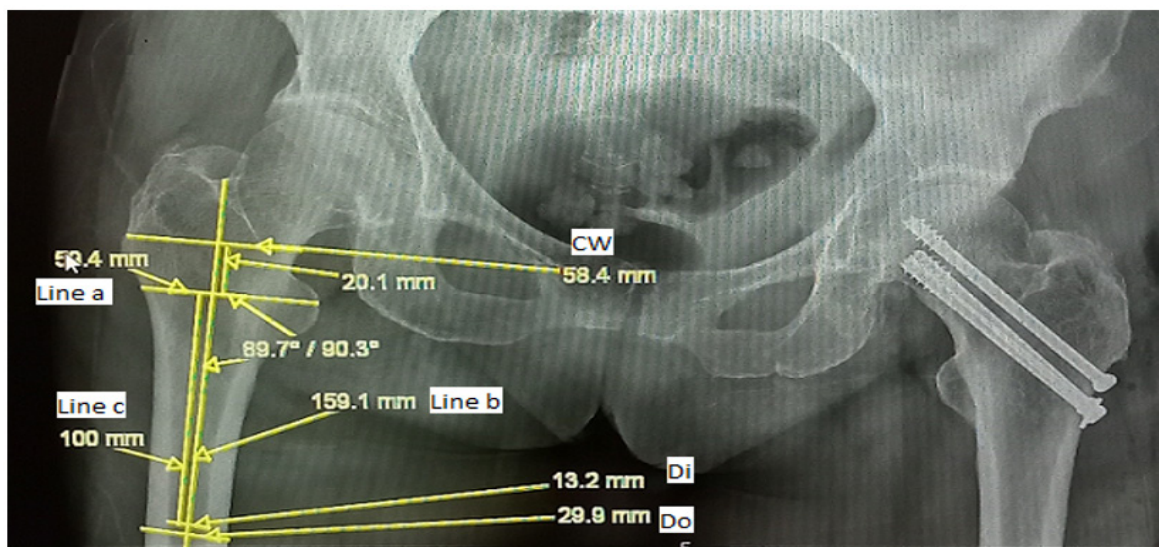


Figure 1. Measurement of the CTI and CFI index on a anteroposterior radiograph of a normal hip (Telemis software). Do: outer diameter (the shaft's outer diameter at 10 cm below the lesser trochanter), Di: inner diameter (the shaft's inner diameter at 10 cm below the lesser trochanter, measured at the same level as Do), CW: canal width (the canal width measured at 2 cm above Line a), Line a: a line drawn perpendicular to the femoral shaft through the middle point of the lesser trochanter, Line b: a line drawn parallel to the shaft to be used as a reference for drawing Line a, Line c: a 10-cm line drawn perpendicular to Line a, used to identify the shaft's inner and Do measurement levels. C.H Emile Roux/France.

Table 1. Distribution of the study population according to age groups, patients recruited from the orthopedic surgery department at C.H Emile Roux/France from May, 2020 to April, 2023.

Age group	Effective	Percentage
≥ 65 - < 76	13	20,0 %
≥ 76 - ≤ 110	52	80,0 %
Total	65	100,0 %

Table 2. Distribution of the study population according to clinical and etiological characteristics, patients recruited from the orthopedic surgery department at C.H Emile Roux/France from May, 2020 to April, 2023.

Variables	N=65	%
X ± ET	23,4 ± 5,04 Kg/m ²	
BMI	Undernutrition	7 / 10,8
	Normal	28 / 43,1
	Overweight	10 / 15,4
	Obese	3 / 4,6
	undetermined	17 / 26,2
ASA score	1	2 / 3,1
	2	17 / 26,2
	3	39 / 60
	4	4 / 6,1
	undetermined	3 / 4,6
Classification from Garden	Type 1	50 / 76,9
	Type 2	15 / 23,1
Affected side	Right	36 / 55,4
	Left	29 / 44,6
Mechanism	Fall from chair	4 / 6,1
	Fall from height	51 / 78,4
	Fall from bed	1 / 1,5
	Fall from bicycle	2 / 3,1
	Slip in shower	1 / 1,5
	undetermined	6 / 9,2

Table 3. Assessment of the CFI and the CTI in our study population, patients recruited from the orthopedic surgery department at C.H Emile Roux/France from May, 2020 to April, 2023.

