Assessment of time factor in managing femoral neck fractures by internal fixation in patients above 55 years of age

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Background
Intracapsular hip fractures account for approximately half of all hip fractures. Present treatment of an intracapsular fracture entails either replacement arthroplasty or preservation of the femoral head. In old age patients, the decision between fixation and arthroplasty becomes an issue: Although fixation is a biological solution for this fracture treatment, it has a high nonunion rate with a long postoperative recumbency period and its known complications; in contrast, arthroplasty has its advantage in early mobilization of the patient but has its well-known complications, starting with infection and ending with loosening and the need for revisions. Evidence from the literature on the effect of timing of fixation on outcomes after femoral neck fractures is conflicting. The purpose of this study was to analyze the effect of timing of surgery on the incidence of nonunion and avascular necrosis (AVN) after internal fixation of femoral neck fractures in patients above the age of 55 years.

Patients and methods
This study included 30 patients (13 men and 17 women) between 56–77 years of age (average 65.1 years) with femoral neck fractures who were treated by closed reduction and internal fixation and were followed up for a minimum of period of 2 years. Nineteen patients (63.33%) had displaced fractures. The average time lag between injury and surgery was 37.5 h (6–144). The patients were divided into two groups: 12 patients (40%) were treated within 12 h after injury (early fixation group) and 18 (60%) were treated more than 12 h after injury (late fixation group). All patients were treated by closed reduction and multiple screw fixation.

Results
The average age of the patients in the early fixation group (12 patients) was 61.9 years and that of patients in the late fixation group (18 patients) was 67.7 years. There were seven women in the early fixation group and 10 in the late fixation group. There were eight cases of displaced fractures (66.67%) in the early fixation group and 11 cases (61.1%) of the same in the late fixation group. The average time lag between injury and fixation was 10.5 h in the early fixation group and 54.78 h in the late fixation group. All fractures united within an average period of 86.8 days (range 60–128). The final results were satisfactory in 22 hips (73.33%) and unsatisfactory in eight hips (26.67%).
No statistically significant difference was found in the duration of fracture union and AVN with regard to sex distribution and mechanism of injury. Variables affecting the final results of treatment were: the time factor, age at surgery and type of fracture.

Conclusion
Closed reduction and internal fixation is a valid contribution to the treatment of femoral neck fractures in patients above 55 years of age (56–65). The rate of nonunion and AVN was affected by a delay of more than 12 h before fixation for femoral neck fractures in this age group. The incidence of failure was significantly higher in patients aged 65 years or above and in cases of displaced fractures.

Keywords:
femoral neck fractures, internal fixation, older age

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Introduction

The incidence of proximal femoral fractures has increased significantly in recent years and is expected to continue to rise with the increasing life expectancy of elderly patients [1]. The incidence of hip fractures increases with advancing age, doubling for each decade beyond 50 years of age [2]. The number of these fractures has been estimated to be ~250 000/year, [3] and the fractures are associated with a 12–20% increase in morbidity and disability compared with the rate in a group of age-matched and sex-matched individuals who have not sustained a fracture [4–6]. Several studies have suggested that reduction and fixation of an intracapsular fracture

of the hip with multiple pins or screws is associated with a lower rate of morbidity and mortality compared with treatment with prosthetic replacement, as the biological joint is preserved. Moreover, this line of treatment has shorter operative time, shorter initial hospital stay and is a less invasive technique with reduced blood loss [7–9]. In addition, the patient still has an option of undergoing total hip replacement electively if late complications such as nonunion or avascular necrosis (AVN) occur [10,11].

The management of intracapsular hip fractures in the elderly, in general, includes resection of the femoral head and hip replacement [6]. In contrast, for patients younger than 60 years, preservation of the femoral head and anatomical reduction and stable fixation of a femoral neck fracture are the main concerns [12]. However, in patients aged between 60 and 80 years, the decision between internal fixation and arthroplasty remains controversial [6]. In the literature, there is no agreement on the definition of the earliest time within which these fractures should be reduced and fixed [13–15].

Aim of the study

The aim of the present study was to evaluate the functional outcome and quality of life in patients above 55 years of age with femoral neck fractures treated with closed reduction and internal fixation and also to report the effect of the timing of surgery on the incidence of nonunion and AVN after this method of treatment in this age group.

