

RESEARCH ARTICLE

Mortality Rates and Forensic Causes after Hip Fracture: A Retrospective Observational Study

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Abstract

Objectives: Despite the widely recognised high mortality rate among patients with hip fracture, the variation in death rates by gender and cause has been less explored. This study aimed to investigate mortality rates and causes of death in patients who underwent hip fracture surgery, and to compare them with those of the general population. A secondary objective was to compare the results of Internal Fixation versus Arthroplasty in these patients.

Methods: A population-based study collected records of 356 consecutive cases of hip fracture. For comparison purposes, data from the general population were also collected, which included residents of Adana city of 65 years and older. Causes of mortality were classified as cancer, dementia, heart disease, lung disease, and digestive disorders, among others. The average follow-up period was 4.2 years, ranging from 0 to 5 years.

Results: 105 (29.49%) of the surgical patients perished in one year. At the end of the follow-up, $n = 308$ (86.52%) of the hip fracture patients had died. Age-adjusted mortality rates after hip fracture surgery were higher for men than for women, with a risk ratio (HR) of 1.48 and a 95% confidence interval (CI) between 1.07 and 2.15. Complications from heart, lung, or blood vessel diseases were the leading causes of death after hip replacement surgery, followed by Alzheimer's disease and dementia. Men were more susceptible to respiratory diseases, cancer, and heart and blood vessel diseases than women. After hip fracture, both the overall mortality rate and the gender-standardised death rate were three times that of the general population for each cause of death.

Conclusion: During the study period, the mortality risk for hip fracture patients was three times that of the general population for the primary causes of death.

Level of evidence: IV

Keywords: Cause of death, Gender differences, Hip fractures, Long-term follow-up, Mortality rate

Introduction

Hip fractures in the elderly are an important public health problem, causing significant morbidity and mortality. These fractures, often resulting from falls, have a profound impact on the health and well-being of the elderly, resulting not only in physical disabilities, but also in psychological suffering and a reduction in quality of life. Despite advances in medical treatment and surgical techniques, mortality rates remain alarmingly high, highlighting a critical area of concern in geriatric health care. This high mortality rate associated with hip fractures is a challenge for health systems around the world, which requires ongoing research and improvement in treatment

strategies.¹

Although studies have extensively analysed acute and short-term mortality after hip fracture, there is a significant gap in understanding long-term mortality and its various determinants, especially after surgery.^{2,3} The long-term consequences of hip fractures extend well beyond the initial recovery period, affecting the overall life expectancy and long-term health of patients. These consequences are multifaceted, including not only the direct effects of fractures and surgery, but also the indirect effects on patient mobility, independence, and mental health. Recognising the divergence in mortality rates between

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genders and understanding the main causes of death after hip fracture surgery are crucial steps in improving patient care.⁴ This aspect of research is vital because it can lead to the development of targeted interventions and personalised care plans that address the specific needs and risks associated with different demographic characteristics of patients. Such tailor-made approaches are increasingly recognised as essential in providing effective healthcare, particularly in the treatment of conditions that predominantly affect older adults.

Research on the differential impact of gender on mortality outcomes after hip fracture has revealed significant findings. Studies indicate that men may experience higher mortality risks due to complications from cardiovascular disease, respiratory illness, and cancer compared to women.^{5,6} This gender disparity in mortality rates points to underlying biological, physiological, and possibly social factors that influence health outcomes in men and women differently. Understanding these differences is key to developing gender-specific strategies for prevention, treatment, and rehabilitation.

Additionally, the forensic causes of death, a categorisation of the medical reasons that directly lead to mortality, remain underexamined in hip fracture patients.^{7,8} This knowledge gap is significant as it limits the understanding of direct medical causes leading to increased mortality in this population. Investigating these causes in more detail could provide valuable insights into the specific health challenges faced by hip fracture patients and help develop more effective strategies to address these challenges.

Furthermore, there is a scarcity of comparative data on how these mortality rates align with those of the general population, especially when standardised for age and gender.² These comparative studies are essential to understand the inherent risks faced by patients with hip fracture relative to the general population. This understanding is crucial for assessing the effectiveness of current treatment protocols and for identifying areas where additional resources and attention are needed.

