

The Effect of Zinc Management on Patients with Femoral Hip Fractures

Kou Hidani ¹, Fumio Okamoto ^{2*}, Kunihiko Hirooka ³

¹Numakuma Hospital, Hiroshima, Japan

²Japan Baptist Hospital, Kyoto, Japan

³Hirooka Orthopedic Clinic, Hiroshima, Japan

*Corresponding Author Email: heuit1@gmail.com

Abstract

Hip fractures, especially femoral neck fractures, significantly burden healthcare systems with prolonged hospital stays (LOS) and high complication rates. This study examined the effects of zinc supplementation on LOS, nutritional recovery, and complications in patients undergoing surgery for femoral neck fractures. A retrospective cohort analysis compared outcomes between zinc-supplemented and non-supplemented groups. Zinc supplementation significantly increased serum zinc levels but did not directly impact LOS or complication rates. However, improved serum albumin (Δ Alb) was strongly associated with reduced LOS, emphasizing the importance of nutritional recovery. Complications, particularly infections, remained a significant determinant of prolonged LOS. These findings suggest that while zinc supplementation enhances biochemical parameters, its clinical benefits require further exploration within holistic postoperative care strategies. Future research should focus on randomized controlled trials to validate zinc's role in enhancing recovery outcomes.

Keywords

Femoral Neck Fracture, Length of Hospital Stay, Nutritional Recover, Zn Supplementation.

INTRODUCTION

Background

Hip fractures, particularly femoral neck fractures, are a growing public health concern worldwide due to aging populations. According to the Global Burden of Disease Study, the incidence of hip fractures increased by 24% from 1990 to 2019 [1]. This trend is particularly pronounced in Japan, where the aging rate is among the highest globally, leading to a sharp rise in femoral neck fractures [2] [3]. These injuries substantially burden healthcare systems, with significant costs related to surgical treatment, extended hospital stays, and rehabilitation [4].

Beyond their economic impact, hip fractures significantly affect patient outcomes, including increased mortality rates and decreased healthy life expectancy [5]. Postoperative recovery is often prolonged due to complications such as infections and poor nutritional status, particularly among elderly patients [6]. Prior studies have highlighted the role of comprehensive nutritional management in mitigating these risks, but specific interventions for hip fracture patients targeting micronutrients, such as zinc, remain underexplored [7]. Early studies also demonstrated that dietary supplementation significantly improved recovery in elderly patients with femoral neck fractures [8].

Zinc, an essential trace element, is critical in immune function, wound healing, and protein synthesis, making it a potentially valuable addition to postoperative care strategies [9].

Problems and Hypothesis

The increasing prevalence of femoral neck fractures poses significant challenges for healthcare systems. Treating these injuries requires a multidisciplinary approach involving surgery, nutritional support, and rehabilitation. However, complications, including infections often hinder recovery, delayed wound healing, and malnutrition [6][7]. These issues are particularly pronounced in elderly patients, who are more vulnerable due to pre-existing comorbidities and declining physiological reserves [5] [10].

Zinc is a crucial micronutrient that supports immune function, reduces inflammation, and promotes tissue repair [11]. Previous research has shown that zinc deficiency is common among hospitalized patients, particularly those undergoing major surgeries, and is associated with poorer outcomes [10]. Given its biological importance, zinc supplementation has been proposed as a potential strategy to enhance recovery in postoperative patients [11].

Despite these theoretical benefits, evidence of the clinical efficacy of zinc supplementation in hip fracture patients is limited. This study hypothesizes that zinc supplementation can enhance recovery outcomes by:

1. Improving serum zinc levels and overall nutritional status.
2. Reducing the frequency and severity of postoperative complications.
3. Shortening the LOS through better immune function and wound healing.

These hypotheses are grounded in existing literature, which suggests that improved nutritional markers correlate with faster recovery and fewer complications [7] [12].

However, the specific effects of zinc supplementation in the context of femoral neck fractures remain underexplored. This study seeks to address this gap by evaluating the role of zinc supplementation in improving recovery metrics such as LOS, nutritional status, and complication rates in femoral neck fracture patients.