Patients and methods

This study included all the patients above 55 years of age who were admitted at Damanhour National Medical Institute with intracapsular fractures of the femoral neck and had been treated with closed reduction and internal fixation between July 2006 and January 2009. Patients were included in this study if they met the following criteria:

(1) Were aged above 55 years.
(2) Had been treated with closed reduction and internal fixation.
(3) Had been followed up for at least 2 years.
(4) Had fractures of Garden type I, II, and III.
(5) Were ambulant before the injury.

Exclusion criteria

(1) Had a fracture of Garden type IV.
(2) Had pathological fractures.
(3) Had pre-existing abnormalities of the femoral head or neck.
(4) Had had a previous hip fracture or had undergone hip surgery.

Patient data

Thirty patients with femoral neck fractures were included in this study: 13 men (43.34%) and 17 women (56.67%) (Table 1). The mean age of the patients at the time of surgery was 65.1 years (range 56–77 years). The right hip was affected in 21 patients (70%). The fractures were undisplaced in 11 (36.66%) patients and were displaced in 19 (63.34%). The average time lag between injury and surgical fixation of the fracture was 37.5 h for all cases included in the study, with a range of 6–144 h. None of the patients in this study were using steroids for the treatment of any other medical condition. Out of the 30 patients, 25 had pre-existing medical conditions, 19 were diabetic, 16 were hypertensive, nine had clinical heart disease and two were being managed with renal dialysis. A 12-h time interval between occurrence of the fracture and surgery was considered in this study as the demarcation between early ($\leq$12 h) and late surgery ($>$12 h), as many studies have demonstrated that this is a reasonable time duration for performing early reduction and capsular decompression and for restoration of the anatomy and of the femoral head vascularity by unkinking the vessels [13]. The patients were allocated into two groups: group A included 12 patients (40%) treated with early fixation and group B included 18 patients (60%) treated with late fixation.

Patients were not randomized in this study to be treated by either early or late surgery. The time lag between injury and fracture fixation was related mainly to the delayed presentation of the patients to the hospital, and medical stabilization before surgery was mandatory. After being admitted to the hospital, all patients were deemed urgent, regardless the time lag between injury and presentation. Proper history taking, clinical examination, preoperative radiographs, computed tomography for some cases and laboratory investigations were carried out. Preoperative radiographs of the pelvis and both hips were

Table 1 Patient data

	N (%)
Age (years)	
56–65	18 (60)
66–77	12 (40)
Sex	
Male	13 (43.33)
Female	17 (56.67)
Trauma	
Fall	19 (63.33)
RTA	11 (36.67)
Type of fracture	
Undisplaced	11 (36.67)
Displaced	19 (63.33)

RTA, road traffic accident.

Table 2 Pain component of the Harris Hip Score [19]

A	Absent, or ignores it
B	Slight, occasional, no compromise in activities
C	Mild pain, no effect on activities, rarely moderate pain with unusual activity, may take aspirin
D	Moderate pain, tolerable but makes concessions to pain, some limitation of ordinary activity or work, may require occasional medicine stronger than aspirin
E	Marked pain, serious limitation of activities
F	Totally disabled, crippled, pain in bed, bedridden

obtained. Anteroposterior (AP) and lateral views of the affected hip were evaluated for the presence of fracture comminution and displacement.

The patients were operated upon under either spinal or epidural anesthesia and were transferred gently to the fracture table. Gentle closed reduction of the fracture under image intensifier control was carried out. All nondisplaced fractures of the femoral neck (Garden I and II) were stabilized with three cannulated screws. Displaced fractures (Garden III) were fixed using this technique if they could be reduced into an anatomical or slightly valgus position of the femoral head on the femoral neck. A primary arthroplasty was considered in patients in whom a satisfactory reduction could not be obtained. Immediate postoperative AP radiographs of the pelvis and affected hip (AP and lateral views) were evaluated for the quality of fracture reduction and adequacy of fixation.