The present study aims to fill these research gaps by examining mortality rates and forensic causes of death in a cohort of patients who underwent hip fracture surgery. This examination will involve a detailed analysis of patient records and mortality data, focussing on identifying patterns and trends that could inform better patient care.⁹

A comparative analysis will be carried out to delineate how these rates and causes differ from those observed in the general population. This comparison is crucial, as it will provide a benchmark against which risks associated with hip fractures can be measured. Understanding these differences is essential for developing strategies to reduce the risk of mortality and improve overall outcomes for patients with hip fracture.

Furthermore, this study will explore the differential outcomes of internal fixation versus arthroplasty in the treatment of hip fractures. This aspect of the study is particularly important, as it contributes to the ongoing discussion about the most effective surgical techniques to treat hip fractures.⁹ By comparing the results of these two common surgical approaches, the study aims to provide

information that can guide surgeons in choosing the most appropriate treatment for individual patients.

The present study aims to determine that this analysis is pivotal in identifying high-risk groups and tailoring postoperative care to mitigate the long-term risk of mortality, hence improving the quality of life and survival rates for hip fracture patients. The insights gained from this study will be invaluable in forming clinical practice and shaping future research in the field of geriatric orthopaedics. By advancing our understanding of the factors that contribute to mortality in patients with hip fractures, this research aims to contribute to the development of more effective treatment and management strategies, ultimately improving patient outcomes and reducing the burden of hip fractures in individuals and healthcare systems.

Materials and Methods

This retrospective study was approved by the local ethics committee of the University Hospital on 20 July 2023 (approval number: 2711). All patients included in the study provided their informed consent before participating. The study was carried out according to the ethical standards in the Declaration of Helsinki and its subsequent amendments.

The study initially reviewed 402 patients who underwent hip fracture surgery at Adana Seyhan State Hospital, targeting the Adana population from January 1, 2017, to January 1, 2023. Only those aged 65 and above at the time of surgery were considered. Due to missing death information for 37 patients (5 men and 32 women) and lost fracture type data for 11 individuals (1 male and 10 females), the final analysis included 356 patients, ensuring comprehensive data integrity for the study's conclusions [Figure 1].

The inclusion criteria for this study were patients 65 years and older who underwent hip fracture surgery at Adana Seyhan State Hospital during the study period. Exclusion criteria were incomplete data on death information and types of fractures.

Hip fractures were classified as cervical or trochanteric according to the original radiographic images. The demographics of the patients, including age and sex, were recorded. The presurgical comorbidities and nature of surgery were drawn from the original patient data. Population data was stratified into three age groups (65-73, 75-84, and 85 years and older).

Information on the causes of mortality was obtained from the Turkish Statistical Institute.¹⁰ No identifiable patient data or images were used in this study. Cause-of-death statistics include the cause of death, age, sex, marital status, and other demographic factors, as well as information on diseases that result in death.¹⁰

Incorporating National Data for Contextual Depth: To provide a robust context for our study, we have integrated the latest available data from the Turkish Statistical Institute (TUIK), focusing on the 2022 "Death and Causes of Death Statistics." This integration is pivotal, especially considering our study meticulously documented 356 hip fracture cases over a period from January 1, 2017, to January 1, 2023. By comparing our findings with national mortality rates and causes of death, we aim to offer a nuanced understanding of the health landscape in Turkey, especially in relation to mortality trends among hip fracture patients.¹⁰

The study design was observational, focussing on mortality rates and causes after hip fracture surgery. Interventions or treatments were the surgeries undergone for hip fractures and their outcomes were measured based on mortality data.

In conducting this study, it is imperative to elucidate the integration of comorbid conditions into our analysis while comparing mortality rates and causes of death between patients who have experienced a hip fracture and the general population. Given the independent influence that comorbid conditions prevalent in the elderly population may exert on mortality rates, our research employs a standardized dataset from the general population, meticulously adjusted for demographic and clinical characteristics such as age, gender, and existing health statuses. This approach allows for the calculation of age-specific mortality rates that are corrected for comorbid conditions, thereby facilitating a more accurate assessment of the increased mortality risk observed in patients with hip fractures, in the context of these comorbid conditions. This clarification not only enhances the reliability of our findings but also underscores the critical importance of considering the impact of comorbid conditions when interpreting the

increased mortality risk associated with hip fractures.

