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**Place of Residence before and Place of Discharge after Femoral Neck Fracture Surgery
Are Associated with Mortality: A Study of 1238 Patients with at Least Three Years'
Follow-up**

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ABSTRACT

Background: Femoral neck fractures constitute a major public health challenge. The risk of death after surgery depends chiefly on the patient's general health and comorbidities. No studies assessing place of residence are available. The objectives of this study were to determine whether mortality differed according to the patient's previous place of residence and to the place of discharge, and to describe the complications occurring after femoral neck fracture surgery.

Hypothesis: After femoral neck fracture surgery, the place of discharge is associated with the risk of death, and the complication rate is high.

Methods: This single-centre retrospective study included 1241 adults who sustained a true femoral neck fracture between 2006 and 2016 and were followed-up for at least 3 years. The following data were collected: age at the time of the fracture, sex, hospital stay length, place of residence before and after the fracture, characteristics of the fracture, type of treatment, time from the fracture to surgery, and whether anticoagulant therapy was given. We then recorded data on mortality and complications.

Results: The 3-year mortality rate was $36.0 \pm 1.4\%$ (95%CI, 33.3-38.7). Place of residence before the fracture was strongly associated with mortality: the risk of death was higher in patients who lived in care homes (hazard ratio [HR], 2.18) or were hospitalised (HR, 1.78) and lower in patients who lived at home (HR, 0.46). The risk of death was also higher in patients discharged to care homes (HR, 1.82) or to hospitals (HR, 1.90) and lower in patients discharged home (HR, 0.30). All these differences were statistically significant ($P < 0.0001$).

Conclusion: Place of residence and likely place of discharge should be evaluated as soon as the patient is admitted to the emergency department, in order to provide the best information possible to the patient and family and to establish the most appropriate treatment strategy. Patient self-sufficiency is a major parameter that should be preserved to the extent possible.

Level of evidence: IV

Key words: Femoral neck fracture. Mortality. Risk factors. Morbidity. Place of residence.

1. Introduction

Femoral neck fractures (FNFs) constitute a major public health challenge. They belong to the group of proximal femoral fractures (PFFs), which accounted for 94 382 hospital admissions between 2008 and 2009 in France. Among these PFFs, 64% were true FNFs.

FNFs occur chiefly in women (76.4%) who are elderly, have osteoporosis, and experience a low-energy trauma such as a fall from standing height [1]. In young patients, in contrast, FNFs are usually caused by high-energy trauma [2,3]. The population in France is aging steadily, with about 9.5% individuals older than 75 years on 1 January 2020 and a projection that this proportion will have increased to 12% by 2023. Consequently, the incidence of FNFs is rising steadily. In 2009, there were 42.5 cases per 10 000 individuals older than 55 years, and 50% of these cases affected individuals aged 80 to 89 years [4]. The risk of death is high, with, in 2009, 5.3% of women and 10% of men dying within 1 month after the fracture and 23.5% of women and 32.9% of men dying within the first year [5][6][7]. Age older than 70 years and male sex are risk factors for excess mortality, with risk increases of 27% after 1 year and 25% after 10 years [7][8]. The medical stakes are high when managing these patients, but so are the economic stakes, given the steady increase in the cost of treating FNFs. Thus, in the US, the cost rose from over 13 billion dollars in 1990 to 17 billion dollars in 2002 [9][10][11][12].

The risk of death depends chiefly on the patient's general health and comorbidities. These factors often determine whether discharge is to the patient's home or to a specialised care facility. To our knowledge, no studies have sought to determine whether mortality is associated with the place of discharge after the surgical procedure. Such a study would help to tailor the information given to the patient and family to each individual situation.

The objectives of this study were to determine whether mortality differed according to the patient's previous place of residence and to the place of discharge, and to describe the complications occurring after FNF surgery. Our working hypothesis was that, after FNF

surgery, the place of discharge is associated with the risk of death, and the complication rate is high.

2. MATERIAL AND METHODS

Study design

We conducted a single-centre retrospective study of patients who were older than 18 years with closed physes and who underwent surgery for a true FNF between 1 January 2006 and 31 December 2016. Only patients with at least 3 years of follow-up after the fracture were included. We excluded patients with other lower limb fractures or with a basicervical or trochanteric fracture. Patients whose vital status after 3 years was unknown were to be excluded (this did not occur in practice). Information on vital status was obtained from the patient's files, the family and usual doctor; if these methods failed, online vital records and the town hall of the patient's place of residence were consulted.

We included consecutive patients with a true FNF, regardless of age and of type of treatment (functional, internal screw fixation, arthroplasty, resection of the neck).

Case ascertainment

We searched the hospital database for patients admitted between 2006 and 2016 and assigned a code for the main diagnosis corresponding to an FNF in the ICD-10. The files of these patients were reviewed to determine whether our inclusion criteria were met. All radiographs taken on the date of the diagnosis were read by an independent observer to confirm the diagnosis of true FNF. These radiographs were used to determine the type of fracture in the Garden [13] and Pauwels [14] classifications.

