Orthopaedics & Traumatology: Surgery & Research 105 (2019) 985–990

Contents lists available at ScienceDirect

Orthopaedics & Traumatology: Surgery & Research

journal homepage: www.elsevier.com

Original article

Non-operative treatment is a reliable option in over two thirds of patients with Garden I hip fractures. Rates and risk factors for failure in 298 patients

Delphine Amsellem[a,b], Sébastien Parratte[a,b], Xavier Flecher[a,b], Jean-Noël Argenson[a,b], Matthieu Ollivier[a,b,*]

[a] CNRS, ISM UMR 7287, Aix-Marseille université, 13288 Marseille cedex 09, France
[b] Department of orthopaedics and traumatology, institute of movement and locomotion, St. Marguerite hospital, 13009 Marseille, France

ARTICLE INFO

Article history:
Received 10 October 2018
Accepted 4 April 2019

Keywords:
Femoral neck fracture
Garden I/non-displaced fracture
Age > 65 years
Non-operative treatment

ABSTRACT

Background: Non-operative treatment for impacted femoral neck fractures is a now rarely used strategy whose indications are controversial. No outcome predictors have been convincingly identified, in part due to the small sizes of available studies. We conducted a large retrospective study with the following objectives: (1) to evaluate the percentage of patients older than 65 years of age with non-operatively treated Garden I femoral neck fractures who experience secondary displacement, (2) to identify predictors of secondary displacement, and (3) to determine the frequency of non-operative treatment failure due to any cause and requiring joint replacement surgery.
Hypothesis: Non-operative treatment is reliable in patients older than 65 years of age with Garden I femoral neck fractures.
Material and methods: Approval was obtained from the French data protection authority to conduct a retrospective observational study of information in the Marseille university hospitals database. Consecutive patients who were older than 65 years of age at traumatology department admission for Garden I femoral neck fractures managed non-operatively between January 2007 and December 2017 were included. Non-operative treatment consisted in a walking test on day 1 followed by radiographs on days 2, 7, 14, 21, and 45 and after 3 and 12 months. Patients with secondary displacement underwent hip arthroplasty. Demographic data, cognitive performance, and radiological parameters were collected for each patient. We evaluated the rates of secondary displacement avascular necrosis, and non-union.
Results: We included 298 patients with a mean age of 82 years (range, 65–101). Mean follow-up was 5 ± 3 years. Secondary displacement occurred in 91 (30%) patients, at a mean of 16 days (range 2–45 days) after the fracture. Avascular necrosis of the femoral head developed in 13 (4.3%) patients and non-union in 11 (3.7%) patients. Secondary displacement was significantly associated with hypnotic treatment (OR, 4.1; 95%CI, 2.2–7.5; $p = 0.039$), institutionalisation (OR, 6.7; 95%CI, 3.1–14.8; $p = 0.028$), a history of repeated falls (OR, 13.5; 95%CI, 6.3–8.4; $p < 0.0001$), having three or more comorbidities (OR, 3.2; 95%CI, 1.7–5.8; $p = 0.046$), and having dementia (OR, 3.5; 95%CI, 1.7–6.9; $p = 0.0003$). Secondary displacement occurred in 18 (12%) of the 151 community-dwelling patients with normal cognition and no history of repeated falls compared to 37 (75%) of the 50 institutionalised patients with dementia.
Discussion: Non-operative treatment was effective in 196 (66%) of 298 patients with Garden I femoral neck fractures. Significant risk factors for secondary displacement were dementia, institutionalisation, hypnotic treatment, multiple comorbidities, and a history of repeated falls. Of 151 community-dwelling patients with normal cognition and no repeated falls, 133 (88%) achieved a full recovery with non-operative treatment alone.
Level of evidence: IV, retrospective cohort study.