The risk of mortality for hip fracture patients was assessed on January 1, 2017, the last day of the follow-up period. To classify causes of death, the International Statistical Classification of Diseases and Related Health Problems (ICD10) was used.¹¹

Measurement methods involved analyzing mortality data, classifying causes of death, and comparing them with the general population. The preoperative comorbidities were grouped in a similar way. The general population mortality rate was evaluated from January 1, 2017, to January 1, 2023, as recorded on December 31, each year.

The statistical analysis included chi-square analyses for demographic characteristics and Cox's proportional hazards model for mortality rates. The duration of follow-up was measured in calendar days and represented in person years, beginning on the date of the procedure and ending on the date of mortality or the conclusion of the follow-up. The results are presented as hazard ratios (HR) with confidence intervals (CI) of 95%. The statistical software used was SAS System for Windows, version 9.1. A p-value of less than 0.05 was considered statistically significant.

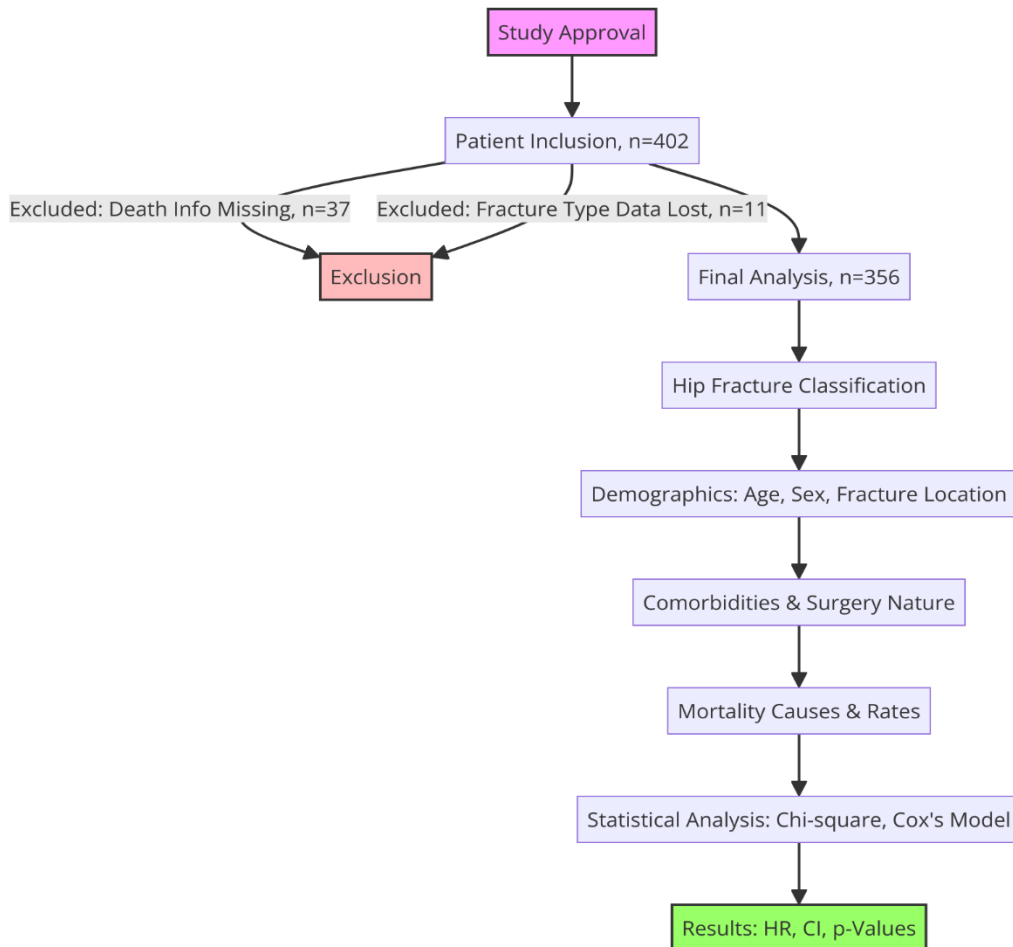


Figure 1: Study Design

Results

Our comprehensive retrospective study, spanning from January 1, 2017, to January 1, 2023, meticulously documented 356 hip fracture cases, diligently monitored until June 30, 2023. This extensive period allowed for an average observation duration of 4.2 years, presenting a broad range from immediate post-operative outcomes to a maximum of 5 years, thereby offering a robust dataset for analysis. The cohort predominantly consisted of women

(72.5%), illustrating a notable gender disparity in hip fracture incidence, with women not only forming the majority but also presenting at an older average age compared to men (76.2 years for women versus 71.0 years for men, $p < 0.001$), as detailed in [Table 1]. This significant age difference underscores potential gender-specific risk factors and outcomes in hip fracture patients [Figure 2].

