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General

Association between Deltoid Muscle Density and Proximal Humeral Fracture in Elderly Patients

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Background

The potential role of deltoid muscle density in the occurrence of proximal humeral fractures remains uncertain. Therefore, the primary objective of this study was to examine the correlation between deltoid muscle density, as measured by CT attenuation value in Hounsfield units (HU), and the incidence of proximal humeral fractures in elderly patients. By investigating this association, we aim to shed light on the possible influence of deltoid muscle density on fracture risk in this specific population.

Methods

A total of 68 patients with computed tomography (CT) images were retrospectively reviewed. Among them, 34 patients presented with fractures following low-energy injuries, while the remaining 34 patients served as controls and underwent CT scans after low-energy injuries without any fractures. The muscle density of the deltoid muscles was assessed at the approximate tubercle of humerus. We compared these parameters between the two groups and conducted analyses considering factors such as age, sex, laterality, and deltoid muscle density of the shoulders.

Results

The demographic factors related to the shoulder did not exhibit any significant association with proximal humeral fracture. However, we observed a noteworthy difference in deltoid muscle density between patients with fractures (40.85 ± 1.35) and the control group (47.08 ± 1.61) ($p = 0.0042$), indicating a lower muscle density in the fracture group.

Conclusion

Based on the findings of this study, we can conclude that there exists a negative correlation between deltoid muscle density and the incidence of proximal humeral fractures. These results suggest that lower deltoid muscle density may be associated with an increased risk of proximal humeral fractures in the elderly population under investigation.

INTRODUCTION

Proximal humerus fractures are prevalent among the elderly population and constitute approximately 6% of all fractures, making them a significant concern in terms of osteoporotic fractures.[1,2] Osteoporotic fractures are known to be a key indicator for future occurrences of similar fractures, making their prevention and management crucial.

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Within the spectrum of osteoporotic fractures, proximal humeral fractures are the third most common, trailing behind fractures of the spine and hip.[3] This highlights the importance of studying and understanding proximal humeral fractures in order to develop effective preventive measures and treatment strategies for this specific type of fracture.

Bone mineral density (BMD), measured using dual-energy X-ray absorptiometry (DXA), is a widely accepted parameter for diagnosing osteoporosis and assessing the risk of proximal humeral fracture.[4,5] However, BMD measurements typically focus on the spine and hip, while the proximal humerus is often overlooked.[6,7]

In recent years, computed tomography (CT) scans have become a common tool for evaluating detailed proximal humeral fracture pattern in patients. The CT value of the proximal humerus can serve as an indicator of bone quality in elderly fracture patients and can be considered an alternative measure of BMD.[8] Furthermore, CT images provide the opportunity to assess muscle size and muscle density.[9,10] Skeletal muscle, as a dynamic tissues, plays a crucial role in various bodily functions and contributes to mobility and engagement in social and occupational activities.[11] Importantly, muscle density has been found to outperform areal bone mineral density (aBMD) measured using hip computed tomography X-ray absorptiometry and muscle size in accurately distinguishing hip fractures.[12]

To date, limited research has been conducted to explore the potential impact of deltoid muscle density on the occurrence of proximal humeral fractures. Therefore, our study aimed to investigate whether deltoid muscle density is a risk factor for proximal humeral fractures. By investigating this relationship, we aimed to provide valuable insights into the potential role of deltoid muscle density as a risk factor for this specific type of fracture.

MATERIALS AND METHODS

In this study, we conducted a retrospective analysis of medical databases, specifically focusing on patients who visited our emergency department and underwent shoulder computed tomography (CT) scans between January 2019 and February 2023. We enrolled patients aged 60 years and above.

In the fracture group, we included patients who were diagnosed with proximal humeral fractures resulting from low-energy trauma, such as falling on flat ground. High-impact injuries caused by events like falls from a height or traffic accidents were excluded. To ensure consistency in body composition, CT scans had to be performed within 48 hours after the injury.

The control group consisted of patients who were diagnosed with shoulder joint injuries without fractures, resulting from low-energy trauma. To ensure a representative control group, a statistician stratified the available controls based on age and sex, and a random sampling rate was applied to meet the requirements of a power analysis. Patient demographic data, including age and gender, were collected for analysis.

The shoulder joint CT data was stored in DICOM format. Using the Mimics software installed on a personal computer, we processed the CT images of the shoulder join. The periphery of the triceps at the top of the coracoid process was marked using the 3D livewire tool. The cross-sectional area (mm^2), perimeter (mm), and average density (HU) of the triceps on the plane were recorded. (Figure 1)

This study was conducted in accordance with the ethical guidelines and received approval from the ethics committee of the Clinical Medical College of Yangzhou University.