* Corresponding author. UMR CNRS 787/AMU, centre hospitalo-universitaire Sud, institut du mouvement et de l'appareil locomoteur, hôpital Sainte Marguerite, 270, boulevard de Sainte-Marguerite, 13009 Marseille, France.
E-mail address: matthieu.ollivier@ap-hm.fr (M. Ollivier).

https://doi.org/10.1016/j.otsr.2019.04.021
1877-0568/

1. Introduction

Garden I fractures (Fig. 1) [1], which account for 15% to 20% of all femoral neck fractures [2], are incomplete fractures characterised by limited displacement and continuity of the posterior capsule. The mechanism of injury is excessive external rotation responsible for valgus and retroversion of the femoral head [3]. There is probably little or no loss of blood supply to the femoral head, and the fracture is stable due to impaction of the two fragments (Fig. 2). Secondary displacement may occur, however, as a result of femoral head retroversion or of poor cortical and cancellous bone quality [4] combined with comminution [5]. Secondary displacement may lead to delayed avascular necrosis by compromising the blood supply to the femoral head and increasing the pressure within the joint capsule via the production of a haematoma around the fracture site [6]. In published studies, the frequency of secondary displacement ranged from 33% [7] to 44.3% [8].

Despite an abundant literature, no consensus exists regarding the optimal management of Garden I hip fractures. Treatment strategies include non-operative management, internal fixation, and arthroplasty. Non-operative treatment has been proven effective in some cases of impacted fractures. Failure of non-operative treatment may require secondary arthroplasty. A 2017 study by Reina et al. [9] found no differences in mortality or functional outcomes between internal fixation and arthroplasty used to treat non-displaced femoral neck fractures in patients older than 80 years of age. Non-operative treatment of impacted femoral neck fractures is now rarely used and has controversial indications. No strong predictors of non-operative treatment outcomes have been identified to date, in part due to the often small size of available studies.

We conducted a large retrospective study with the following objectives:

- to evaluate the percentage of patients older than 65 years of age with non-operatively treated Garden I femoral neck fractures who experience secondary displacement;
- to identify predictors of secondary displacement;
- to determine the frequency of non-operative treatment failure due to any cause and requiring joint replacement surgery.

The working hypothesis was that non-operative treatment is reliable in patients older than 65 years of age with Garden I femoral neck fractures.

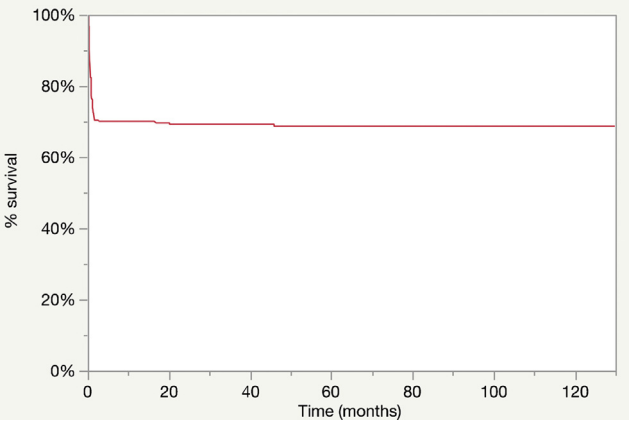

Fig. 2. Kaplan-Meier curve of survival without secondary displacement.

2. Material and methods

2.1. Patients

A multicentre retrospective cohort study was conducted in consecutive patients older than 65 years of age who were admitted to traumatology departments in the university hospital network in Marseille, France, between January 2007 and December 2017 and who received non-operative management of a true Garden I femoral neck fracture. Approval was first obtained from the French data protection authority (*Commission de l'Informatique et des Libertés*, CNIL).

Inclusion criteria were age older than 65 years; true, initially impacted, Garden I femoral neck fracture visible on antero-posterior and lateral pelvic radiographs; and non-operative management. Exclusion criteria were age younger than 65 years at the time of the fracture; pathological fracture; non-displaced Garden II or displaced Garden, III or IV fracture; pertrochanteric or subtrochanteric fracture; and peri-prosthetic fracture. We included the 298 patients who met all the inclusion criteria and none of the exclusion criteria.