For each patient, we collected age at the time of the fracture, sex, date of birth, and date of the fracture. We also recorded the following information relevant to the admission: date and time of arrival at the emergency department, hospital length of stay, place of residence before the admission, and place of discharge. Data on the fracture and surgical procedure included the side involved and the type of treatment (functional, internal fixation, hemiarthroplasty [HA], total hip arthroplasty [THA], or resection of the femoral head and neck). The case notes and radiographs were then reviewed to obtain information on the complications identified during surgery, within 6 weeks after surgery (early complications), and more than 6 weeks after surgery (late complications). Complications included local adverse events (orthopaedic, infection, thromboembolism), systemic adverse events, surgical revision, and secondary displacement of the fracture or material.

Patient assessment and follow-up

Our primary endpoint was the 3-year mortality rate. First, the hospital database and vital records were searched. Then, each patient was contacted, re-evaluated, or seen by the usual doctor.

Statistical analysis

The data were analysed using Stata v15 software (StataCorp, College Station, TX, USA). The curves were plotted using Excel™ (Microsoft, Redmond, WA, USA) and Addinsoft (2020) XLSTAT (Long Island, NY, USA). All tests were two-tailed, and *p* values below 0.05 were considered statistically significant. To describe the population, qualitative and categorical variables were expressed as *n* (%) and continuous variables as mean±SD.

Comparisons of complication rates were with the chi-square test (or Fisher's exact test where appropriate) for categorical variables and Student's test (or the Mann-Whitney test when the distribution was not normal) for continuous variables.

Overall survival was assessed by plotting survival curves according to Kaplan-Meier, with the date of the fracture as the start date and death as the end date; for survivors, the data were censored on the date information was last obtained. Comparisons of survival across groups were with the log-rank test for categorical variables and a Cox model for continuous variables. A multivariate analysis of survival was then conducted by building a Cox model and adjusting on clinically relevant criteria or criteria identified by the univariate analysis. The hazard ratios (HRs) with their 95% confidence intervals (95% CIs) were computed. Schoenfeld residuals were used to check that the proportional hazards assumption was met. These survival analyses were censored at 3 years.

2. RESULTS

1. Study patients

Of 1745 identified patients, 507 were excluded because they did not meet our inclusion criteria, usually because they had erroneously coded trochanteric fractures. The remaining 1238 patients were included. No patient was lost to follow-up for the main criteria (vital status and place of discharge). The treatments are shown in **Figure 1**: 901 (72.6%) patients underwent arthroplasty, including 205 (16.5%) who had THA and 696 (56.0%) who had HA; 159 (12.8%) patients were managed by functional treatment; 157 (12.6%) patients had internal fixation by triangulated screws; 13 (1.1 %) underwent resection of the head and neck; and 11 (0.9%) died before the surgical treatment.

Of the 1238 included patients, 882 were women and 356 were men. Mean age at surgery was 77.3 ± 14.4 years (range, 20.2-102.2 years) (**Table 1**). Only 177 (14.3%) patients were younger than 60 years. **Figure 2** illustrates the distribution of the patients by age at the time of the fracture and by sex.

The right side was involved in 592 (47.8%) patients. **Figure 3** depicts the distribution of the patients by fracture type: 191 (16.5%) patients were Garden 1, 42 (3.6%) were Garden 2, 134 (11.6%) were Garden 3, and 786 (68.0%) were Garden 4. The mean Pauwels angle was $47.2^\circ \pm 14.4^\circ$ (range, 8° - 84°). The mean time from the fracture to death was 3.2 ± 3.6 years (range, 0-12.7 years).

Of the 1238 patients, 32 (2.6%) were hospitalised at the time of the fracture, 12 (1.0%) were in convalescence centres, 967 (78.1%) lived at home, and 214 (17.3%) lived in care homes.

2. Outcomes

2.1. Place of discharge

Figure 4 shows the place of residence of the patients before the fracture and the place of discharge. Whereas over three-quarters of the patients initially lived at home, less than one-quarter were able to return home directly. The differences in places of residence before and after surgery were statistically significant ($p < 0.0001$).

2.2. Mortality according to the place of residence before the fracture and to the place of discharge

The place of residence before the fracture was strongly associated with mortality. Thus, the HRs were 2.18 for patients living in care homes and 1.78 for those already hospitalised, indicating an excess risk of death. In contrast, patients who lived at home were at lower risk for death (HR=0.46).

Similarly, the risk of death was higher in patients discharged to care homes (HR=1.82) or to a hospital (HR=1.90) and lower in patients discharged home (0.30). **Figure 5** is the survival curve according to place of discharge. The 3-year mortality rate was $36.0 \pm 1.4\%$ (95%CI, 33.3-38.7). **Table 2** reports the data on the risk of death according to the place of residence before the fracture and to the place of discharge.

