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Retrospective Analysis of the Impact of Demographics and Comorbidities on Hounsfield Unit Scale for Predicting Surgical Methods in Proximal Femur Fractures

Prof. Irismetov M. E., Qodirov R. R.

Republican Specialized Scientific and Practical Medical Center of Traumatology and Orthopedics

R. S. Kadirov

Republican Scientific Centre of Emergency Medical Care, the branch of Tashkent region

Abstract: Background and aim: Proximal femur fractures are common among the elderly, often resulting from low-energy trauma. Effective management requires consideration of various factors, including patient demographics and comorbidities, to optimize outcomes. This retrospective analysis aimed to assess the impact of demographics and comorbidities on the Hounsfield unit (HU) scale for predicting surgical methods in proximal femur fractures.

Methods and results: The medical records of 70 patients undergoing either arthroplasty or osteosynthesis were analyzed. Age and comorbidities were assessed, and Hounsfield Unit (HU) values were compared between non-complicated and complicated cases in arthroplasty and osteosynthesis surgeries. Linear regression was employed to evaluate the relationship between age and the Hounsfield index by gender, and a T-test was used to compare continuous data between the two groups.

There were no significant age differences between complication groups, however, a negative correlation between age and HU, was more pronounced in females. Osteoporosis and systemic diseases significantly affected HU values.

Optimal bone density for non-complicated outcomes differed between genders, with women showing an optimal bone index at the age 65.4 ± 9.2 years and a corresponding Hounsfield index of 97.29 ± 20.8 statistically significant at p=0.0015 and a moderate relationship found r=-0.48. For men showing an optimal bone density of 69.7 ± 11.01 years and a mean Hounsfield index of 95.44 ± 19.26 as well as significant at p=0.0035, r=-0.27. 78.33 ± 11.49.

Comorbidities and Hounsfield index analysis shows that the average HU index is 80.31 ± 11.24 for osteoporotic individuals and 102.56 ± 19.34 for non-osteoporotic patients 87.75 ± 15.0 (p<0.0001), diabetic individuals 97.75 ± 20.42 for non-diabetic patients 77.42 ± 11.19 (p<0.0486), for individuals with systemic diseases compared to 102.56 ± 19.34 for those without systemic diseases (p<0.00006), for patients with cardiovascular diseases (CVD), the average HU index was 78.33 ± 11.49, whereas for non-CVD patients, it was 100.29 ± 19.47 (p<0.0001)

Conclusion: The effectiveness of arthroplasty remained consistent regardless of the presence of comorbidities, whereas the outcomes of osteosynthesis were contingent upon the absence of comorbid conditions. Complications were observed to be associated with lower Hounsfield Unit (HU) values. The optimal age for osteosynthesis was approximately 70 years for males and 65 years for females. Additionally, the consideration of comorbidities emerged as a crucial factor in surgical planning.

Keywords: Proximal femur fractures, Hounsfield unit scale, surgical methods, demographics, comorbidities, arthroplasty, osteosynthesis, bone density, age, gender.

Introduction:

Proximal femur fractures are particularly common among elderly populations and pose a significant challenge in orthopaedic practice due to their high morbidity and mortality rates. These fractures usually result from low-energy trauma such as falls, which are prevalent in older individuals with reduced bone density and stability [1][2]. Effective management of these injuries requires careful consideration of various factors including the type of fracture, patient age, bone quality, and overall health status, which are critical in optimizing recovery and minimizing complications [3][4]. Proximal femur fractures encompass several types of injuries, including fractures of the femoral neck, intertrochanteric fractures, and subtrochanteric fractures. Studies have shown that these injuries occur in approximately 8.2% of elderly patients and are more prevalent among women, primarily due to the higher incidence of osteoporosis in this demographic group [5]. The impact of these injuries is significant, leading to hospitalization and surgical interventions that aim to restore mobility and reduce pain. The incidence of proximal femur fractures increases with age, predominantly affecting older individuals, with a notably higher prevalence in women. This increased prevalence is largely attributable to osteoporosis, a condition that weakens bones and makes them more susceptible to fractures from minor impacts [6]. The presence of chronic diseases such as diabetes and cardiovascular conditions further exacerbates the risk, compounding the challenges faced in the management of these fractures [7][8][9]. The gender disparity in the incidence of these fractures is significant. Women, particularly those who are post-menopausal, experience a decrease in estrogen levels, which plays a vital role in maintaining bone density and strength. This hormonal change significantly contributes to the higher rates of osteoporosis among women and, consequently, a greater risk of sustaining proximal femur fractures.