RESEARCH AND METHODS

This study employed a retrospective cohort design to evaluate the impact of zinc supplementation on recovery outcomes in patients undergoing surgery for femoral neck fractures. Patients were selected from a single center, with data collected for two distinct cohorts: those treated in 2021 without zinc supplementation (Non-Zinc Management Group) and those treated in 2023 with zinc supplementation (Zinc Management Group).

The inclusion criteria were patients aged 65 years or older who had undergone surgical intervention for femoral neck fractures. Patients who experienced in-hospital mortality and were transferred for treatment of other conditions were excluded to ensure the homogeneity of the study population. As a result, 64 patients were included in the Non-Zinc Management Group and 59 in the Zinc Management Group, resulting in 123 patients initially screened. After applying the exclusion criteria, a final cohort of 116 patients was analyzed.

The zinc supplementation protocol involved administering Polaprezinc (17 mg/day) to the Zinc Management Group. Serum zinc levels were measured on postoperative days 1–2 and approximately three weeks later to assess the biochemical response to supplementation. Both groups received equivalent nutritional support provided by dietitians and speech-language therapists to minimize confounding effects related to general dietary care.

The study's primary outcome was the length of hospital stay (LOS), measured in days from admission to discharge. Secondary outcomes included changes in serum albumin levels (Δ Alb) during hospitalization and the incidence of postoperative complications, such as infections. Serum albumin was used as a marker of nutritional recovery, while complications were categorized based on their impact on recovery and LOS.

Statistical analyses were performed using STATA (version 17). Continuous variables were compared between groups using independent t-tests, and categorical variables were analyzed with chi-square tests. Multivariate linear regression models were employed to account for potential confounders, adjusting for factors such as age, gender, baseline nutritional status, weight, Δ Alb, and complications. The significance level was set at 5%, and a power of 80% was used to ensure adequate sample size for detecting meaningful differences.

This robust methodological approach was designed to provide insights into the clinical relevance of zinc supplementation in the recovery process of femoral neck fracture patients while controlling for potential confounders and ensuring the comparability of the two patient groups.

RESULT

Descriptive Statistics

One hundred twenty-three patients were initially included, with 64 in the Non-Zinc Management Group (2021) and 59 in the Zinc Management Group (2023). Both groups showed similar baseline characteristics, including age, gender distribution, and nutritional status at admission, with no statistically significant differences. Exclusion criteria removed patients under 65, those with in-hospital mortality, and those transferred for other treatments. The final analyzed cohort consisted of 116 patients.

Table 1. Patient Characteristics by Group

Patient Back Ground	Non-Zn Management	Zn Management
Age (years, Mean \pm SD)	89.49 \pm 6.04	87.17 \pm 6.93
Gender (Male, n)	10 (15.9%)	12 (20.3%)
Weight (kg, Mean \pm SD)	44 \pm 8.59	46.28 \pm 9.71
Base line Alb (g/dL, Mean \pm SD)	0.34 \pm 0.41	0.38 \pm 0.35
CCr (ml/min/1.73m ² , Mean \pm SD)	38.63 \pm 15.62	43.41 \pm 16.17
Diabetes Mellitus (Yes, n)	10 (15.9%)	10 (16.9%)

Zinc Levels

In the Zinc Management Group, 57 out of 59 patients had serum zinc levels measured on postoperative days 1–2 and again at approximately 3 weeks. Zinc levels significantly increased over time ($p < 0.001$, t-statistic -13.91), confirming the efficacy of zinc supplementation in restoring serum zinc status. Despite this biochemical improvement, no direct association was found between increased zinc levels and shorter LOS or reduced complication rates.