STATISTICAL ANALYSES

Independent t-tests were conducted to compare continuous variables, while the chi-square test was utilized to analyze categorical variables such as sex or laterality. A significance level of $p < 0.05$ was considered statistically significant. All statistical analyses were performed using SPSS software, (version 20; IBM Inc., NY, USA).

RESULTS

GENERAL RESULTS

In this retrospective study, a total of 68 elderly patients were included, with 34 patients in the proximal humeral fracture group and 34 patients in the control group. Among the proximal humeral fracture group, there were 22 men and 12 women, with an average age of 68.65 ± 1.048 years. The control group consisted of 21 men and 13 women, with an average age of 67.97 ± 1.055 years (p=0.6506). The detailed information of all 68 patients can be found in Table 1.

Figure 2 illustrates the CT-based measurement of deltoid muscle density attenuation around the shoulder joint in the proximal humeral fractures group. The deltoid muscle density was 40.85 ± 1.354 in fracture group. However, the deltoid muscle density was 47.08 ± 1.608 in control group. A statistically significant difference was observed, with the deltoid muscle density in the fracture group being significantly lower than that in the control group (p = 0.0042).

DISCUSSION

The findings of this study suggest that deltoid muscle density may be a significant risk factor for the development of proximal humeral fractures. The analysis revealed a significantly lower deltoid muscle density in the fracture group compared to the control group, indicating a potential association between decreased muscle density and increased fracture risk. The findings of this study contribute to our understanding of the risk factors associated with proximal humeral fractures.

Epidemiological studies have consistently identified several risk factors associated with proximal humeral fractures. These risk factors include age, with individuals over the age of 60 being more susceptible to fractures. Gender has also been identified as a factor, with females having a higher risk compared to males. Other factors such as recent

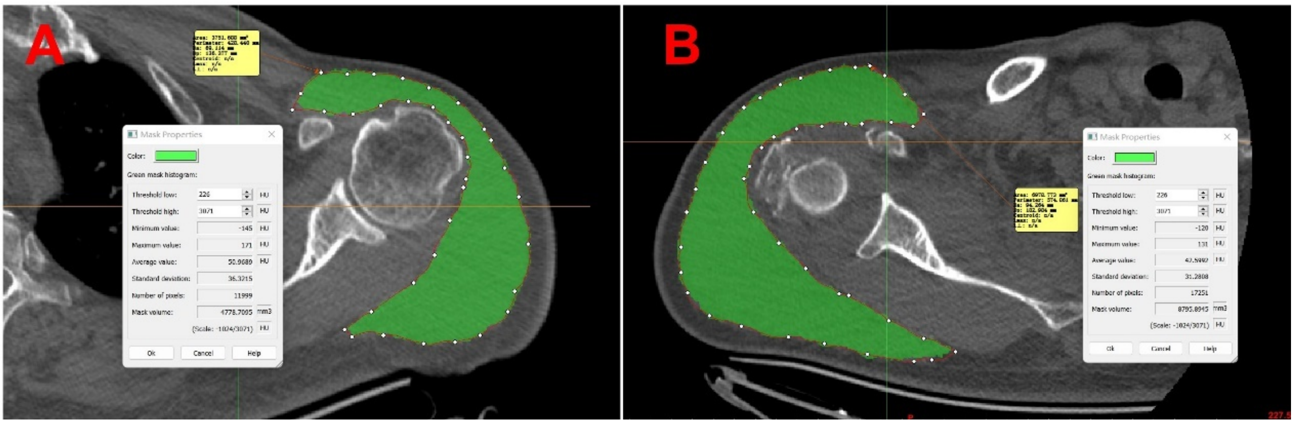

Figure 1. Measurement of cross-sectional area and mean computed tomography values of the deltoid muscle at the top of the coracoid process.

Deltoid muscle region is represented by the area highlighted in green. (A) the control group, (B) the fracture group.

Table 1. Demographic Information and Outcomes of Patients

Group	Age (year)	Gentle (n)	
		Male	Female
Control	67.97 ± 1.055	21	13
Fracture	68.65 ± 1.048	22	12
P value	0.6506	0.801	

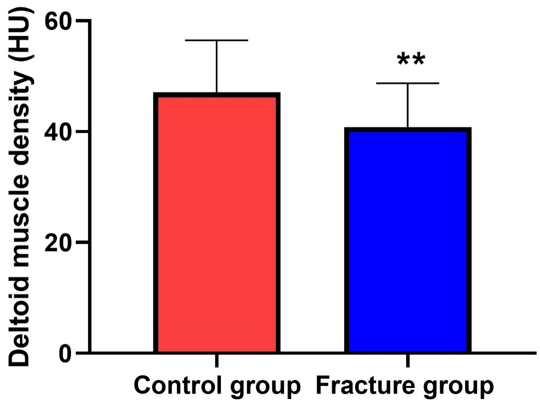

Figure 2. Deltoid muscle density in control and fracture groups. (, p<0.01)**

decline in health, insulin-dependent diabetes mellitus, infrequent walking, and neuromuscular weakness have also been associated with an increased risk of proximal humeral fractures.[13,14]