Table 1. Patient Characteristics, Mortality Rate, and p-Values

Characteristic	Total (n=356)	Men (n=98)	Women (n=258)	p-Value
Average Age (years)	74.9	71.0	76.2	$P < 0.001$
Fracture Location	Neck - 65%, Other - 35%	Neck - 62%, Other - 38%	Neck - 67%, Other - 33%	$P > 0.05$
Arthroplasty Surgery	49%	48%	50%	$P > 0.05$
Osteosynthesis Surgery or Internal Fixation Surgery	51%	52%	50%	$P > 0.05$
Death Location	Hospital - 62%, Home - 2%, Other - 1%	Hospital - 60%, Home - 2%, Other - 1%	Hospital - 63%, Home - 2%, Other - 1%	$P > 0.05$
Deaths at 30 days	39	12	27	$P > 0.05$

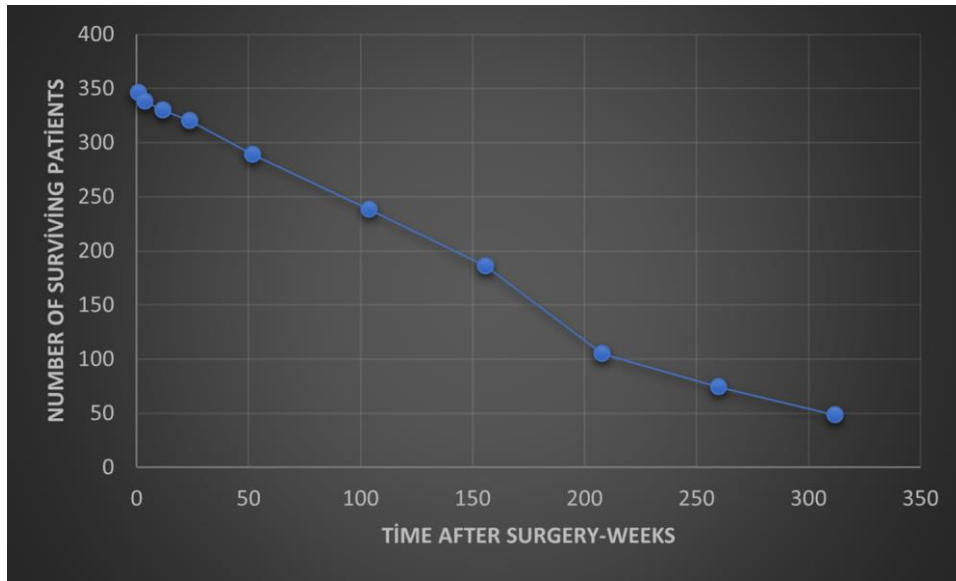


Figure 2. Graph of Mortality Rates Over Time

The investigation into fracture locations and surgical interventions revealed a balanced distribution between arthroplasty and osteosynthesis surgeries, highlighting the tailored approach to patient care based on individual medical needs rather than a one-size-fits-all methodology. Importantly, the mortality locale data indicated a predominant hospital setting for the demise of these patients, a critical insight into the potential complications and care requirements of this vulnerable population post-surgery.

Our findings also delved into the immediate and long-term mortality post-surgery, revealing a staggering 86.5%

mortality rate by the end of the follow-up period. The primary causes of death evolved over time, with circulatory system diseases, dementia, Alzheimer's, lung diseases, cancer, and digestive system diseases leading the fatal outcomes, as systematically categorized in [Table 2]. This pattern emphasizes the multifaceted nature of health risks following a hip fracture, necessitating a comprehensive care approach.

In Table 3, we present a detailed comparison of postoperative complications between arthroplasty and osteosynthesis surgery types [Table 3]. The incidence of infection was slightly higher in osteosynthesis surgeries (6%) compared to arthroplasties (5%), though the

difference was not statistically significant ($p>0.05$). Similarly, venous thromboembolism showed a minor variation between the two surgery types, with arthroplasty cases reporting a 4% incidence rate compared to 3% in osteosynthesis, again without statistical significance ($p>0.05$).