We performed an analysis of the possibly more vulnerable subgroup of 641 patients who lived at home at the time of the fracture but were discharged to a convalescence centre (n=533), a care home (n=55), or a hospital (n=53). These patients lost part of their self-sufficiency due to the fracture. We compared them to the 214 patients living in care homes before the fracture (i.e., having little self-sufficiency) and to the 383 other patients (probably having good self-sufficiency). In the 641 patients who lost self-sufficiency, 231 died, yielding a 3-year mortality rate of 36.1% (95%CI, 32.3-39.8). This 3-year mortality rate was significantly higher than in the most self-sufficient patients (24.3%; 95%CI, 20.0-28.6; $p < 0.001$) and significantly lower than in the patients initially in care homes (54.7%; 95%CI, 48.0-61.4; $p < 0.001$). These data are depicted in **Figure 6**.

2.3. Complications within the first 3 years

The overall 3-year complication rate (deaths excluded) regardless of treatment type was 21.6% (95%CI, 0.20-0.24). Thus, complications occurred in 268 patients.

Intra-operative complications occurred in 17 (1.4%) patients and consisted in 12 greater trochanter fractures, 1 calcar fracture, 1 femoral cortex perforation, 1 forgotten gauze pad, and 2 systemic complications, namely, thromboembolism and ischemic stroke. All 17 complications occurred during the implantation of a prosthetic hip.

Complications occurred after surgery in 251 (20.3%) patients. Among them, 17 experienced both an early complication (within 6 weeks) and a late complication (after 6 weeks).

There were 196 (15.8%) early complications: secondary displacement, n=92; surgical-site infection, n=24; dislocation, n=11; major haematoma requiring surgical revision, n=4; sciatic nerve deficit (common fibular nerve), n=5; limb ischaemia, n=2; peri-prosthetic fracture, n=5; distal femoral fracture, n=1; heterotopic calcifications, n=2; tibial fracture, n=1; deep vein thrombosis, n=3; pulmonary embolism, n=7; lower respiratory tract infection, n=5; respiratory insufficiency, n=6; urinary tract infection, n=5; anticoagulant overdoses, n=2; acute pulmonary oedema, n=6; acute urinary retention, n=3; subdural hematoma, n=2; cerebrovascular accident, n=5 (including 1 case of transient ischaemic attack); bowel obstruction, n=1; arrhythmia, n=1; acute coronary syndrome, n=1; heel eschar, n=1; and *Clostridium difficile* intestinal infection, n=1.

After 6 weeks, 153 (12.4%) late complications were recorded: contralateral FNF, n=91 (including 2 in patients who had had an infection of the first hip); infections, n=8; secondary displacement, n=17; hip osteoarthritis, n=2; peptic ulcer disease n=1; osteonecrosis, n=9; malunion, n=6; peri-prosthetic fracture, n=6; delayed sciatic deficit, n=1; dislocation, n=3; non-union, n=3; heterotopic calcifications, n=2; implant loosening, n=2; pulmonary embolus, n=1; and peripheral occlusive arterial disease, n=1.

Surgical revision was required in 157 (12.4%) patients.

No significant risk factors for overall complications according to place of discharge were identified ($p=0.158$). In contrast, when the late complications (>6 weeks) were analysed separately, significant variations were apparent according to place of discharge ($p=0.001$): the relative risk of having a complication was 1.65 for patients discharged to care homes and 0.27 for those discharged to hospitals.

4. DISCUSSION

In our study, the mortality rate in the overall population of patients with true FNFs was 36.0% at 3 years and 68.8% at 10 years. These high rates are comparable to those reported by others [16]. The original feature of our study is that it highlights an excess risk of morbidity and mortality associated with certain places of discharge. Mortality was lower in the patients who lived at home and were discharged home. Patients who lived in care homes, in contrast, had marked excess mortality at 3 years. Similarly, patients coming from a hospital or discharged to a hospital, who had a heavy comorbidity burden, also had a higher mortality rate. These data may help to explain the seriousness of the situation to the patient and family. The other factors associated with higher mortality were a Garden 4 fracture, implantation of a prosthesis (most notably bipolar hemiarthroplasty), and blood transfusion during the hospital stay. Surprisingly, mortality was not higher in patients with bilateral fractures or post-operative complications.

Late complications were more common in patients discharged to care homes and less common in those discharged to hospitals. This finding supports a need for close monitoring of the most vulnerable patients with a preference for discharge to a hospital when appropriate. It also raises questions about pressures to constantly decrease the mean stay length in hospitals, with the attendant economic issues. However, this specific point was not evaluated in our study.

Regarding patient autonomy, we found that patients living in care homes and therefore having only limited self-sufficiency before the fracture, had a higher mortality rate. The same was true of patients who lived at home before the fracture but were discharged to a medical centre, indicating a somewhat less severe loss of self-sufficiency. These findings can help to inform the patient and family and should encourage us to maintain as high a degree of autonomy as possible in these fragile patients.