2.2. Methods

Non-operative management involved early ambulation in a walking frame to decrease weight-bearing on the affected side and

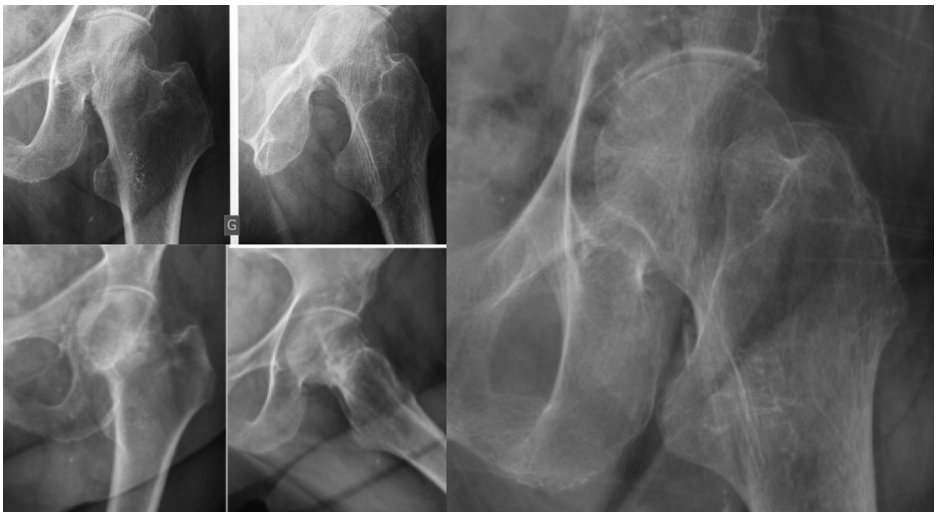

Fig. 1. Radiographs taken at admission then 1 and 5 years later in a 77-year-old woman with a Garden I fracture on the left hip.

Table 1
Main demographic and radiographic features in the overall population.

Features	*n* of patients or mean (range)
Total number of patients	298
Age (years)	81 (65–101)
Females/males	245/53
Body mass index (kg/m^2)	25 (15–36)
Left hip/right hip	144/154
Institutionalised	57
Dementia	66
Parker score	7 (3–9)
Hypnotic agents	106
History of falls	86
Three or more comorbidities	139
Pauwel's angle	
I	18
II	241
III	38
Valgus,°	23 (2–49)
Femoral head retroversion,°	13.4 (0–42)

a walking test on the day after the fracture (day 1) conducted by a physiotherapist under medical supervision. Follow-up radiographs consisting of an antero-posterior view of the pelvis and antero-posterior and lateral views of the affected hip were scheduled on days 2, 7, 14, 21, and 45; after 3 and 12 months; and annually thereafter (Fig. 1). Patients were informed that secondary displacement might occur and would require arthroplasty.

2.3. Assessment methods

For each patient, we recorded the following information from the electronic patient files in the hospital databases: age, sex, body mass index, institutionalisation at the time of the fall, use of hypnotic agents, comorbidities, and the Parker score (Table 1). The radiographs were reviewed by two different physicians, one of whom was a senior surgeon (MO). The following were measured on the radiographs obtained at admission: Pauwel's angle (1, 2, or 3), degree of valgus on the antero-posterior radiograph of the hip, and degree of femoral head retroversion on the lateral radiograph of the hip. During follow-up, the radiographs were evaluated for evidence of secondary displacement, which was defined as varus displacement and classified as Garden III or IV.

The primary outcome measure was the occurrence of secondary displacement during follow-up. The secondary outcome measures were time to secondary displacement, hospital stay length, type of surgery, and morbidity and mortality associated with secondary displacement. Arthroplasty during follow-up was recorded as a marker for failure of non-operative management due to any cause (avascular necrosis, pain, or non-union).