Variables	X ± ET	Min - max
CFI	4,02 ± 0,9	2,3 - 7,4
CTI	0,53 ± 0,08	0,26 - 0,79

Table 4. Identification of cases of complications in our study population, patients recruited from the orthopedic surgery department at C.H Emile Roux/France from May, 2020 to April, 2023.

Treatment failure	Effective	Percentages
Oui	11	16,9 %
Non	54	83,1 %
Total	65	100,0 %

Table 5. Correlation between general characteristics and therapeutic failure, patients recruited from the orthopedic surgery department at C.H Emile Roux/France from May, 2020 to April, 2023 (N=65).

Variables	Analyses univariées			
	Good progress	Treatment failure	OR (IC 95%)	p
Age				
X±ET	84,1±9,3	88,6±4,7	-	0,025
Sex				
Male	16	4	1	
Female	38	7	1,4 (0,3-5,2)	0,045
BMI				
Normal	29	6	2,1(0,4-9,3)	0,302
Overweight/Obese	9	4	1	
ASA				
1-2	17	2	1	
3-4	34	9	1,7 (0,2-6,6)	0,019
Garden				
1	41	9	0,7(0,13-3,7)	0,050
2	13	2	1	
Affected side				
Right	29	7	0,7(0,17-2,5)	0,075
Left	25	4	1	

Table 6. Correlation between CTI/ CFI and postoperative complications, patients recruited from the orthopedic surgery department at C.H Emile Roux/France from May, 2020 to April, 2023 (N=65).

	Treatment failure	N	X ± ET	p
CTI	No	54	0,531 ± 0,083	0,218
	Yes	11	0,528 ± 0,101	
CFI	No	54	4,05 ± 0,81	0,162
	Yes	11	3,91 ± 1,09	

Discussion

In our study, we analysed 65 records of patients operated on by triple neck screw fixation for Garden 1 and 2 hip fractures, with an average setback of 94.1 days. The sample was predominantly female, with a sex ratio of 2.2 F/M. The mean age of our study population was 84.9 ± 8.9 years, with a predominance

of people over 75 (52/65, equals 80%). This female representation is reported in the literature and is justified by the osteoporosis of postmenopausal women, considered a major determinant of the risk of femoral neck fracture after a benign fall [2, 10]. Kelsey in 1989 reported the influence of female gender, age, Caucasian race, early ovarian ablation, etc. as established risk factors for osteoporosis, with

a significant fracture risk [10]. Roberfroid in 2011 reported 14,720 femoral neck fractures in osteoporotic women after the age of 40 [11].

We identified 11 cases of mechanical complications occurring postoperatively, i.e. 16.9%. Ehlinger and colleagues, in a study of early complications in cervical femur fractures treated with triple screw fixation or screw-plate fixation, noted a frequency varying between 3% and 10% in an unrestricted age sample [12]. Mille Fanny and colleagues, in a study based on the prediction of neck screw fixation failure, noted that 10% of garden 1 and 2 fractures were displaced secondarily (post-operatively), and 21% of patients with an average age of 67 were affected by this complication [6].