Acute renal failure and cardiac complications were equally distributed across both surgery types, each reported at a

rate of 2% and 3%, respectively, further indicating no significant difference in the risk of these complications post-surgery ($p>0.05$). Pneumonia rates were also comparable, with a slightly higher incidence in osteosynthesis surgeries (5%) versus arthroplasties (4%), not reaching statistical significance ($p>0.05$).

Table 2. Cause of Death, Mortality Rate, and Hazard Ratio

Cause of Death	Total Deaths (n=308)	Percentage	HR (Men)	95% CI (Men)	p-Value (Men)	HR (Women)	95% CI (Women)	p-Value (Women)
Circulatory system	129	41.88%	1.6	1.3 - 2.7	>0.005	1.2	1.0 - 1.6	>0.05
Dementia & Alzheimer's	42	13.64%	1.2	0.95 - 1.45	0.51	1.3	1.1 - 1.7	>0.05
Lung disease	41	13.31%	2.0	1.1 - 4.1	>0.005	1.7	1.3 - 2.6	>0.05
Cancer	27	8.77%	2.0	1.1 - 4.3	>0.005	1.5	1.2 - 2.2	>0.05
Digestive system	13	4.22%	1.3	1.0 - 1.9	0.15	1.4	1.1 - 2.0	>0.05
Other	56	18.18%	1.4	1.1 - 2.0	0.09	1.5	1.2 - 2.2	>0.05

Table 3. Comparison of Postoperative Complications by Surgery Type

Complication	Arthroplasty (%)	Osteosynthesis Surgery (%)	p-Value
Infection	5	6	P>0.05
Venous Thromboembolism	4	3	P>0.05
Acute Renal Failure	2	2	P>0.05
Pneumonia	4	5	P>0.05
Cardiac Complications	3	3	P>0.05

This comparative analysis underscores the similar safety profiles of both surgical approaches concerning the most common postoperative complications. However, the nuanced differences, albeit non-significant, highlight the importance of tailored post-operative care protocols to mitigate specific risks associated with each surgical type. These findings align with our broader study objectives, emphasizing the critical role of personalized medical

strategies in improving outcomes for hip fracture patients.

The nuanced understanding of long-term functional outcomes and rehabilitation success further enriched our study's findings, highlighting the critical role of age and gender in recovery trajectories, as meticulously documented in [Table 4].

Table 4. Long-term Functional Outcomes and Rehabilitation Success

Outcome	Total (%)	Men (%)	Women (%)	Age <75 (%)	Age 75+ (%)	P-Value
Full Mobility Restoration	45	50	42	55	35	P<0.01
Partial Mobility Restoration	40	35	43	30	50	P<0.01
Independent in Daily Activities	60	65	58	70	50	P<0.05
Required Long-term Care	25	20	28	15	35	P<0.01
Readmission Within 1 Year	20	18	22	10	30	P<0.05

The gender-based analysis brought to light the heightened mortality risk in men during the follow-up period, a concerning trend that was consistently observed across various causes of death. This gender disparity in mortality risk, particularly pronounced in deaths due to pulmonary diseases, cancer, and cardiovascular diseases, calls for a gender-sensitive approach in post-operative care and long-term management of hip fracture patients.

The juxtaposition of mortality rates between our study cohort and the general population illuminated the starkly elevated risk faced by hip fracture patients, reinforcing the urgent need for targeted interventions aimed at mitigating these risks. The age, sex, and cause of death-standardized mortality rates offered a grim comparison, showcasing mortality rates in hip fracture patients as 2.5 to 7.4 times higher than those in the general population, a compelling

evidence of the severe impact of hip fractures on patient mortality.

Discussion

During a five-year follow-up period, the mortality rate from all causes among senior and male hip fracture patients was three times that of the national average, according to this comprehensive population-based analysis. There was a correlation between elevated mortality rates and a multitude of causes of death, such as malignant tumors, dementia, circulatory disorders, respiratory disorders, and digestive disorders. Adana, a municipality in Turkey, has divergent mortality rates compared to the country, which is considerably more expansive. The observed disparity in mortality rates between people who suffered hip fractures and the remaining participants may be accounted for by this regional heterogeneity. Male hip fracture patients had a higher incidence of substantial complications compared to their female counterparts; specifically, men maintained a higher death rate during the follow-up phase.