2.4. Statistical analysis

We compared the groups with and without secondary displacement (primary outcome measure). Distribution of each variable was assessed to guide the choice between parametric and non-parametric tests for comparing quantitative and qualitative criteria. Kaplan-Meier curves were plotted to assess survival without delayed surgery for any reason and for secondary displacement. There were no missing data.

A multivariate logistic regression analysis was performed to identify predictors of secondary displacement. First, univariate analyses were done to identify variables whose distribution differed between the groups with and without displacement, with p values < 0.20). These variables were then entered into the multivariate model. The adjusted odds ratios (ORs) were computed with their 95% confidence intervals (95%CIs). Correlations between quantitative parameters were assessed by computing Spearman's correlation coefficient (R^2). Values of p lower than 0.05 were taken to indicate significant differences.

3. Results

3.1. Secondary displacement rate

Over the 11-year study period, 298 patients met our selection criteria, including 245 (86%) women. Mean age was 81.5 years (range, 65-101 years) and 183 (61%) patients were older than 80 years. Mean follow-up was 5 ± 3 years. The right hip was fractured in 154 (51%) patients.

Secondary displacement occurred in 91 (30%) patients, at a mean of 16 days (range, 2–45 days) after the fracture, and was consistently managed by arthroplasty. Times to secondary displacement were as follows: ≤ 2 days, n = 2; 3–5 days, n = 17; 6–8 days, n = 14; 9–10 days, n = 7; 11–15 days, n = 14; 16–20 days, n = 5; 21–30 days, n = 21; and 31–45 days, n = 11.

3.2. Non-operative treatment failure rate

Avascular necrosis of the femoral head occurred in 13 (4.3%) patients. Surgery was required in 11 (3.7%) patients for non-union or pain. Mean hospital stay length was 8 days (range, 2–34 days) overall, 7 days (range, 2–20 days) in the group without secondary displacement, and 13 days (range, 5–34 days) in the group with secondary displacement. Of our 298 patients, 26 (9%) died during follow-up, at a mean of 19 months (range, 0.3–96 months) after the fracture. Mean 5-year survival without secondary surgery (for any cause) was 70% ± 26% and mean 5-year survival without secondary displacement was 68.8% ± 27.4% (Fig. 2).

3.3. Predictors of secondary displacement

Age, sex, and body mass index were not significantly associated with secondary displacement. Six factors were significantly associated with secondary displacement, namely, institutionalisation, dementia, use of hypnotics, a history of falls, three or more comorbidities, and a smaller angle of valgus displacement (Table 2).

The multivariate logistic regression analysis identified five factors independently associated with a higher risk of secondary displacement (Table 3), i.e., use of hypnotic agents (OR, 4.1; 95%CI, 2.2–7.5; p = 0.039), institutionalisation (OR, 6.7; 95%CI, 3.1–14.8; p = 0.028), a history of repeated falls (OR, 13.5; 95%CI, 6.3–8.46; p < 0.0001), three or more comorbidities (OR, 3.2; 95%CI, 1.7–5.8; p = 0.046), and dementia (OR, 3.5; 95%CI, 1.7–6.9; p = 0.0003). The angle of valgus displacement, in contrast, correlated with a lower risk of non-operative treatment failure (R^2 = 0.43 and p < 0.0001). Thus, impaction in valgus protected against secondary displacement.

Of the 50 institutionalised patients with dementia, 37 (75%) experienced secondary displacement. In contrast, of the 151 self-sufficient community-dwelling patients without repeated falls or cognitive disorders, only 18 (12%) experienced secondary displacement.

4. Discussion

To date, no consensus exists about the optimal management of Garden I fractures. Available treatment options include arthroplasty, internal fixation, and non-operative treatment. Fixation using three percutaneously inserted screws is another alternative to arthroplasty that decreases the risk of secondary displacement while allowing early ambulation. However, a secondary displacement rate of 5.4% has been reported with this technique [10], which

Table 2
Comparison of the groups with and without secondary displacement.