Skeletal muscle plays a critical role in our human body, providing the necessary strength and mobility for various activities. Loss of skeletal muscle mass and quality can significantly increase the risk of adverse outcomes. Assessing muscle function and mass is important for evaluating muscle health, and various methods are currently available.[11,15] However, measuring muscle mass typically requires specialised equipment, limiting its accessibility in clinical settings.[16] Hand grip strength has emerged as a simple and cost-effective measure to assess muscle function and identify older adults at risk of falls and fractures. It serves as a useful screening tool, providing valuable information about overall muscle strength.[14,17] However, in patients with acute proximal humeral fractures, the assessment of hand grip strength can be challenging due to pain and immobility. Furthermore, accurately measuring muscle quantity and quality in this specific patient population is not easily achievable.

In recent years, CT has gained attention as a valuable tool for assessing muscle quality, including fatty muscle degeneration. CT allows for the measurement of the cross-sectional area of the muscle, providing insights into muscle composition and quality. This imaging technique has been actively studied and investigated for its potential in assessing muscle health.[18,19] Nevertheless, it is important to note that the correlation of muscle mass measured by CT and muscle strength or function is relatively low in some studies. This suggests that muscle mass alone may not fully capture the functional capacity of the muscle.[17,20] Therefore, a comprehensive evaluation of both muscle mass and function is necessary to obtain a more accurate assessment of muscle health.

Skeletal muscle density, as measured by CT using Hounsfield Units (HU), is a widely utilized parameter in research studies. While muscle size and density measurements have been extensively studied in various anatomical locations such as the thigh, hip, and trunk, there is a paucity of studies focusing on quantitative imaging of shoulder muscles.[20]

The deltoid muscle, which constitutes approximately 20% of the shoulder musculature, plays a crucial role in shoulder joint stability and function.[21] A decrease in muscle density may lead to diminished muscle strength and functionality, compromising the ability to stabilize the proximal humerus during daily activities. This instability may increase the vulnerability of the shoulder joint to fractures, particularly in elderly individuals who may already have compromised bone health. It is noteworthy that preoperative deltoid fatty degeneration is frequently observed in displaced proximal humeral fractures (PHF) in the elderly. Interestingly, previous studies have demonstrated that muscle density correlates better than muscle size with handgrip strength and functional tests such as the Timed Up and Go (TUG) test, particularly in women.[20,22] Given the common use of three-dimensional (3D) shoulder CT scans for assessing fracture patterns and planning surgical interventions in proximal humeral fractures, CT is an ideal tool for evaluating the deltoid muscle in this context.

In summary, this study highlights the significant association between the rate of decline in physical performance and fracture risk, independent of age, bone mineral density (BMD), and other common risk factors. This implies that repeated measurements of muscle strength and performance may aid in identifying older individuals at a higher risk of fractures. Further investigations are warranted to determine whether incorporating muscle strength and performance measurements into existing fracture risk prediction tools can enhance their predictive accuracy.[23]

Limitations of this study include its retrospective design, potentially introducing selection bias and limiting generalizability. The study population from a specific emergency department may not represent the broader elderly population. The small sample size affects statistical power and precision. The study focused solely on the association between deltoid muscle density and proximal humeral fractures, without considering other potential risk factors or confounding variables. The study did not investigate longitudinal changes in deltoid muscle density or its predictive value for future fracture risk. Future research should consider larger sample sizes and longitudinal designs for a more comprehensive understanding.

Despite these limitations, this study provides valuable preliminary insights into the potential role of deltoid muscle density in proximal humeral fractures. Further research with prospective designs and diverse populations is needed to confirm and expand upon these findings.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was approved by the ethics committee for clinical research at Northern Jiangsu People's Hospital. Written informed consent was obtained from all patients prior to commencement of the study.

AVAILABILITY OF SUPPORTING DATA

All data are fully available without restriction.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

FUNDING

None.

AUTHORS' CONTRIBUTIONS

Wang JC and Chen PT conceived of the design of the study. Hu JL, Yang LX, Liang Y, Zhang JL participated the experiment. He JS analyzed the data. Liang Y and Yang LX finished the manuscript. All authors read and approved the final manuscript.

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