Postoperative regimen

All patients were kept nonweight bearing immediately after surgery for at least 6 weeks until radiographic evidence of early healing of the fracture was obtained. Thereafter, the patients were allowed partial weight

Table 3 Comparison of patient data between the early and late fixation group

	Early fixation group ≤12 h	Late fixation group >12 h
Number of patients	12	18
Age (years)	56–73 (mean 61.92)	57–77 (mean 67.56)
Female : male	7 (58.34%) : 5 (41.66%)	10 (55.56%) : 8 (44.44%)
Type of fracture displaced : undisplaced	8 (66.67%) : 4 (33.33%)	11 (61.1%) : 7 (38.9%)
Average time to reduction (range)	10.5 h (6–12)	54.72 h (13–144)

Figure 1

A 57-year-old male patient who had a displaced fracture of the right femoral neck after a road traffic accident. Treatment of high (a, b) Radiograph and computed tomography scan of the right femoral neck after admission to the hospital (36 h after initial injury) showing a displaced fracture. (c) Immediate postoperative radiographs showing anatomical reduction of the fracture with fixation using three cancellous screws. (d, e) Anteroposterior and lateral radiographs of the right femoral neck 40 months after surgery showing healing of the fracture with no radiographic evidence of avascular necrosis.

bearing within tolerable limits until radiological evidence of complete healing of the fracture was obtained. The criterion used for fracture union was the development of a definite trabecular pattern across the fracture site after 1 year [16]. Accordingly, in the present study the diagnosis of a definite nonunion of the femoral neck was confirmed if no crossing trabeculae were observed in the radiograph after 1 year [16,17]. All patients were assessed for the development of radiographic evidence of AVN of the femoral head according to the criteria of Ficat [18]. Pain was evaluated using the pain component of the Harris Hip Score [19] (Table 2).

The implant was considered to have survived if the screw fixation was successful, the fracture had healed and the patient was able to walk freely for at least 1.5 years after fracture healing and had no signs of osteonecrosis. The presence of a nonunion at 6–12 months postoperatively or any change in neck position was considered a failure of internal fixation. A subchondral fracture (a crescent line), loss of sphericity of the femoral head and segmental collapse were considered to represent osteonecrosis and were also considered failures. Patients were followed up by taking serial radiographs every 3 months for a minimum follow-up period of 2 years (range 24–41 months).

Statistical analysis

The rates of AVN and fracture union were analyzed with respect to the potential predictor variable (time from injury to fracture reduction). Patients were stratified into two groups depending on whether they had undergone early or late fixation: group A included 12 patients (40%) treated with early fixation (≤ 12 h) and group B included 18 patients (60%) treated with late fixation (<12 h).

The prevalence of nonunion and AVN was compared between the two groups with the use of a *t*-test and analysis of variance.

Results

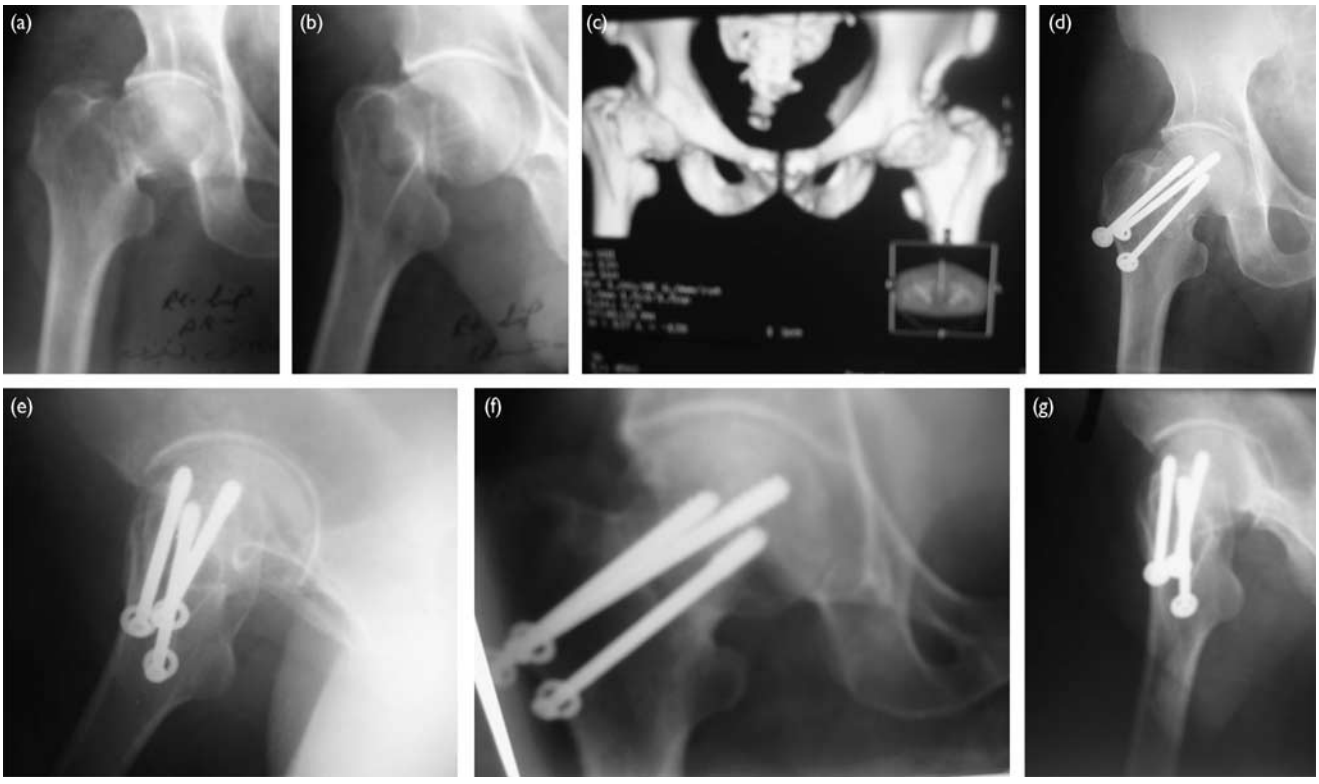
The average age of the patients at the time of injury was 61.92 years (range 56–73) in the early fixation group and 67.56 years (range 57–77) in the late fixation group. There were seven female patients (58.34%) in the early fixation group and 10 (55.56%) in the late fixation group.