Features*n* of patients or mean (range)	No displacement	Displacement	*p* value
Number of patients	207	91 (30%)	–
Age (years)	78 (65–97)	80 (65–101)	0.058
Females/males	176/31	76/15	0.764
Body mass index (kg/m^2)	24.8 (17–32)	25.3 (15–36)	0.311
Left side/right side	108/190	47/44	–
Institutionalisation	15	42	<0.0001
Dementia	26	40	0.0003
Parker score	7 (4–9)	6 (3–9)	0.061
Hypnotic agents	45	59	<0.0001
History of falls	21	65	<0.0001
Three or more comorbidities	68	71	<0.0001
Pauwel's angle			0.173
I	16	2	
II	166	75	
III	24	14	
Valgus,°	24.3 (3–43)	20.1 (2–49)	0.0046
Femoral head retroversion,°	14.5 (0–35)	12.5 (0–42)	0.384

Table 3
Multivariate analysis of factors potential independent predictors of secondary displacement.

Features*n* of patients or mean (range)	No displacement	Displacement	Odds Ratio	*p* value
Age (years)	78 (65–97)	80 (65–101)		NS
Females/males	176/31	76/15		NS
Body mass index (kg/m^2)	24.8 (17–32)	25.3 (15–36)		NS
Left side/right side	108/190	47/44		NS
Institutionalised	15	42	6.7 (3.1–14.8)	0.028
Dementia	26	40	3.5 (1.7–6.9)	0.0003
Parker score	7 (4–9)	6 (3–9)	1.5 (0.9–2.3)	
Hypnotic agents	45	59	4.1 (2.2–7.5)	0.039
History of falls	21	65	13.5 (6.3–28.4)	<0.0001
Three or more comorbidities	68	71	3.2 (1.7–5.8)	0.046
Valgus,°	24.3 (3–43)	20.1 (2–49)		NS
Femoral head retroversion,°	14.5 (0–35)	12.5 (0–42)		NS

NS: non-significant.

also exposes patients to complications related to the anaesthesia and to the surgery itself (e.g., surgical-site infections) [11], as well as to a need for material removal [12]. To the best of our knowledge, no previous study has demonstrated associations linking secondary displacement to institutionalisation, hypnotic agent use, or a history of repeated falls. Assessments of these potential risk factors are not usually performed, as they would require splitting small patient groups, thereby reducing statistical power. The large number of patients in our study combined with the in-depth evaluation that older patients receive at admission in our hospital network allowed us to demonstrate significant associations linking the non-operative treatment success rate to institutionalisation, dementia, medication use, and a history of repeated falls, rather than to older age at the time of the fall. Our findings confirm our working hypothesis that non-operative treatment is reliable in patients older than 65 years admitted for Garden I femoral neck fractures. Among the entire population of patients older than 65 years and admitted to university hospitals in Marseille between 2007 and 2017, 70% achieved a full recovery with non-operative treatment alone. The risk of secondary displacement was not associated with age, sex, or body mass index [13,14]. Significant risk factors for secondary displacement were institutionalisation, dementia, hypnotic agent use, three or more comorbidities, and a history of repeated falls.

In previous studies, the proportion of patients with secondary displacement ranged from 20% [15] to 66% [16] (Table 4). A prospective study by Buord et al. [7] of 56 patients older than 65 years and treated by unrestricted mobilisation starting 48 h after the fracture showed a secondary displacement rate of 33%. In their work reported 1978, Hansen et al. [17] described a 28% secondary displacement rate after weight bearing resumption, similar to that found in our study. Verheyen et al. [13] observed a high secondary displacement rate of 46% in a retrospective review of patients with Garden I fractures managed non-operatively with partial weight bearing. Of their 110 patients, 5 were excluded when a review of their radiographs showed that they had Garden II or III fractures. In our study, the rate of avascular necrosis was 4.3% (13 patients). This complication is classified among treatment failures, as it requires arthroplasty. In a study of 319 patients managed non-operatively, Raaymakers et al. [18] found an 11% rate of avascular necrosis after 2 years of follow-up.