Men have been found to be at a greater risk of mortality from lung disease, malignant tumors, and cardiovascular disease after experiencing a hip fracture compared to women. Mortality disparities associated with post-hip fractures have received limited attention in research.¹² There have not been previous inquiries that have analyzed the correlation between gender and cause of death over an extended period of time after hip fracture surgery. Immediately after hip fracture surgery, the age-adjusted mortality rate for men was found to be greater than that for women in this study. This tendency persisted until the end of the trial. This aligns with the results of several studies.^{13,14} Men were perceived to be weaker than women at the time of the fracture.¹⁵ The precise causes of this discrepancy remain uncertain. However, an elevated incidence of challenges with daily functioning, mobility, and mobility after hip fractures may suggest a more substantial depletion of physiological reserve, hence increasing the mortality risk.¹⁴

Although our study has illuminated significant gender disparities in mortality rates following hip fracture surgery, it prompts a further investigation into the underlying social and behavioral factors contributing to these differences. Lifestyle factors, such as smoking and physical activity levels, along with differential access to healthcare services, may play pivotal roles in mediating the observed discrepancies in mortality outcomes between genders. For instance, previous research indicates that smoking prevalence and reduced levels of physical activity are more common among men, which could exacerbate postoperative complications and mortality risks.¹⁵ Moreover, disparities in accessing timely and effective healthcare may further compound these risks, particularly in men.¹⁶

Alignment with National Health Trends: Our study's findings, notably the staggering 86.5% mortality rate observed in our cohort by the end of the follow-up period, starkly contrast the general mortality trends reported by TUIK for 2022. While our findings indicate circulatory system diseases, dementia, Alzheimer's, lung diseases,

cancer, and digestive system diseases as leading causes of death, the national data highlight circulatory system diseases as the most common cause of death at 35.4%, followed by tumors at 15.2%. This discrepancy underscores the specific vulnerability of hip fracture patients to a range of post-operative complications and diseases, necessitating targeted healthcare interventions. Furthermore, the gender disparity in mortality risk, particularly pronounced in our cohort and reflected in the national data's observation of higher male mortality rates, calls for a gender-sensitive approach in healthcare planning and intervention.¹⁰

Therefore, to develop a more nuanced understanding of the mortality risk associated with hip fractures, future research should incorporate a comprehensive analysis of these social and behavioral determinants. Such an approach would not only shed light on the mechanisms driving gender disparities in mortality rates but also inform the development of targeted interventions aimed at mitigating these risks. Addressing the complex interplay of lifestyle factors and healthcare access requires a multidisciplinary strategy that encompasses healthcare policy changes, patient education, and community-based support systems designed to promote healthier lifestyles and ensure equitable healthcare access for all patients recovering from hip fractures.¹⁷

In our research, we identified variations in the causes of mortality after a hip fracture based on gender. Our research indicates that lung disease is the leading cause of death among men. Not all initial medical records contained details on smoking habits, a behavior that is notably more prevalent among elderly Turkish men.¹⁸ It is postulated that pulmonary complications increase in males subsequent to hip fracture surgery, leading to higher mortality rates. Additionally, smoking could explain the increased mortality rates in men due to malignant neoplasms. Sex and smoking have been implicated in cancer-related mortality disparities between nations, according to European studies.¹⁹ Existing literature suggests that people with compromised circulation, such as those with cardiovascular disease or Alzheimer's disease, have a greater susceptibility to hip fractures and falls.^{1,20} Additionally, inadequate blood flow can increase the mortality risk subsequent to a fracture. Likewise, those who are immobile or have osteoporosis may be more susceptible to fractures, which can lead to an elevated risk of mortality. Men who have suffered a hip fracture are at increased risk of dying from cardiovascular disease, potentially as a result of inadequate care, according to our research. The incidence of coronary heart disease among middle-aged Turkish men has reduced during the past 10–20 years.²¹ Consequently, men may be more susceptible than women to chronic and severe vascular disease.