Surgical intervention is the mainstay of treatment for these fractures, with the choice of procedure being influenced by the specific characteristics of the fracture, the patient's bone quality, and their overall health condition. Options include internal fixation, which involves the use of screws and plates to stabilize the fracture; hemiarthroplasty, where the femoral head and neck are replaced with a prosthetic implant; and total hip arthroplasty, recommended for patients with more complex fractures or additional joint disease [10][11][12]. The management of these fractures requires careful evaluation of individual patient needs, expert surgical intervention, and diligent postoperative care to ensure the best possible outcomes.

Bone mineral density (BMD) is crucial for choosing the appropriate surgical intervention for proximal femur fractures. However, BMD measurement is not always available, as it requires specialized equipment that may not be accessible in all healthcare settings. Fortunately, BMD is highly correlated with the Hounsfield index (HU), a measure obtained from rou b tine CT scans that quantifies radiodensity [13]. In this study, we analyzed the impact of age, sex, and comorbidities on the Hounsfield unit (HU) scale to predict the appropriate surgical methods for treating proximal femur fractures.

Aim: The above facts as mentioned earlier we conducted a retrospective analysis of proximal femur fractures to find out the impact of the demographic and comorbidities on the mineral mass of the proximal femur neck. It is important to choose of surgery method for the proximal neck fracture.

Methodology: A retrospective analysis was conducted at the Republican Specialized Scientific and Practical Medical Center of Traumatology and Orthopedics, examining the medical records of 70 patients who underwent either arthroplasty or osteosynthesis due to the proximal femur fractures. Among these patients, n=29 (41.4%) was male and n= (58.57%) were female (Table 1).

All patients underwent computed tomography examination before the surgery and were checked for comorbidities.

Statistical analysis: All data were recorded using Excel 2019 (Microsoft Corp, USA), and analysis was performed using JMP 17 software. Continuous data were checked for normality test, after confirming normality, data were compared by T-test. The Pearson coefficient was used to test Linear regression. The chi-squared test was used to compare nominal groups. Analyses were considered statistically significant when p was less than 0.05.

Result:

No significant difference was found by age among the non-complication and complication groups in the Arthroplasty and osteosynthesis groups. The average age was 71.57 years for non-complicated arthroplasty and 64.3 for osteosynthesis non-complicated group. Significant differences were found in the distribution of comorbidities among the complicated and non-complicated groups. Osteoporosis was 10% (n=7) of non-complicated CVD and Systematic diseases 4,2% n=(4) patients. From Table 1 we can see that Arthroplasty is effective even if a patient has comorbidities, however, non-complication outcome among osteosynthesis patients depends on the absence of comorbidities. In both the Arthroplasty and Osteosynthesis groups, patients who experienced complications had significantly lower average Hounsfield Units (HU) compared to those who did not have complications. In the Arthroplasty group, the average HU was 94.05 ± 7.61 for the non-complication group and 78.55 ± 10.69 for the complication group, with a statistically significant difference ($p = 0.0038$). In the Osteosynthesis group, the average HU was 110.67 ± 17.54 for the non-complication group and 90 ± 16.37 for the complication group, with a highly statistically significant difference ($p < 0.0005$) (Table 1).