There were eight cases (66.67%) of displaced fractures of the femoral neck in the early fixation group (12 patients) and 11 cases (61.1%) of the same in the late fixation group (19 patients).

The average time lag between injury and surgery in the early fixation group was 10.5 h (range 6–12) and 54.72 h (range 13–144) in the late fixation group (Table 3).

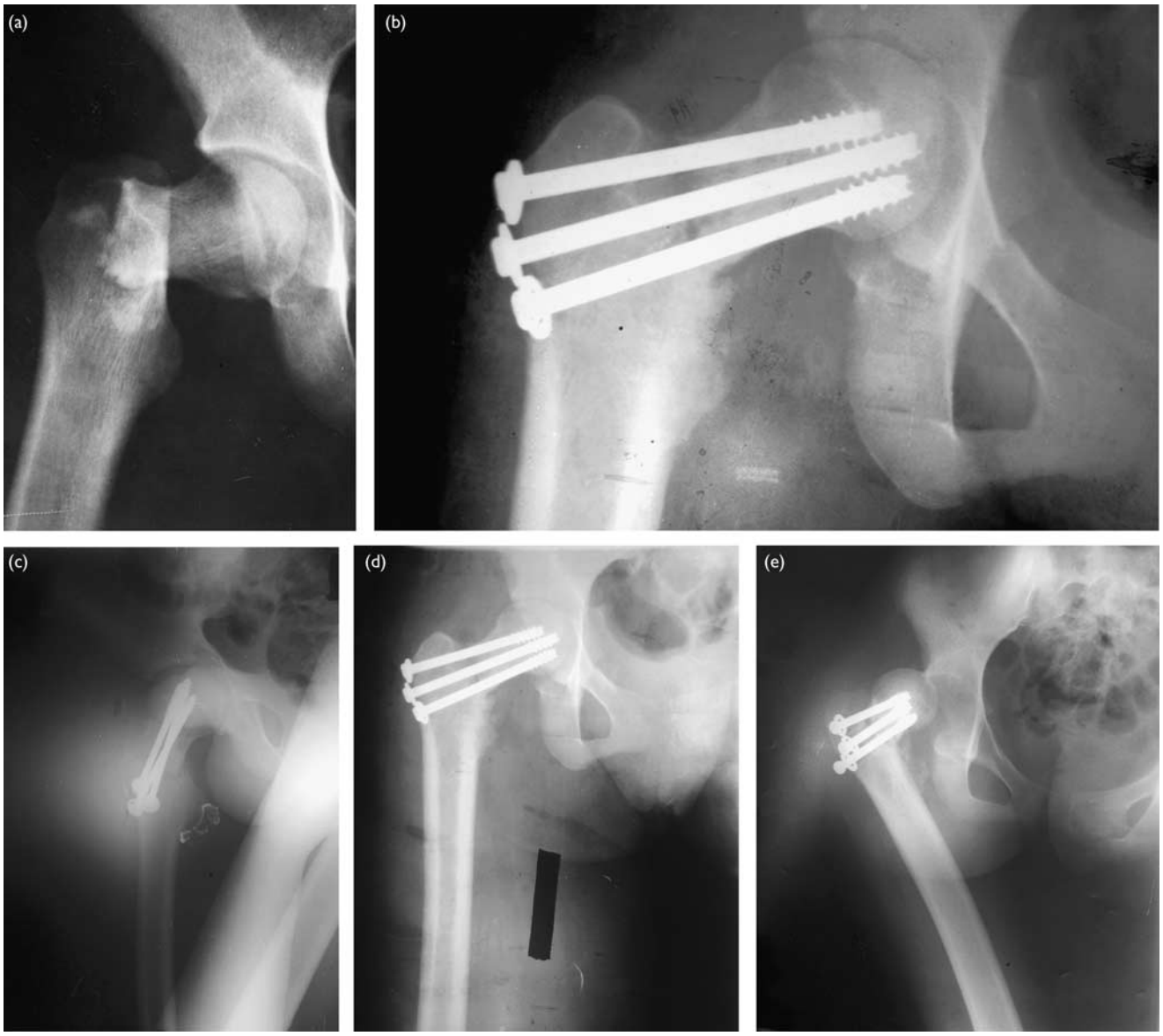
Anatomical reduction could be achieved in 17 of the 19 displaced fractures (89.47%) (Figs 1 and 2). In the