A 2002 study by Raaymakers [21] (Table 5) demonstrated that the risk of secondary displacement was higher in patients older than 70 years. In a SoFCOT symposium multicentre study reported by Simon et al. in 2008 [22], secondary displacement occurred in 31% of patients and correlated with age. In contrast, age was not significantly associated with secondary displacement in our population. This apparent discrepancy may be ascribable to the many confounding factors, such as cognitive function, use of hypnotic agents, and place of residence, which were identified in our study: we suggest that these factors, rather than older age, were associated with a higher risk of secondary displacement. In studies of impacted femoral neck fractures conducted by Hansen and Solgaard [17] and Otremski et al. [23], secondary displacement was not associated with Pauwel's angle, valgus displacement, or femoral head retroversion. In our population, in contrast, valgus impaction protected against secondary displacement (24.3° in the group without vs. 20.1° in the group with secondary displacement), and the difference was statistically significant ($p = 0.0046$).

Our retrospective cohort design was a hybrid of an epidemiological study and a descriptive analysis. We therefore obtained data over a short period in a specific population. Furthermore, our study relied entirely on the Garden classification, which has a

Table 4
Previous studies of outcomes of non-operative management for Garden I fractures.

Authors	*n* of patients	Age, years	Follow-up	Secondary displacement	Treatment method
Hansen and Solgaard [17]	46	47–93	> 3 months	29%	Immediate partial weight bearing with canes
Cserhati et al. [15]	122	Mean, 72	–	20%	7-10 days of bedrest, weight bearing after 8 weeks
Raaymakers and Marti [18]	167	14–94	6 months–10 years	14%	7 days of bedrest then partial weight bearing with canes
Bel et al. [16]	23	65–100	> 2 years	66%	7-10 days of bedrest, weight bearing after 6 weeks
Tanaka et al. [19]	38	68–92	6 months–7 years	63%	14 days of bed rest, weight bearing after 6 weeks
Verheyen et al. [13]	105	17–97	3 months–4 years	46%	Immediate partial weight bearing
Shuqiang et al. [20]	115	60–80	2 months–5 years	48%	Immobilisation for 6 weeks
Buord et al. [7]	56	65–99	12–28 months	23%	Bed rest for 48 h then partial weight bearing with canes
Taha et al. [8]	61	37–96	3 months–5 years	55%	Immediate partial weight bearing with canes

Table 5
Potential predictors of secondary displacement evaluated in previous studies.

	n of patients (*n*)	Factors studied	
		Significant	Not significant
Hansen and Solgaard [17]	46	–	Pauwel's angle, amount of valgus, femoral head retroversion
Raaymakers [21]	167	Age > 70 years ($p = 0.0002$) Comorbidities ($p < 0.001$) Femoral head retroversion > 20° ($p = 0.009$) Pauwel's III ($p = 0.012$)	Valgus > 20°, early weight bearing, break in anterior cortex
Tanaka et al. [19]	38	Bed rest < 14 days ($p < 0.01$) Dementia ($p < 0.05$)	Age, sex, amount of valgus, femoral head retroversion
Bel et al. [16]	23	–	Age, comorbidities, place of residence, Parker, ASA, femoral head retroversion
Verheyen et al. [13]	105		Age, Pauwel's, ASA
Shuqiang et al. [20]	115	Age 60–80 years ($p = 0.03$)	ASA, Pauwel's
Buord et al. [7]	56	–	Age, sex, dementia, comorbidities, Pauwel's angle, amount of valgus
Taha et al. [8]	61	Garden II ($p < 0.001$) Osteoporosis ($p = 0.028$)	Age, sex, BMI, ASA, history of fracture, contralateral THA
Our study, 2018	298	≥ 3 comorbidities, dementia, institutionalisation, hypnotic agents, repeated falls	Age, sex, BMI, Parker score, amount of valgus, femoral head retroversion, Pauwel's angle

ASA: American Society of Anesthesiology score; BMI: body mass index; THA: total hip arthroplasty.