In our series, the mean CFI and CTI were 4.02 ± 0.9 and 0.53 ± 0.08 respectively. Nguyen in Japan, in a series of patients aged over 50, found a CFI and CTI of 3.40 and 0.55 respectively, which are in line with our results [7]. Bozgeyik in Turkey, also found results close to our own, with a mean CFI of 2.81 (1.71-3.378) and a CTI of 0.45 (0.20-0.65) [13]. Sah and colleagues in 2007, comparing radiological parameters with bone mineral density, noted a close correlation and found an ITC of 0.46 ± 0.09 and 0.55 ± 0.08 respectively in osteoporotic and non-osteoporotic subjects over 50 years of age [8]. This leads us to believe that there is no great variation in these indices between European and Asian populations. But this would need to be proven by a study comparing the 2 populations from a radiological point of view. A low ITC is associated with osteoporosis and may, by extension, predict hip fracture.

We found that therapeutic failure was more common in female subjects (7f/4h), with a statistically significant difference ($p=0.025$) and a 1.4-fold greater strength of association with failure, in univariate analysis: [OR=1.4 (0.3-5.2)]. The same observation was made for patients with an ASA score between 3 and 4, where this risk was multiplied by 1.7. On the other hand, patients with a Garden 1 score [OR=0.7 (0.13-3.7)] were at much lower risk of treatment failure than patients with a Garden 2 score, and

the p-value was borderline in univariate analysis ($p=0.05$). In multivariate analysis, no variable was retained. Yang et al, in a study evaluating the risk of complication of femoral neck screw fixation, found that the occurrence of pseudarthrosis was related to the type of displacement according to Garden, the quality of postoperative reduction and the triple screw fixation (triangular with 2 proximal screws) [14]. Araujo et al. identified postoperative reduction on an anteroposterior view as the only risk factor for complications in triple screw fixation of the femoral neck [15]. Sprague et al, in their study of factors associated with revision triple neck screw fixation, identified female gender, body mass index, Garden fracture type, implant quality and smoking as factors implicated in treatment failure [16].

The mean CTI for patients with therapeutic failure was 0.528 ± 0.101 and the mean CFI was 3.91 ± 1.09 , with no significant difference when compared to patients with uncomplicated operative follow-up. We therefore found no relationship between the radiological characteristics provided by CFI and CTI and the occurrence of mechanical complications in our study population. According to the work of Pothong [8], CTI is a determinant of the mineralization status of the proximal femur, reflecting bone fragility and thus predicting subsequent hip fracture, while CFI, as described by NOBLE, reports the effect of age on the shape of the proximal femur, as well as the degree of bone mineralization [17]. We have not found a study that relates these radiological indices to the dismantling of osteosynthesis materials post triple screw fixation of the femoral neck.

• **Limitations of the study**

The results of the present study cannot lead to global conclusions, simply because the sample is not consistent and the duration is not sufficiently extended.

Conclusion

We found no correlation between post-operative dismantling of the triple screw fixation and the CFI

and CTI indices. Female gender, high ASA score and degree of initial neck displacement were associated with post-osteosynthesis disassembly but were not determinant.

What is already known on this topic

In the literature, we were unable to find any study demonstrating or investigating a link between the radiographic characteristics of the proximal femur and post-operative dismantling of the triple screw-retained femoral neck, whatever the age of the population. This is the basis of our study. All we know is that :

CTI is a determinant of the mineralization status of the proximal femur, reflecting bone fragility and predicting subsequent hip fracture ;

CFI reports the effect of age on the shape of the proximal femur, as well as the degree of bone mineralization.

What this study adds

This study, which is devoted to the prediction of a mechanical complication of femoral neck screw fixation using radiological parameters, is a first and needs to be enriched by other parameters in order to refine the results. we are firmly convinced that :

This study sheds light on the question of whether bone fragility of the proximal femur, defined by radiological characteristics (CFI and CTI), can predict the occurrence of osteosynthesis device disassembly (triple screw fixation of the femoral neck) in elderly patients treated for Garden 1 or 2 fractures in our study population.

This 3-year retrospective study showed that there was no association between postoperative disassembly of osteosynthesis devices and calculated radiological parameters (CFI and CTI) in our population.

Contribution of the authors

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have read and approved the final version of this manuscript.

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