In the literature, older age and male sex are risk factors for death after an FNF [16][15][17][18]. Schroder and Erlandsen reported that male sex was a risk factor only after 70 years of age and that in younger patients there was no difference between the two sexes [6]. We found no difference between males and females. Age in our cohort was similar to that in other studies of FNFs. In keeping with a report by Holmberg et al., the place of residence played a key role: the risk of death was increased 3- to 4-fold among patients living in institutions (care homes and hospitals), with a 16% survival rate after 6 years compared to 54% in patients living at home [7]. In this study, blood transfusion was a risk factor for death at 10 years but not at 2 years of follow-up. In the literature, other authors such as Ercin *et al.* identified blood transfusion as associated with a higher 2-year mortality rate [4][19][20][21].

Complications were experienced by more than 1 in 5 patients (21.6%). This finding underscores the vulnerability of this patient population. A randomised controlled trial by Tol *et al.* compared THA to HA in patients aged 70 years or older who had a displaced FNF but no major cognitive impairments, hip osteoarthritis, rheumatoid arthritis, or metastases [22]. Follow-up was 12 years. Survival was similar to that in our study, with 20% of patients still alive after 12 years. No significant differences existed between the two groups regarding the Harris Hip Score, the revision rate, or the complication rate. Tol *et al.* advocated cemented HA for displaced FNFs in patients aged 70 years or older [22]. Other studies support this conclusion, such as the randomised controlled trial by Avery *et al.* [23]. Others, however, do not support a preference for HA over THA. For instance, Ravikumar *et al.* found better functional outcomes after THA [24] and Keating *et al.* recommended THA rather than internal fixation [25]. Bekerom *et al.* had a preference for HA over THA in patients aged 70 years or older [26].

Our study has several limitations. The retrospective design complicated the collection of some of the data. Power for the long term analysis was limited, since the number of patient

decreased year on year during the 3-year minimum follow-up. Some of the patients lost to follow-up may have died. The high mortality rate undoubtedly masked the occurrence of delayed complications. The surgeons and management modalities changed over the 10-year inclusion period; thus, functional treatment has been almost completely abandoned in our department for several years [27]. The high post-fracture complication rate and the very high surgical revision rate in the group treated functionally bias the results, notably regarding the association between the Garden type and the risk of complications. In this study, we included all patients with FNFs to obtain a broad picture of this condition. However, this undoubtedly influenced our findings by attenuating the effects of problems related to fragility fractures, dependency, and the place of residence, particularly in elderly patients. Nevertheless, we were able to determine the distribution of young and elderly individuals among patients with FNFs and to obtain a global vision of this condition.

Despite these limitations, our work examined a large cohort of patients and demonstrated that the outcome of FNF depended chiefly on the pre-operative evaluation of patient-related risk factors and on making the therapeutic decision best suited to each individual patient, with strong emphasis on preserving autonomy whenever possible. This work is necessary and carries high medical, social and economic stakes given the year on year increase in the number of patients with FNFs and the aging of the population [28].

5. CONCLUSION

An evaluation of patients as soon as they arrive at the emergency room is critical to provide appropriate information to the patient and family and to develop the treatment strategy best able to minimise risks in each individual patient, with multidisciplinary input.

The main goal in these patients is probably a return to normal function as soon as possible with interventions as needed to allow discharge to the home.

Conflicts of interest

None of the authors have any conflicts of interest related to the study.

SB is a consultant for Zimmer.

SD is a consultant for SERF, EUROS, and Depuy.

GV was a consultant for FH Orthopedics.

None of the other authors has any financial conflicts of interest to disclose.

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Contributions of each author

RE contributed to develop the project, collect the data, perform the statistical analysis, draft the article, and revise the article for important intellectual content.

GV contributed to develop the project, draft the article, and revise the article for important intellectual content.

SD contributed to develop the project and revise the article for important intellectual content.

SB contributed to develop the project and revise the article for important intellectual content.

FIGURE LEGENDS

Figure 1: Patient flow diagram

Figure 2: Age distribution at the time of the fracture

Figure 3: Distribution of the fractures in the Garden classification

Figure 4: Place of residence of the patients before the fracture and place of discharge after surgery

Figure 5: Kaplan-Meier survival curve according to place of discharge

Conval: convalescence

Figure 6: Kaplan-Meier survival curve according to place of discharge; $p < 0.001$