Figure 2



(a) Anteroposterior (AP), (b) lateral radiographs, and (c) computed tomography views showing a displaced Garden III right femoral neck fracture in a 65-year-old man. (d, e) AP and lateral views after internal fixation with cannulated hip screws. (f, g) At 31 months, AP and lateral views showing complete healing of the fracture with satisfactory results.

Figure 3



(a) Preoperative radiograph showing a displaced right femoral neck fracture in a 66-year-old woman. (b, c) Immediate postoperative anteroposterior (AP) and lateral radiographs 96 h after injury. (d) Five weeks postoperative radiograph. (e) At 2 months, AP radiograph of the hip showing loss of reduction and lateral migration of the hip screws with dislocation of the hip. The patient was made to undergo total hip arthroplasty.

remaining two cases (10.53%), the reduction was in varus position and was less than Garden index 160/180, with improper placement of the screws (Fig. 3). In contrast, all undisplaced fractures were reduced in slight valgus position as close as possible to a Garden index of 170/180 [20]. Fixation of all fractures was carried out using three cancellous 6.5/16 or 32 mm screws *in situ* (Fig. 4).

Clinical results

Pain

In the 22 united fractures, there was no hip pain at final follow-up in 20 hips (66.67%), whereas a slight ache after prolonged standing, not limiting the patient's activity, was encountered in two hips (6.67%). Moderate to marked pain that limited the patient's daily activity was encountered in eight failed hips (26.67%) (Table 4).