number of limitations, as pointed out by Van Embden et al. [24]. The Garden types can be simplified into displaced and non-displaced fractures. For rare potential risk factors of secondary displacement, the number of patients may have been too small to provide sufficient statistical power to detect significant associations. In our daily practice, we do not obtain computed tomography scans in patients with impacted femoral neck fractures. Our study therefore relied on radiographic criteria, which were both qualitative (type of fracture) and quantitative (displacement, change in trabecular orientation). Determining the exact value of Pauwel's angle [25] requires a true antero-posterior radiograph, which may be difficult to obtain in older patients with pain from a fracture [26]. Zhang et al. [27] described a new angle that was measured more reliably than Pauwel's angle in patients with early failure of femoral neck fracture fixation using three compression screws. Femoral head retroversion can be measured only on a true lateral radiograph of the hip, whose acquisition requires sedation in hip fracture patients [28]. Finally, our study does not provide data on important points such as quality of life and medical and surgical complications associated with non-operative treatment alone and with non-operative treatment followed by delayed surgery.

5. Conclusion

Non-operative treatment alone provided a full recovery in about 70% of elderly patients with Garden I fractures followed up for a mean of 5 years. Dementia, institutionalisation, hypnotic agent use, multiple comorbidities, and a history of repealed falls were associated with a higher risk of secondary displacement. Awareness of these criteria can help to select patients for non-operative treatment: thus, among self-sufficient community-dwelling patients with no history of repeated falls, only 14% experienced secondary displacement.

Disclosure of interest

None of the authors has any conflicts of interest to declare in relation to this work.

Delphine Amsellem declares he has no competing interest.

Sébastien Parratte is an educational consultant for Zimmer, Adler, Arthrex, and Newclip.

Xavier Flecher is an educational consultant for Zimmer and Adler.

Matthieu Ollivier is an educational consultant for Stryker, Arthrex, and Newclip.

Jean-Noel Argenson is a consultant for Symbios, Zimmer, and Adler and receives royalties from Symbios and Zimmer.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Contributions of each author

Delphine Amsellem and Matthieu Ollivier conceived the project, designed the protocol, processed the study data, performed the statistical analysis, and wrote the manuscript.

Sébastien Parratte, Jean-Noel Argenson, and Xavier Flecher revised the manuscript for important intellectual content.