No statistically significant disparities were observed in terms of mortality rates or etiology of death between fractures of the trochanter and neck fractures. A Greek study of 499 patients with hip fractures indicated that the 5- to ten-year death rate was higher for trochanteric hip fractures than for cervical hip fractures.²² After an average of 2.6 years of follow-up, a Danish study identified no significant differences in mortality rates between patients with cervical hip

fractures and those with per trochanteric hip fractures.²³ A potential overestimation of mortality risk in individuals with hip fractures compared to the general population is one of the limitations of our study. This is because individuals with physical and functional impairments or greater frailty are more prone to hip fractures, which can result in increased mortality rates even in the absence of a fracture. Another possible issue that may arise is the difficulty in ascertaining the "ultimate" cause of death in the presence of numerous coexisting diseases. A study of the patient's original medical records yielded information about additional health issues, which may not be completely complete or correct.

In delving deeper into the complexities of determining the ultimate cause of death in patients with hip fractures, it becomes apparent that the presence of multiple coexisting conditions significantly obfuscates this process. This ambiguity presents a considerable challenge in accurately interpreting mortality data, raising questions about the extent to which a hip fracture serves as a direct contributor to mortality or exists as a concurrent condition. The intricacies involved in distinguishing the primary causes of death are not only methodological in nature but also have profound implications for our study's conclusions.²⁴

Given the multifaceted health profiles of the elderly population, the likelihood of overlapping health issues complicates the attribution of a singular cause of death. This complexity necessitates a cautious approach in analyzing and interpreting mortality outcomes, emphasizing the need for a nuanced understanding of the contributing factors. Therefore, our findings should be considered in the context of these methodological challenges, acknowledging that the direct impact of hip fractures on mortality may be intertwined with a range of other health conditions.²⁵

Future research endeavors should strive to develop more sophisticated methodologies capable of disentangling the contributions of comorbid conditions to mortality in hip fracture patients. This may involve the use of advanced statistical techniques or longitudinal studies designed to track the progression of health status post-fracture, thereby offering clearer insights into the causal relationships between hip fractures and mortality outcomes.²⁶⁻²⁸

Limitations

Selection biases: Study participants were older individuals with hip fractures. These individuals are more likely to be frail or to have physical and functional problems than the general population. Such factors could overestimate the mortality risk associated with hip fractures, as these individuals may have higher baseline mortality risks even without fractures.

Determination of Cause of Death: The challenge of determining the "ultimate" cause of death is a significant limitation due to the potential presence of multiple coexisting conditions. Although attempts were made to accurately record the cause of death based on patient records, this approach may not accurately reflect the complex interplay of factors leading to mortality in these patients.

Limited Information: There were gaps in the information obtained from the original patient records, especially on lifestyle factors like smoking, which could be a confounding variable in our analysis. This lack of complete information can introduce a degree of uncertainty into our conclusions.

Lack of data on postoperative complications: We had no information on postoperative complications or functional recovery, which are critical factors that affect patient outcomes and mortality rates.

Regional Differences: The study was carried out on the western coast of Finland, and the results might not be applicable to other geographical locations due to varying mortality rates, healthcare systems, and population characteristics.

Single-Time-Point Assessment: The study captured a single point in time, which may not accurately reflect long-term outcomes or the dynamic health status of the elderly.

Limited Data on Different Types of Fractures: Although the study considered neck fractures and trochanteric fractures, it did not consider a detailed analysis based on the type of fracture. Future studies could address this gap by comparing the outcomes between different types of fractures.

Conclusion

In summary, our research highlights the significantly higher mortality rate across all causes among patients who suffered hip fractures over the course of the 5-year follow-up period. This rate is three times that of patients who suffered other types of fractures.

This tendency was observed in all fatal cause categories. Optimal treatment of coexisting conditions, specialized postoperative care, comprehensive rehabilitation programmes, nutritional evaluations, and the employment of specialised personnel for fracture treatment are all recommended to reduce the risk of mortality after hip fractures.²²⁻²⁵ Long-term partnerships between primary and specialised health care are also essential to extend the survival period following a hip fracture.

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Authors Contribution:

Serdar Menekse: Conceptualization, validation, writing original draft, writing review and editing, visualization, project administration.

Fatih Arslanoglu: Supervision, writing review and editing, project administration.

Hakan Zora: Conceptualization, methodology, software, formal analysis, data curation, writing review and editing.

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Declaration of Ethical Approval for Study: This study was approved by the local ethics committee of the University Hospital on 20 July 2023 (approval number: 2711). All participants gave their informed consent prior to participating in the study.

Declaration of Informed Consent: N/A (study does not include identifiable patient information).

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