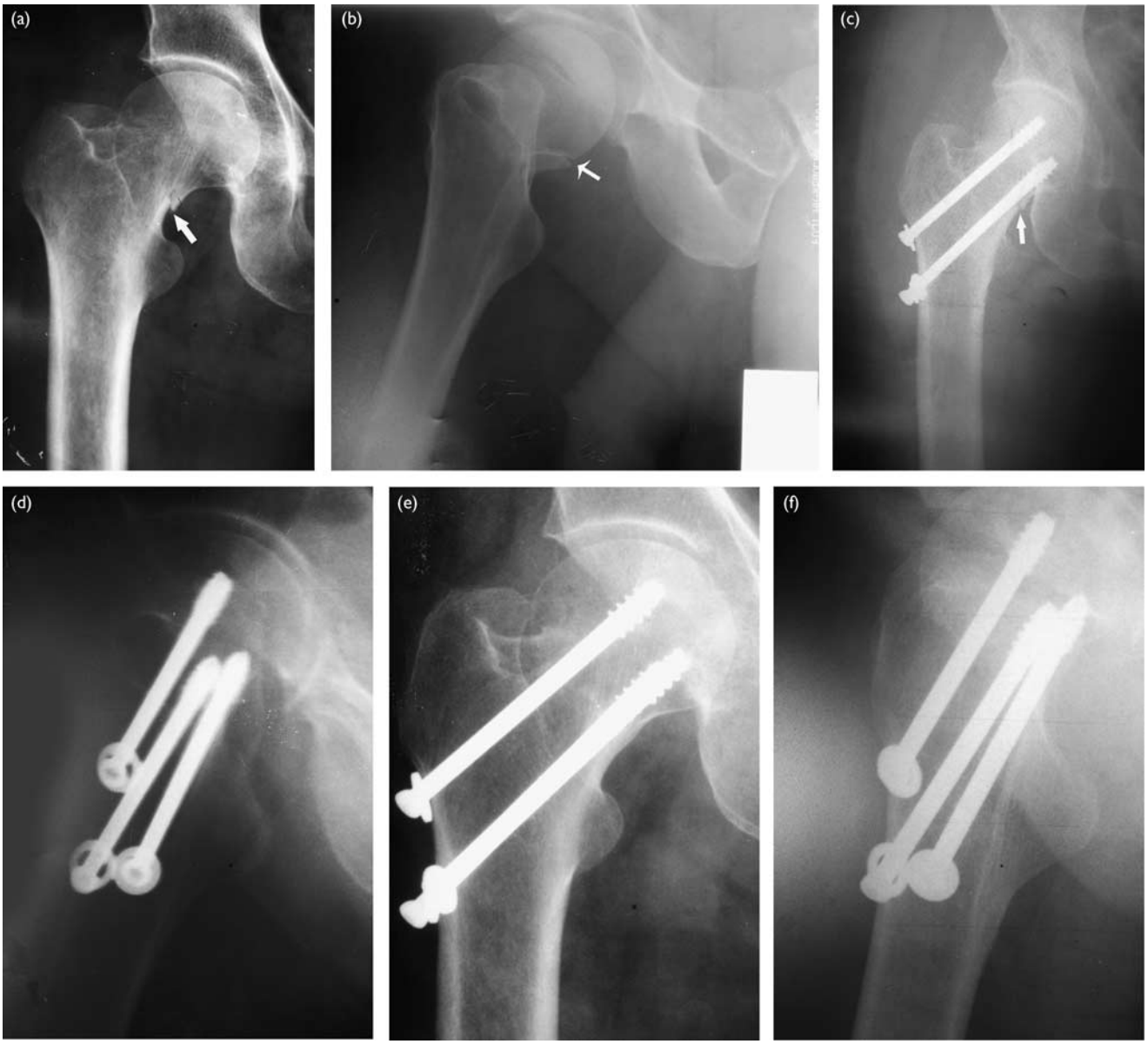
Union

Bony union of the fracture site occurred in 22 patients (73.33%) within a mean period of 86.81 days (range 60–128). The Harris Hip Score [19] was determined for all these patients and averaged 86 points at final follow-up (range 71–90 points).

Failure

The fracture failed to unite or a loss of reduction and AVN were encountered in eight patients (26.67%). All these patients had displaced fractures that were fixed late (< 12 h) and were above 65 years of age. Among them, one patient had a loss of reduction and dislocation of the

Figure 4



A 61-year-old female patient who had an undisplaced fracture of the right femur (Garden II) after a fall. (a, b) Anteroposterior (AP) and lateral radiographs of the right femoral neck after admission to the hospital (6 h after initial injury). (c, d) Immediate postoperative AP and lateral radiographs showing fixation of the fracture with three cancellous screws *in situ*. (e, f) AP and lateral radiographs of the right femoral neck 36 months after surgery showing healing of the fracture with no evidence of avascular necrosis.

hip joint within the first 6 weeks because of early weight bearing and improper placement of the screws (Fig. 3), and another patient was found to have Ficat stage IV osteonecrosis of a large portion of the femoral head at about 6 months [18] (Fig. 5). In addition, six patients developed AVN within the first year. All these eight patients were made to undergo a total hip arthroplasty.

Radiological results

Avascular necrosis

The minimum follow-up period was 2 years (range 24–41 months). All patients were assessed for the development of radiographic evidence of AVN of the femoral head. The incidence of these complications was statistically higher in cases of displaced fractures. The relation between the type of fracture and avascuar necrosis is shown in Table 5.

Table 4 Pain component of the 30 patients with femoral neck fractures managed by cancellous screw fixation

	Union					
	No + avascular necrosis		Yes		Total	
Residual pain	Count	%	Count	%	Count	%
Ignores	–	–	20	66.67	20	66.67
Mild	–	–	2	6.67	2	6.67
Moderate or marked	8	26.67	–	–	8	26.67
	8	26.67	22	73.33	30	100

Fisher's exact test = 0.0052 significant.