Table 2. The Change of Zink Levels

	Mean \pm Standard Deviation
Zn-POD1 (μ g/dL)	52.95 \pm 14.73
Zn-POD21 (μ g/dL)	93.3 \pm 22.24

T-test analysis for Length of Stay (LOS)

After statistical adjustments, the primary outcome, LOS, showed no significant difference between the two groups. The average LOS in the Non-Zinc Management Group was 18.2 \pm 3.7 days, while the Zinc Management Group averaged 17.9 \pm 3.5 days ($p = 0.5266$). A log transformation was applied to normalize LOS data, which was confirmed by the Shapiro-Wilk test. Despite normalization, the mean difference of 0.0425 days remained statistically insignificant.

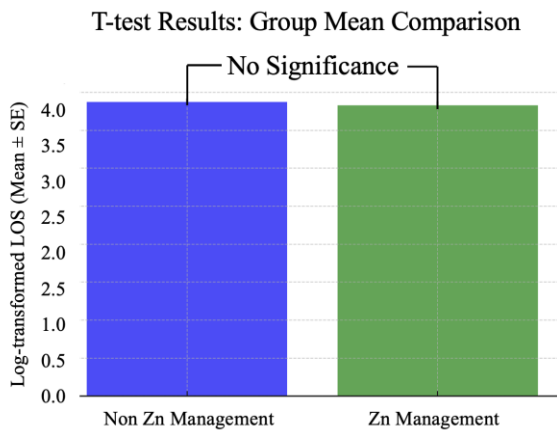


Figure 1. Log Transformed T-test for LOS

Multivariate Regression Analysis

Length of Stay (LOS)

Regression analysis accounting for confounders such as age, gender, weight, Δ Alb, waited period until surgery, and complications showed no significant relationship between zinc supplementation and LOS ($p = 0.556$).

Nutritional Improvement (Δ Alb)

The secondary outcome, Δ Alb, was significantly associated with LOS reduction ($p = 0.03$). Patients with more remarkable improvement in serum albumin levels during hospitalization experienced shorter LOS. However, the specific impact of zinc supplementation on Δ Alb was not statistically significant, suggesting that other factors, such as overall nutritional management, may play a more prominent role.

Complications

Postoperative complications, particularly infections (e.g., urinary tract infections and pneumonia), significantly increased LOS. Complications occurred in 25.0% of the Non-Zinc Management Group and 22.0% of the Zinc Management Group, with no statistically significant difference ($p = 0.40$). Multivariate analysis revealed that complications were the strongest predictor of prolonged LOS ($p < 0.001$).

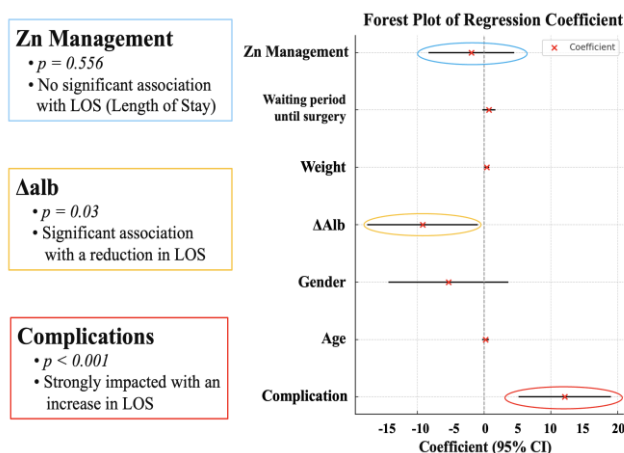


Figure 2. Forest Plot for Multiple Linear Regression Analysis

Key Insights

While zinc supplementation improved serum zinc levels, its lack of direct impact on clinical outcomes such as LOS and complications highlights the multifactorial nature of recovery in femoral neck fracture patients. The absence of significant differences between groups underscores the need for a holistic approach to postoperative nutritional and medical management.

DISCUSSION

This study investigated the impact of zinc supplementation on the clinical outcomes of patients undergoing surgery for femoral neck fractures, focusing on Length of Stay (LOS), serum albumin changes (Δ Alb), and complication rates. Although zinc supplementation significantly improved serum zinc levels, it did not directly reduce LOS or the frequency of complications. These findings emphasize the multifactorial nature of recovery in hip fracture patients and the complexity of optimizing postoperative care.