Table 1. Distribution of patient demographics by AO/ASIF classification

	Arthroplasty			Osteosynthesis		
	Non-complication	Complication	p-value	Non-complication	Complication	p-value
Number	21	7	-	31	11	-
Sex (M:F)	8:13	2:5	-	0.554166667	6:5	-
Age year (mean/SD)	71.57±6.57.84	71.85±6.91	0.462	64.3±10.27	65.8±13.63	0.656
AO/OASIF (N/%)						
31A1	10 (14%)	2 (3%)	-	8 (11%)	5 (7%)	-
31A2	8 (11%)	3 (4%)	-	18 (26%)	4 (6%)	-
31A3	3 (4%)	2 (3%)	-	5 (7%)	2 (3%)	-
Comorbidities (N,%)						
Osteoporosis	7 (10%)	1 (1.4%)	0.239	1 (1.4%)	6 (8.5%)	<0.0007
CVD	3 (4.2)	2 (2.8%)	<0.002	1 (1.4%)	3 (4.28%)	<0.04
Diabetes melitius	2 (2.8%)	1 (1.4%)	<0.043	1(1.4%)	1 (1.4%)	0.58
Systemic diseases	3 (4.28%)	1 (1.4%)	<0.0407	1(1.4%)	2 (2.8%)	0.17
Average HU (mean, SD)	94.05 ±(7.61)	78.55 (±10.69)	<0.0038	110.67(±17.54)	90 (±16.37)	<0.0005

p-value derived from T-test (continuous data). Chi-squared test used to compare nominal goup.

Our analysis revealed a negative correlation between age and the Hounsfield index, indicating a decline with increasing age, with this trend being more pronounced in females. Upon examining procedures with favorable outcomes, we identified the optimal bone index for women as 65.4 ±9.2, corresponding to a Hounsfield index of 97.29 ± 20.8, a finding that was statistically significant at $p=0.0015$. Similarly, in the analysis of favourable outcomes in men, it was determined that the optimal bone density was 69.7 ± 11.01 years, with a mean Hounsfield index of 95.44 ± 19.26, a finding that was statistically significant at $p=0.0035$.

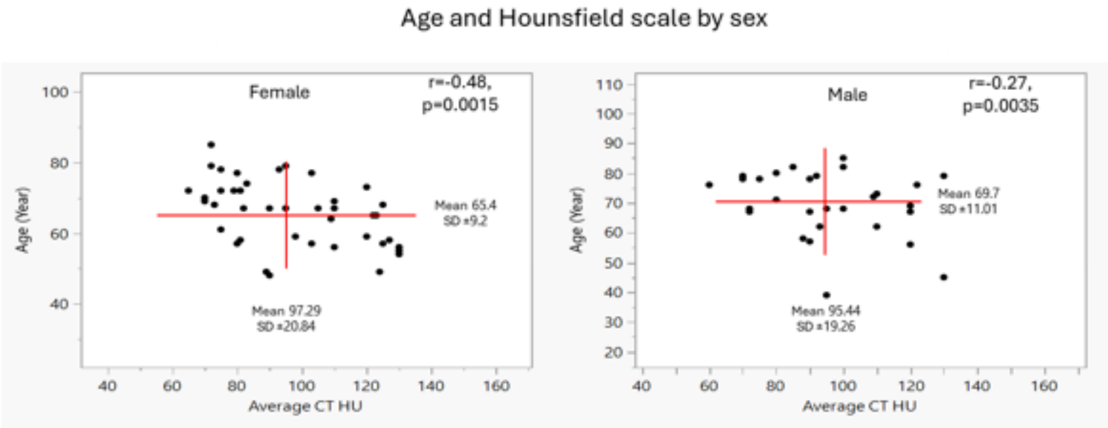

Figure 1. Hounsfield scale by age and sex. A-Female. B-Male

In our analysis of the impact of comorbidities on the Bone Hounsfield index, we observed significant differences. For patients with cardiovascular diseases (CVD), the average HU index was 78.33 ± 11.49, whereas for non-CVD patients, it was 100.29 ± 19.47 (Figure 2.A). This indicates a substantial difference in bone density between the two groups.

Additionally, patients with osteoporosis exhibited a decreased Hounsfield Unit (HU) index, with values of 80.31 ± 11.24 for osteoporotic individuals and 102.56 ± 19.34 for non-osteoporotic patients (Figure-2.C). This finding further underscores the impact of osteoporosis on bone density, with significant differences observed between the two groups.