Figure 5

(a) Radiograph of the right hip joint showing a displaced femoral neck fracture in a 70-year-old man. (b, c) Immediate postoperative anteroposterior (AP) and lateral views 72 h after injury. (d, e) AP and lateral view radiographs showing avascular necrosis of the femoral head and nonunion at the fracture site 6 months after closed reduction and internal fixation.

Table 5 Relation between the type of fracture and avascular necrosis

	Sum of squares	Degree of freedom	Mean square	*F*-value	Significance
Between groups (undisplaced and displaced)	28.09	2 – 1 = 1	28.09	17.02	0.01 (S)
Within groups (undisplaced and displaced)	46.21	30 – 2 = 28	1.65		
Total	74.30	30 – 1 = 29			

S, statistically significance difference between displaced and undisplaced fractures.

Fracture union

No statistically significant difference between the type of fracture and duration of fracture union was observed (Table 6).

Factors affecting the results

Age at time of surgery

To determine the effect of age, the patients were divided into two groups as follows: patients aged 56–65 (18

Table 6 Relation between the duration of fracture union and type of fracture

	Sum of squares	Degree of freedom	Mean square	*F*-value	Significance
Between groups (undisplaced and displaced)	20.14	1	20.14	0.63	NS
Within groups (undisplaced and displaced)	895.11	28	31.96		
Total	915.25	29			

Analysis of variance: no statistically significance difference between type of fractures (displaced and undisplaced) and duration of fracture union.

Table 7 Duration of fracture union in relation to the age group in 30 patients with femoral neck fractures internally fixed with three cancellous screws

	Sum of squares	Degree of freedom	Mean square	*F*-value	Significance
Between groups (56–65 and 66–77 years)	64.55	1	64.55	7.11	0.01 (S)
Within groups (56–65 and 66–77 years)	254.24	28	9.08		
Total	318.79	29			

Analysis of variance by using Scheffe's test.
S, statistically significance difference between two age groups.

Table 8 Duration of fracture union in relation to sex in 30 patients with femoral neck fractures internally fixed with three cancellous screws

Sex	*N*	Mean	SD	*t*-value
Male	13	66	13.19	0.31 (NS)
Female	17	64.71	9.86	

NS, no statistically significant difference.

patients, 60%) comprised group A and those aged 66–77 years (12 patients 40%) comprised group B. The incidence of complications was statistically higher in patients above 65 years of age (group B). The relation between the duration of fracture healing among the two groups is shown in Table 7.

Sex

The patient's sex had no effect on the degree of duration of fracture union. No statistically significant difference was observed (Table 8).

Timing of surgery

A statistically significant difference was observed in terms of duration of fracture union and occurrence of AVN with regard to the timing to fixation (early vs. late). The occurrence of complications was statistically lower in the early fixation group (Table 9).

Type of fracture

The type of fracture (undisplaced vs. displaced) was a statistically significant factor affecting the occurrence of AVN (Table 5).

Type of trauma

As regards the type of trauma (road traffic accident and fall), no statistically significant difference was observed (Table 10).

Discussion

Despite tremendous advances in the science and practice of orthopedic surgery as well as anesthesia and pre-operative care, repair of displaced fractures of the neck of the femur is still associated with complications in up to one-third of patients. The risk of nonunion, and of osteonecrosis in particular, is virtually the same today as what it was in the 1930s. Recent data from well-designed outcome studies indicate that the most predictable, durable and cost-effective procedure for an active elderly patient with a displaced femoral neck fracture is total joint arthroplasty; however, not all patients are candidate for this procedure, and the potential complications of arthroplasty, including mortality, may be more difficult to manage and more severe than those associated with internal fixation. The laudable goal of obtaining fracture healing and maintaining a viable femoral head can be successfully achieved in a number of patients [21–25].

Evidence from the literature on the effect of timing of surgery on outcomes after intracapsular hip fractures is conflicting [14]. Swiontkowski *et al.* [26] achieved good results and reported that their results were at least partially related to the short time interval between the occurrence of fracture and reduction. Tooke and Favero [16] reported similar results by achieving the best possible reduction and fixation of most fractures on the day of the injury. Jain *et al.* [13] suggested that the rate of AVN might be higher when reduction and fixation is delayed for more than 12 h after a subcapital hip fracture.