Comparison with Existing Literature

Numerous studies have highlighted the importance of nutritional management in reducing LOS for hip fracture patients [5] [6]. Prior research has suggested that improvements in nutritional status, including albumin levels, are associated with shorter hospital stays and fewer complications [7] [10]. For instance, Williams et al. [6] demonstrated that early nutritional interventions significantly reduced LOS among malnourished patients. Similarly, Ibrahim et al. [11] conducted a meta-analysis showing the modest benefits of zinc supplementation in lowering infectious complications. However, as observed in our study, the direct impact of zinc supplementation on LOS remains inconclusive, aligning with previous reports indicating that zinc's effects might be context-dependent and influenced by baseline nutritional status [10].

Nutritional Recovery as a Key Factor

Our results underline the significance of Δ Alb as a predictor of reduced LOS, consistent with Elmatbagy et al. (2024), who demonstrated that nutritional improvements, mainly through zinc supplementation, were associated with shorter hospital stays and faster symptom resolution in children hospitalized with pneumonia [12]. Similar findings have been reported in sarcopenic patients with femoral fractures, where nutritional interventions combined with muscle exercises improved recovery outcomes [13]. Despite zinc's biochemical effects, its contribution to Δ Alb was not statistically significant, suggesting that comprehensive nutritional strategies beyond single-nutrient supplementation may be necessary. Future studies should explore the interplay between zinc and other micronutrients in promoting nutritional recovery and mitigating postoperative risks.

Complications and LOS

Postoperative complications, particularly infections such as urinary tract infections and pneumonia, emerged as the

strongest predictors of prolonged LOS in our study. This finding is consistent with those of He et al. [10] [11], who demonstrated that zinc supplementation reduced infection rates in specific clinical populations. However, our analysis did not replicate this association, potentially due to the relatively low overall complication rates and the limited sample size. Addressing complications early through proactive monitoring and interventions, including nutritional support, remains a cornerstone of effective postoperative care [10].

Implications for Zinc Supplementation Protocols

Although zinc supplementation increased serum zinc levels significantly, the lack of clinical benefits observed in this study may reflect specific limitations in protocol design. Zinc administration was not stratified based on baseline nutritional deficiencies, and the dose (17 mg/day) may not have been sufficient to yield tangible clinical improvements. Ibrahim et al. [11] noted that the efficacy of zinc in reducing hospital stays varies with dosage and timing of administration. Future research should consider personalized supplementation protocols tailored to individual patient profiles, including baseline zinc levels, nutritional status, and comorbidities.

Limitations

This study's retrospective design may have introduced selection biases and limited the ability to control for unmeasured confounders, such as socioeconomic factors and detailed comorbidity profiles. The single-center setting also reduces generalizability to other populations and healthcare systems. Furthermore, while adequate for initial analysis, the sample size may have been insufficient to detect smaller effect sizes or interactions between zinc and other variables. Finally, focusing on short-term outcomes, such as LOS and Δ Alb, does not account for potential long-term benefits of zinc supplementation, such as improved functional recovery or quality of life.

Future Directions

Given the mixed results, future research should prioritize randomized controlled trials to elucidate the role of zinc supplementation in hip fracture recovery. These studies should include:

1. Stratified dosing protocols based on baseline zinc levels and nutritional status.
2. Multicenter designs to improve generalizability.
3. Long-term follow-up to assess functional recovery, readmission rates, and quality of life.
4. Integration of zinc supplementation with comprehensive nutritional and rehabilitation strategies.

Additionally, systematic reviews and meta-analyses incorporating data from similar retrospective studies could help clarify the broader applicability of zinc in postoperative care for hip fracture patients.

Clinical Implications

Despite the lack of direct evidence linking zinc supplementation to reduced LOS, our findings underscore the importance of monitoring and supporting nutritional recovery. Healthcare providers should prioritize comprehensive nutritional interventions and early identification of complications to optimize patient outcomes. While not a standalone solution, zinc supplementation may play a complementary role when integrated into a holistic postoperative care plan.

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