References

[1] Netter FH. Atlas anatomie humaine. 6eme edition; 2015.
[2] Aufranc OE, Jones WN, Harris WH. Undisplaced femoral neck fracture. JAMA 1964;189:314–7.
[3] Garden RS. Low-angle fixation in fractures of the femoral neck. J Bone Joint Surg Br 1961;43:647–63.
[4] Ollivier M, Le Corroller T, Blanc G, Parratte S, Champsaur P, Chabrand P, et al. Radiographic bone texture analysis is correlated with 3D microarchitecture in the femoral head, and improves the estimation of the femoral neck fracture risk when combined with bone mineral density. Eur J Radiol 2013;82:1494–8.
[5] Bel J, Fischer P. Non displaced femoral neck fractures of the oldest olds. Functional or orthopedic treatment: comparison is not right. Académie Nationale de Chirurgie 2012. http://www.academie-chirurgie.fr/ememoires/005_2012_11_4_021x026.pdf. Access 1/9/2018.
[6] Holmberg S, Dalen N. Intracapsular pressure and caput circulation in nondisplaced femoral neck fractures. Clin Orthop Relat Res 1987;219:124–6.
[7] Buord JM, Flecher X, Parratte S, Boyer L, Aubaniac JM, Argenson JN. Garden I femoral neck fractures in patients 65 years old and older: is conservative functional treatment a viable option? Orthop Traumatol Surg Res 2010;96:228–34.
[8] Taha ME, Audigé L, Siegel G, Renner N. Factors predicting secondary displacement after non-operative treatment of undisplaced femoral neck fractures. Arch Orthop Trauma Surg 2015;135:243–9.
[9] Reina N, Bonnevialle P, Rubens Duval B, Adam P, Loubignac F, Favier T, et al. Internal fixation of intra-capsular proximal femoral fractures in patients older than 80 years: still relevant? Multivariate analysis of a prospective multicentre cohort. Orthop Traumatol Surg Res 2017;103:3–7.
[10] Chen WC, Yu SW, Tseng IC, Su JY, Tu YK, Chen WJ. Treatment of undisplaced femoral neck fractures in the elderly. J Trauma 2005;58:1035–9 [discussion 1039].
[11] Rodríguez-Merchán EC. In situ fixation of nondisplaced intracapsular fractures of the proximal femur. Clin Orthop Relat Res 2002;339:42–51.
[12] Rogmark C, Flensburg L, Fredin H. Undisplaced femoral neck fractures–no problems? A consecutive study of 224 patients treated with internal fixation. Injury 2009;40:274–6.
[13] Verheyen CCPM, Smulders TC, van Walsum ADP. High secondary displacement rate in the conservative treatment of impacted femoral neck fractures in 105 patients. Arch Orthop Trauma Surg 2005;125:166–8.
[14] Helbig L, Werner M, Schneider S, Simank HG. Garden I femoral neck fractures: conservative vs. operative therapy. Orthopade 2005;34:1040–5.
[15] Cserháti P, Kazár G, Manninger J, Fekete K, Frenyó S. Non-operative or operative treatment for undisplaced femoral neck fractures: a comparative study of 122 non-operative and 125 operatively treated cases. Injury 1996;27:583–8.
[16] Bel JC, Hafez M, Erhard L, Forissier D, Frébault C, Herzberg G. Résultats actuels du traitement initialement fonctionnel des fractures non déplacées du col fémoral chez les patients très âgés : à propos de 35 cas. Rev Chir Orthop 2004;90:153.
[17] Hansen BA, Solgaard S. Impacted fractures of the femoral neck treated by early mobilization and weight-bearing. Acta Orthop Scand 1978;49:180–5.
[18] Raaymakers EL, Marti RK. Non-operative treatment of impacted femoral neck fractures. A prospective study of 170 cases. J Bone Joint Surg Br 1991;73:950–4.
[19] Tanaka J, Seki N, Tokimura F, Hayashi Y. Conservative treatment of Garden stage I femoral neck fracture in elderly patients. Arch Orthop Trauma Surg 2002;122:24–8.
[20] Shuqiang M, Kunzheng W, Zhichao T, Mingyu Z, Wei W. Outcome of non-operative management in Garden I femoral neck fract. Injury 2006;37:974–8.
[21] Raaymakers ELFB. The non-operative treatment of impacted femoral neck fractures. Injury 2002;33:C8–14.
[22] Simon P, Gouin F, Veillard D, Laffargue P, Ehlinger M, Bel JC, et al. Femoral neck fractures in patients over 50 years old. Rev Chir Orthop 2008;94:S108–32.
[23] Otremski I, Katz A, Dekel S, Salama R, Newman RJ. Natural history of impacted subcapital femoral fractures and its relevance to treatment options. Injury 1990;21:379–81.
[24] Van Embden D, Rhemrev SJ, Genelin F, Meylaerts SaG, Roukema GR. The reliability of a simplified Garden classification for intracapsular hip fractures. Orthop Traumatol Surg Res 2012;98:405–8.
[25] Parker MJ, Dynan Y. Is Pauwels classification still valid? Injury 1998;29:521–3.
[26] Bartonícek J. Pauwels' classification of femoral neck fractures: correct interpretation of the original. J Orthop Trauma 2001;15:358–60.
[27] Zhang YL, Zhang W, Zhang CQ. A new angle and its relationship with early fixation failure of femoral neck fractures treated with three cannulated compression screws. Orthop Traumatol Surg Res 2017;103:229–34.
[28] Bel J. Fracture du col du fémur après 65 ans : traitement fonctionnel des Garden 1-problématique et données de la littérature. Rev Chir Orthop Traumatol 2008;94:108–32.