Osteosynthesis preserving the head of femur is an emergency procedure and needs to be performed within 6 h [27]. In previous studies, some authors reported that there was no difference in outcomes between fractures fixed within 24–72 h, whereas others reported that the incidence of nonunion and AVN for early or late fixation were statistically significant [14,28].

In this study, a 12-h time interval between injury and surgery was considered as the demarcation between early and late surgery, as this duration is considered to be a reasonable period of time for the patient to be admitted to hospital, investigated and prepared for surgery and for an operating room to be available [13,16]. The results of the present study suggest that the rate of nonunion and AVN and time of fracture union were higher when reduction and fixation is delayed for more than 12 h after injury.

Table 9 Relation between time of surgery and duration of fracture union

	Sum of squares	Degree of freedom	Mean square	*F*-value	Significance
Between groups (early and late)	17.32	2 – 1 = 1	17.32	13.01	0.01 (S)
Within groups (early and late)	37.27	30 – 2 = 28	1.33		
Total	54.59	30 – 1 = 29			

Analysis of variance by using Scheffe's test.
S, statistically significance difference between early and late groups.

Table 10 Relation between fracture union and type of trauma

	Sum of squares	Degree of freedom	Mean square	*F*-value	Significance
Between groups (RTA and fall)	12.02	1	12.02	0.17	NS
Within groups (RTA and fall)	1979.6	28	70.7		
Total	1991.62	29			

Analysis of variance: no statistically significance difference between type of trauma (fall and RTA) and duration of fracture union.
RTA, road traffic accident.

In the present study, the cutoff point for follow-up was 2 years. Alho *et al.* [29] reported that after internal fixation with cannulated screws a duration of 3 months was critical for planning rehabilitation, and most failures occurred within this time period. Two years is also a reasonable period of time for AVN of the femoral head to develop, although it can occur even after 2 years [30].

The incidence of nonunion and early redisplacement has been reported as being ~5% for undisplaced fractures and 21–32% for displaced ones [16,31,32].

AVN has been reported to occur in 10% of undisplaced intracapsular fractures and in 12–16% of displaced intracapsular ones [31–34].

In a meta-analysis of 18 published studies, the overall incidence of nonunion was reported to be 50/564 (8.9%) and that of AVN to be 130/564 (23.0%) [14]. Moreover, many reports in the literature have declared a higher incidence of AVN in displaced fractures when compared with undisplaced ones [14,16,26].

In the present study, the fracture failed to unite, had a loss of reduction and developed AVN in eight patients (26.67%). All eight patients had displaced fractures, were above 65 years of age and had undergone fixation after 12 h from injury (late fixation).

The other factors that affected the results in this study were: the quality of reduction achieved during surgery, placement of the screws, fixation technique used and age of the patients. It is well documented in the literature that the adequacy of reduction attained with displaced femoral neck fractures affects the rates of nonunion and AVN [5,14,20]. Garden [20] demonstrated that AVN increased from 7 to 65% when the alignment index was less than 155° or more than 180° in either the AP or lateral view.

In the present study, anatomical reduction of the fracture was achieved in 17 of the 19 displaced fractures (89.47%), and in the remaining two cases (10.53%) the reduction was in the varus position (Fig. 3). This reduction position was not in accordance with the Garden alignment index and resulted in nonunion and AVN.

Keating *et al.* [35] recently compared reduction and internal fixation with hemiarthroplasty and total hip arthroplasty in patients older than 60 years of age with displaced femoral neck fractures. In their study, at the 2-year follow-up, the rate of reoperation in the internal fixation group was 39% compared with 5% in the arthroplasty groups. Frihagen *et al.* [36] also reported that among people above 60 years of age, arthroplasty is associated with better functional outcome, higher health-related quality of life, and more independence compared with internal fixation. In the present study, all united fractures (22 cases, 73.33%) were associated with a better functional outcome. The occurrence of AVN was significantly higher in the group of patients above 65 years of age (eight cases, 26.67%). All patients were made to undergo total hip arthroplasty.

Conclusion

The results of the present study suggest that the rate of nonunion and AVN was affected by a delay of more than 12 h before fixation of femoral neck fractures in patients above the age of 55 years. Other factors such as age, type of the fracture, anatomical reduction of the fracture, and placement of the screws might be more influential in determining the rate of AVN after such fractures. Thus, in this age group, the optimal treatment should be individualized depending on the fracture pattern, displacement, preoperative ambulation, disability, general health status of the patient, and time between injury and fixation.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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