Table 1: Main features of the included patients

POPULATION (1238)	n (%)	Mean	SD	Range
Sex				
Female	882 (71.2%)			
Male	356 (28.8%)			
Age at fracture (years)		77.3	14.3	20.2-102.2
<60	177 (14.3%)			
≥60	1061 (85.7%)			
Side involved				
Right	592 (47.8%)			
Left	646 (52.2%)			
Garden Classification				
1	191 (16.5%)			
2	42 (3.6%)			
3	134 (11.6%)			
4	786 (68.0%)			
Indeterminate (pre-operative radiographs unavailable)	82 (6.6%)			
Place of residence before the fracture				
Home	967 (78.1%)			
Care home	214 (17.3%)			
Hospitalised	45 (3.6%)			
Convalescence centre	12 (1.0%)			
Place of discharge				
Home	305 (24.6%)			
Care home	268 (21.6%)			
Hospitalised	85 (6.9%)			

Convalescence centre	553 (44.7%)			
Died during the hospitalisation	27 (2.2%)			
Treatment				
Functional	158 (12.8%)			
Died before treatment	11 (0.9%)			
Surgical:	1069 (86.3%)			
Internal fixation	157 (12.7%)			
Head and neck resection	13 (1.1%)			
Arthroplasty	899 (72.6%)			
HA	694 (56.1%)			
THA	205 (16.6%)			
Time to surgery (days)		2.1	2.6	0.0-37.0
Time to death (years)		3.2	3.6	0.0-15.1

HA: hemi-arthroplasty; THA: total hip arthroplasty

Place of residence before surgery	Hazard Ratio for death	<i>p</i> value
Home	0.46 95%CI[0.39-0.53]	<0.0001
Care home	2.18 95%CI[1.85-2.57]	<0.0001
Convalescence centre	1.30 95%CI[0.68-2.52]	0.79
Hospital	1.78 95%CI[1.28-2.49]	0.001
Place of discharge	Hazard Ratio	<i>p</i> value
Home	0.30 95%CI[0.24-0.37]	<0.0001
Care home	1.82 95%CI[1.56-2.13]	<0.0001
Convalescence centre	1.07 95%CI[0.93-1.23]	0.34
Hospital	1.90 95%CI[1.49-2.44]	<0.0001

Table 2: Risk of death according to place of residence before the fracture and to place of discharge

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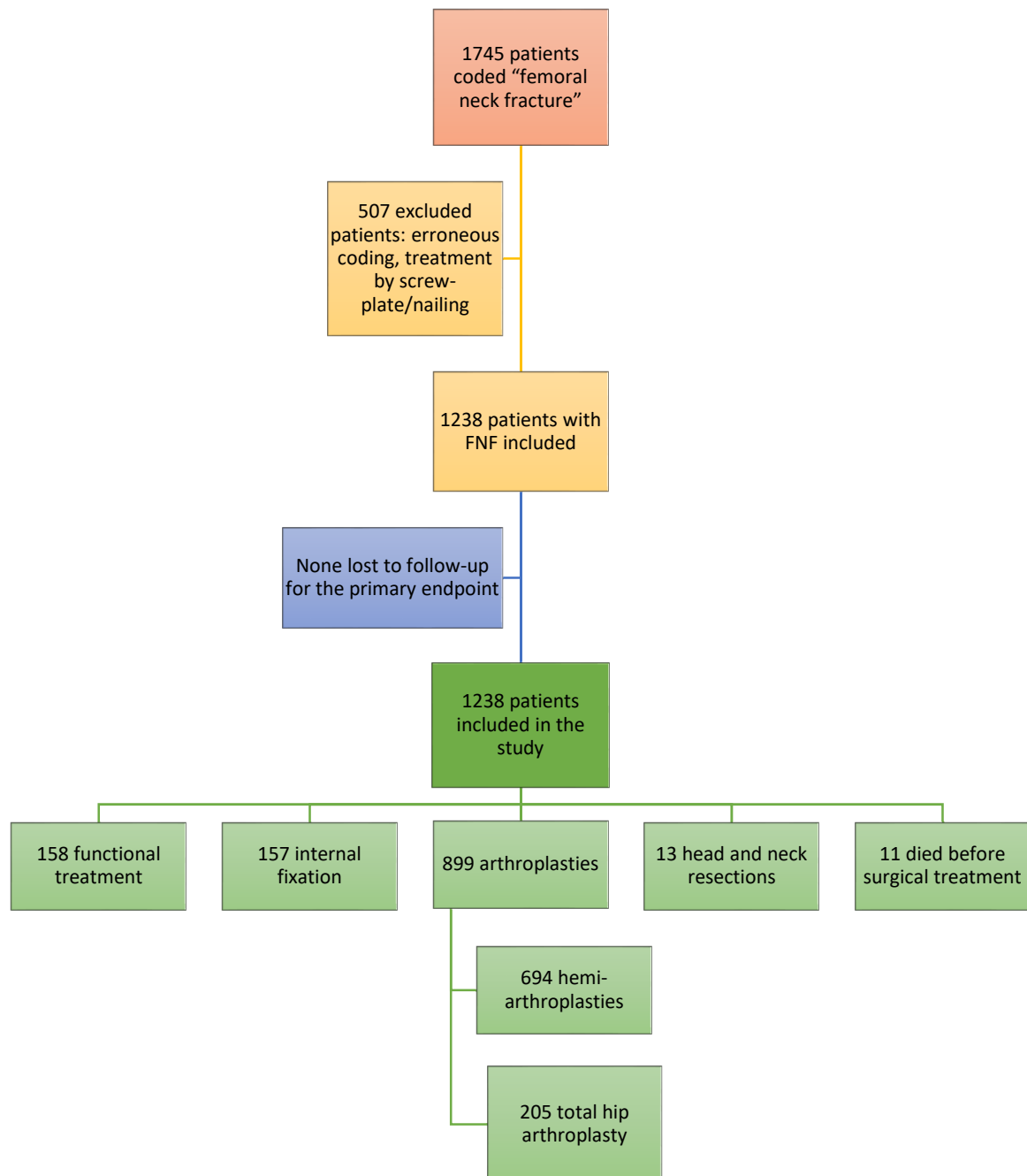
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Figure 1:



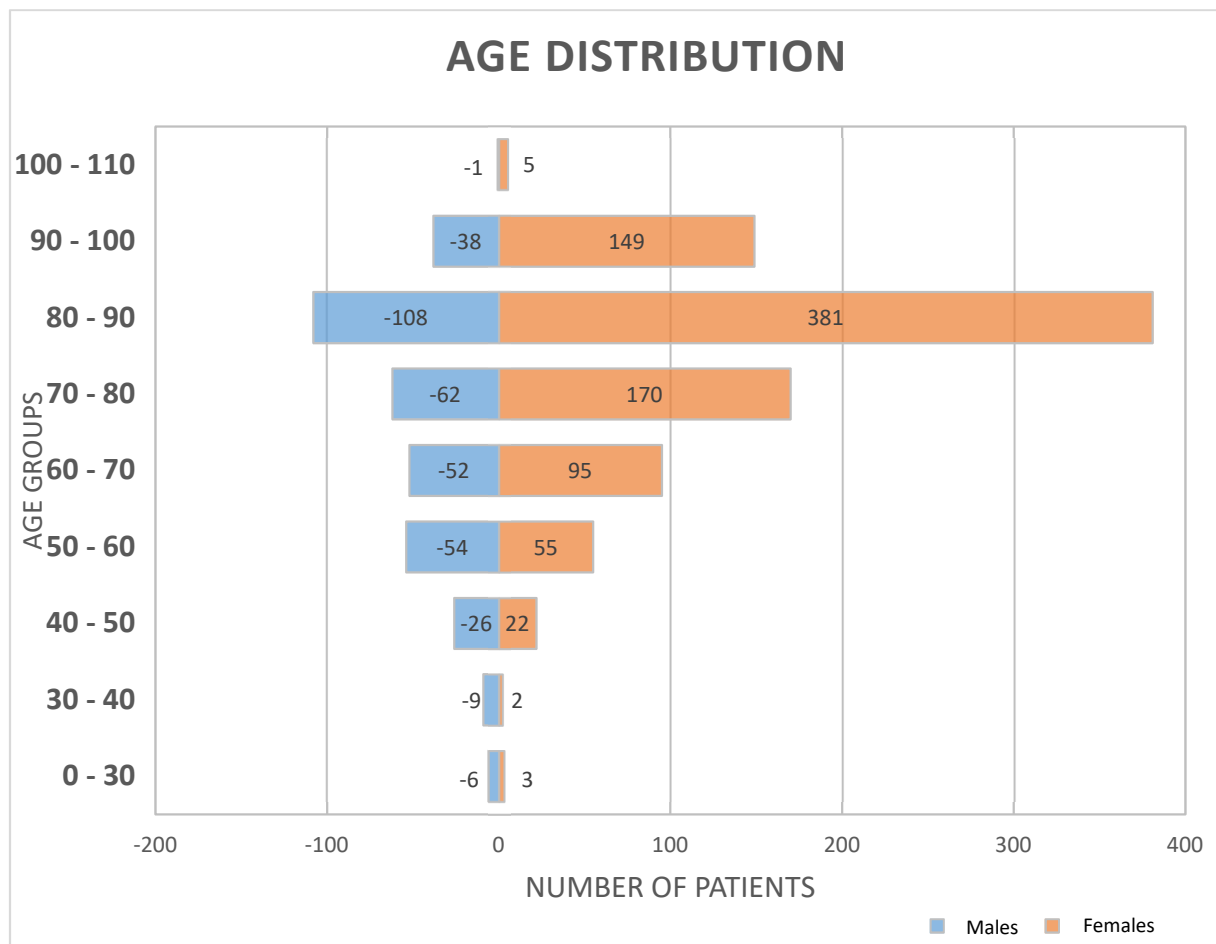


Figure 2:

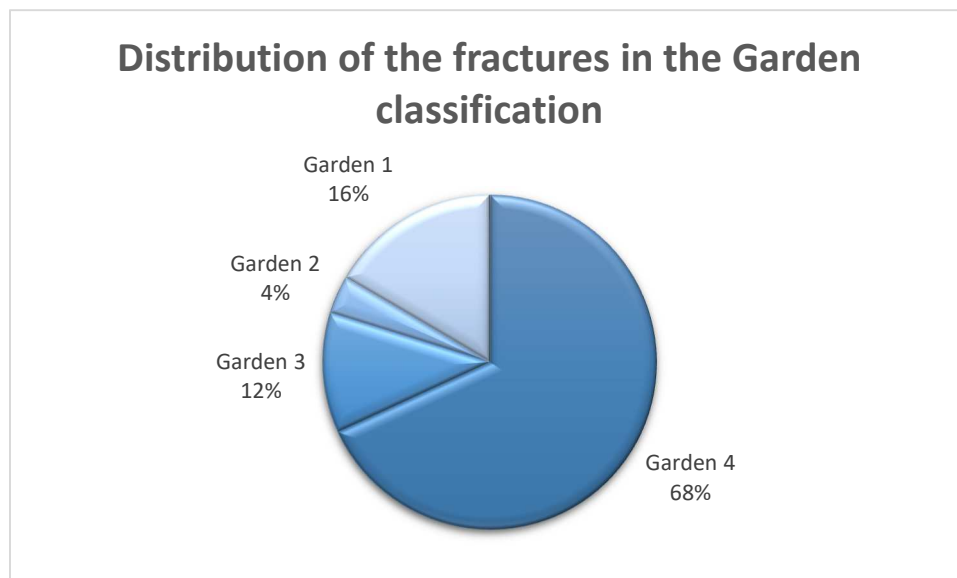


Figure 3:

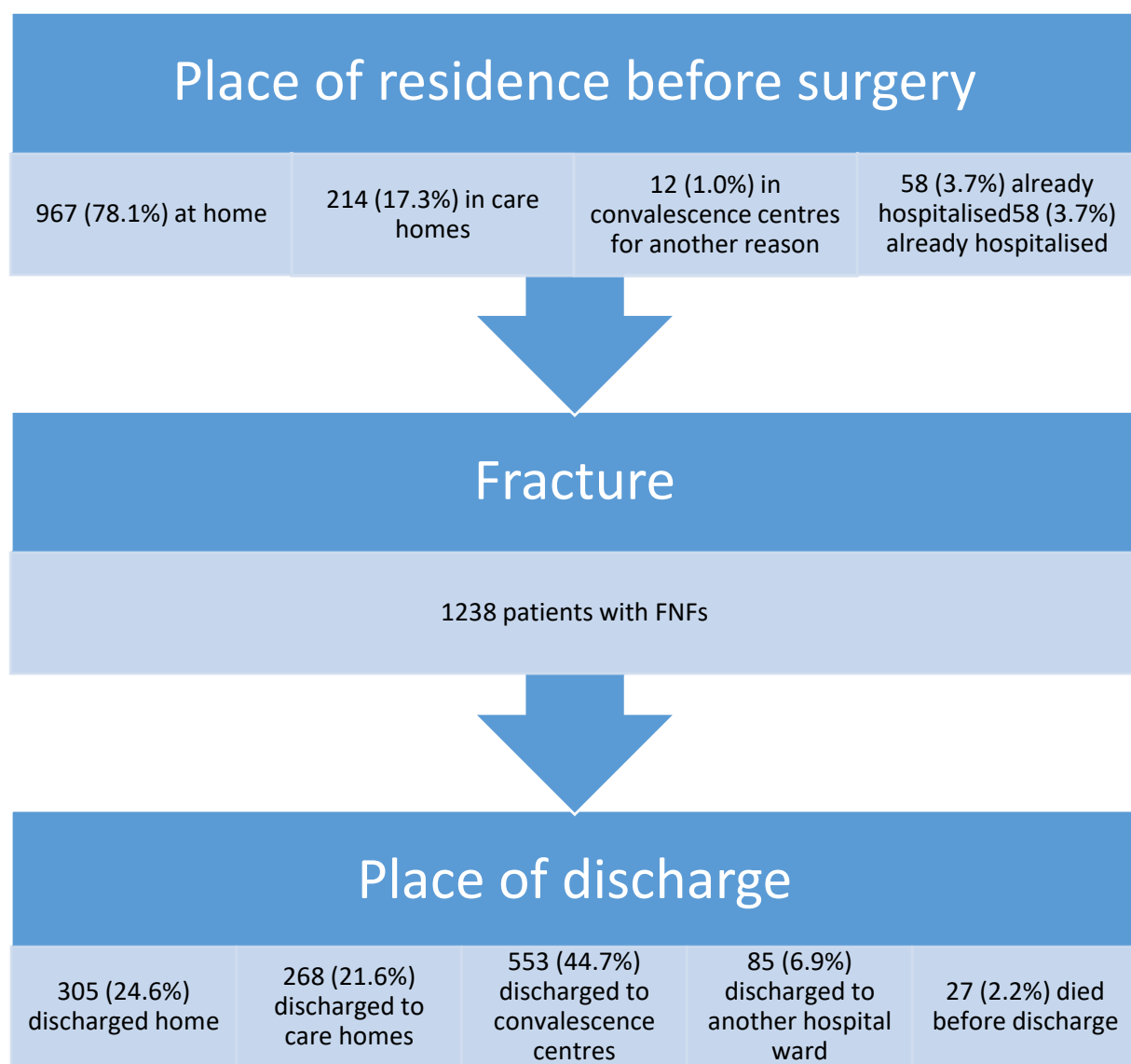


Figure 4:

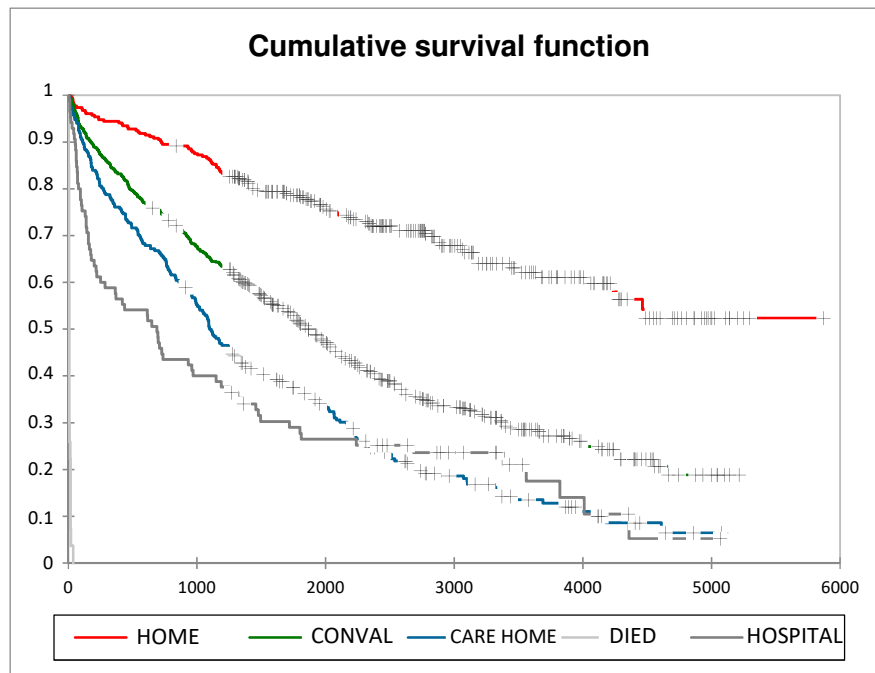


Figure 5 :

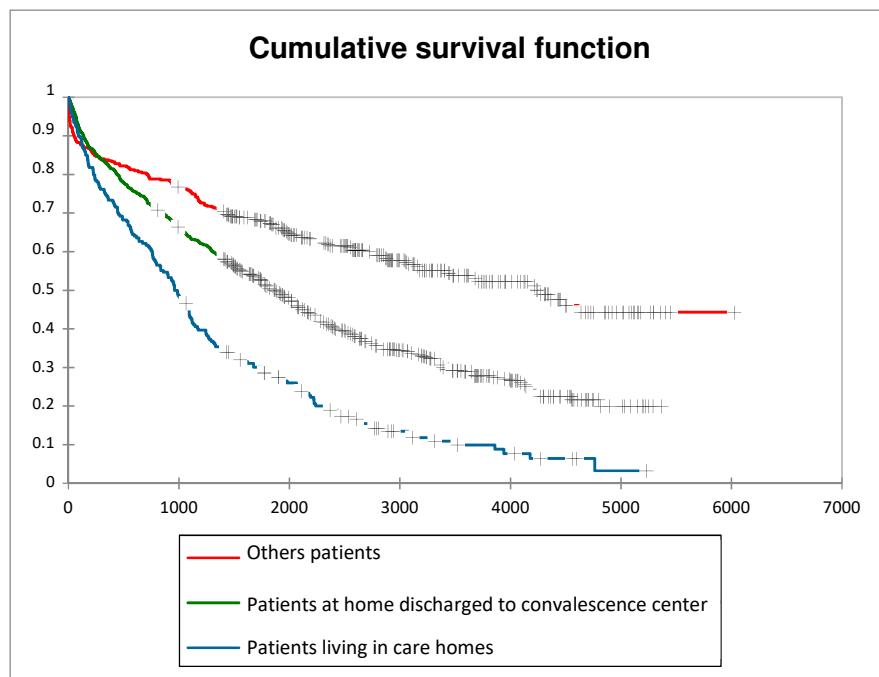


Figure 6 :