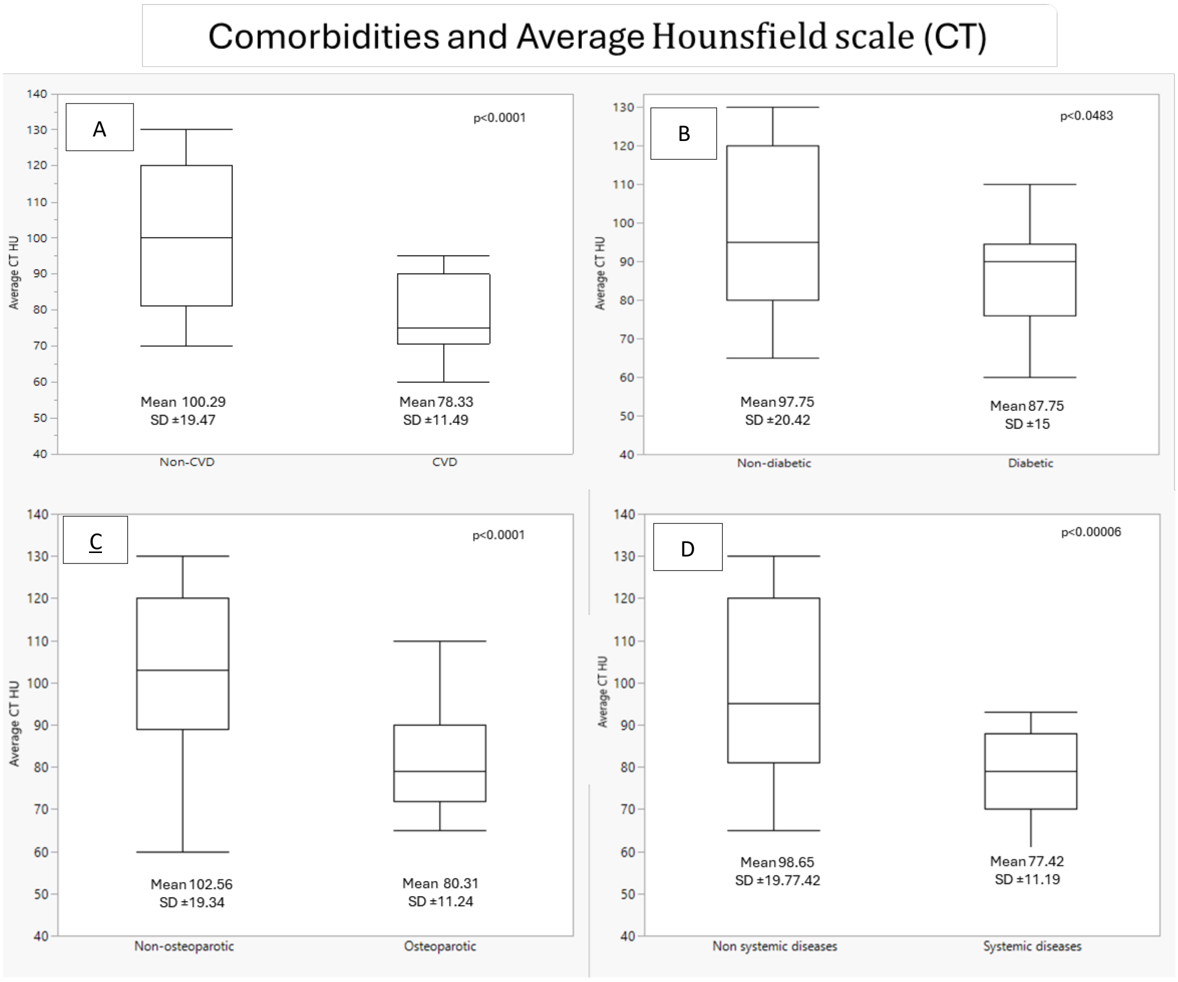

Figure 2. Hounsfield scale by comorbidities.
A-with CVD, B-with Diabetic, C-with Osteoporotic, D-Systematic diseases

Similarly, patients with diabetes demonstrated a decreased Hounsfield Unit (HU) index, with values of 87.75 ± 15.0 for diabetic individuals and 97.75 ± 20.42 for non-diabetic patients (Figure-2. B). This suggests that diabetes also has a notable effect on bone density, as indicated by the significant difference between diabetic and non-diabetic patients. Patients with systemic diseases showed a decreased Hounsfield Unit (HU) index, with values of 77.42 ± 11.19 for individuals with systemic diseases compared to 102.56 ± 19.34 for those without systemic diseases (Figure 2. D).

Discussion:

The findings of our study provide valuable insights into the impact of comorbidities on bone density, as measured by the Hounsfield Unit (HU) index, in patients undergoing arthroplasty and osteosynthesis procedures. Interestingly, we found no significant age differences between the non-complication and complication groups in either the arthroplasty or osteosynthesis cohorts. However, we find that in our study a significant negative relationship between age and the Hounsfield index, a measure of bone density, with important gender-specific differences. We observed a negative correlation between age and the Hounsfield index, indicating a decline in bone density with increasing age. This trend was found to be more pronounced in females compared to males. Previous, studies suggest that age and bone density have a moderate negative relationship [14, 15, 19]. Chinese scientists have identified a negative association between the Hounsfield index of bone and age, predominantly observed in women, which initiates a decline after the age of 50 [16].

In addition, significant differences were observed in the distribution of comorbidities among the complicated and non-complicated groups. Osteoporosis was present in 10% of non-complicated cases, indicating its potential impact on surgical outcomes. Similarly, systemic diseases were present in 4.2% of non-complicated cases, highlighting the importance of considering comorbidities in treatment planning.

Our analysis also revealed that arthroplasty appears to be effective even in patients with comorbidities, as indicated by the lack of significant differences in outcomes between those with and without comorbidities. In contrast, the non-complication outcome among osteosynthesis patients seems to depend on the absence of comorbidities, suggesting that these patients may require more careful consideration and possibly additional interventions to minimize complications.

Furthermore, patients who experienced complications in both the arthroplasty and osteosynthesis groups had significantly lower average Hounsfield Units (HU) compared to those who did not have complications. This highlights the importance of bone density in predicting surgical outcomes and suggests that patients with lower HU values may be at a higher risk of complications.

Our study indicates a significant impact of comorbidities on bone density, consistent with previous research demonstrating the influential role of comorbidities on the Hounsfield index [17]. Additionally, a separate study has shown that a lower Hounsfield index is a predictor of osteoporosis and can be managed through physical exercise [18].

Limitation. The retrospective nature of the study introduces the possibility of selection bias and incomplete or inaccurate medical records. The study's reliance on CT scans for Hounsfield Unit (HU) measurements may also be a limitation, as variations in imaging protocols and equipment could affect the accuracy and consistency of the measurements. Furthermore, while we controlled for age and comorbidities in our analysis, there may be other factors not accounted for that could influence surgical outcomes and HU values. Future studies with larger, more diverse samples and prospective designs are needed to confirm and expand upon our findings

Conclusion. Our retrospective analysis of proximal femur fractures highlights the importance of considering patient demographics and comorbidities in the management of these fractures. We found a significant negative correlation between age and the Hounsfield index, indicating a decline in bone density with increasing age, particularly pronounced in females. Comorbidities such as osteoporosis and systemic diseases were also found to significantly affect Hounsfield Unit (HU) values. Arthroplasty was effective regardless of comorbidities, while the outcomes of osteosynthesis depended on the absence of comorbidities. Complications were associated with lower HU values, suggesting that patients with lower bone density may be at a higher risk of complications. These findings underscore the importance of assessing bone density and comorbidities in treatment planning for proximal femur fractures. Overall, our study provides valuable insights into the impact of demographics and comorbidities on the Hounsfield unit scale for predicting surgical methods in proximal femur fractures. Further research is warranted to validate these findings and explore their implications for clinical practice.

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