Monaldi Archives for Chest Disease

eISSN 2532-5264 https://www.monaldi-archives.org/

Monaldi Arch Chest Dis 2026 [Online ahead of print]

To cite this Article:
Batra S, Rasukatchula AK, Rudraraju VSD, Syal K. **The silent fractures: unmasking osteoporosis in south Indian chronic obstructive pulmonary disease patients**. Monaldi Arch Chest Dis doi: 10.4081/monaldi.2026.3784

Submitted: 22-10-2025
Accepted: 5-05-2026

The silent fractures:
unmasking osteoporosis in south Indian chronic obstructive pulmonary disease patients

Sakshi Batra,[1] Arun Kumar Rasukatchula,[2] Vasavi Sri Dattasena Rudraraju,[1] Kirtimaan Syal[3]

[1]Department of Respiratory Medicine, Malla Reddy Institute of Medical Sciences, Malla Reddy Vishwavidyapeeth (Deemed to be University), Suraram, Hyderabad, Telangana; [2]Department of Respiratory Medicine, Government Medical College, Nizamabad, Telangana; [3]Department of Biological Sciences, Birla Institute of Technology and Sciences-Pilani, Hyderabad campus, Hyderabad, Telangana, India

Correspondence: Sakshi Batra, Department of Respiratory Medicine, Malla Reddy Institute of Medical Sciences, Malla Reddy Vishwavidyapeeth (Deemed to be University), Suraram, Hyderabad 500055, Telangana, India.
Tel.: +911-8953671551. E-mail: sakshibatra82@gmail.com

Contributions: Sakshi Batra, Rasukatchula Arun Kumar: concept and design of study, experiments performing. Kirtimaan Syal, Vasavi Sri Dattasena Rudraraju: analysis and interpretation of experimental results. Vasavi Sri Dattasena Rudraraju, Sakshi Batra: review and editing. All the authors have read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Conflict of interest: the authors declare no conflicts of interest.

Ethics approval and consent to participate: this study was approved by the Malla Reddy Institute of Medical Sciences, Suraram, Hyderabad, Telangana, India, Ethics Committee with Certificate number: MRIMS/DHR-IEC-49/2022. Data collection was conducted after all participants signed the consent forms and after the study objectives were duly appraised, using participant information sheets.

Informed consent: the authors certify that they have obtained all appropriate written informed patient consent forms prior to completing the study. The manuscript does not contain any individual person's data in any form.

Patient consent for publication: obtained at the time of data collection.

Availability of data and materials: the data supporting the findings of this study are available from the corresponding author upon request

Abstract

Chronic obstructive pulmonary disease (COPD) is a progressive lung disorder characterized by persistent airflow limitation and chronic respiratory symptoms. COPD is the second leading cause of death in India and the third leading cause of death worldwide. Osteoporosis, a significant and often overlooked comorbidity of COPD, presents a major challenge. The disease itself, combined with multiple risk factors, including the use of inhaled corticosteroids—a cornerstone of COPD treatment—contributes to a decline in bone mineral density (BMD). This cross-sectional study investigates the prevalence of osteopenia and osteoporosis among COPD patients at a tertiary care center in South India, with a particular focus on the impact of inhaled and systemic corticosteroids on BMD and other associated risk factors. One hundred COPD patients were assessed for their BMD. Our findings reveal a strikingly high prevalence (88%) of reduced BMD among COPD patients, with 69% diagnosed with osteoporosis and 19% with osteopenia. Most COPD patients are middle-aged smokers and frequently use steroid-containing inhalers, which contribute to decreased BMD and an increased risk of fractures.

The study highlights a significant association between osteoporosis and factors such as smoking history, COPD severity (GOLD classification), and cumulative steroid exposure. These results highlight the urgent need for proactive, regular screening and early intervention to assess bone health in COPD care.

Key words: chronic obstructive pulmonary disease, bone mineral density, osteoporosis, inhaled corticosteroids, systemic corticosteroids.

Abbreviations: COPD (Chronic Obstructive Pulmonary Disease), CAT Score (COPD Assessment Test), BMD (Bone Mineral Density), Inhaled Corticosteroids (ICS), Oral Corticosteroids (OCS).

Introduction

Chronic Obstructive Pulmonary Disease (COPD) is the most common and prevalent respiratory condition, characterized by persistent airflow limitation and chronic airway inflammation [1]. COPD has a prevalence rate ranging from 6-9% (approximately 8%) in India and contributes to over 9.5% of all the deaths, ranking as the second leading cause of mortality and disability-adjusted life years (DALYs) according to the Global Burden of Disease (GBD) report [2,3]. COPD is also observed to be one of the top three causes of death worldwide [4]. COPD is frequently associated with a range of comorbidities, including cardiovascular conditions such as ischemic heart disease, heart failure, arrhythmias, and hypertension, as well as systemic manifestations like osteoporosis, muscle wasting, cachexia, anemia, polycythemia, and metabolic syndrome. Among these, osteoporosis stands out as one of the most common, debilitating, yet often underdiagnosed comorbidities. Our study specifically focuses on this condition. Notably, osteopenia represents the preclinical stage of osteoporosis [4].

The World Health Organization (WHO) defines osteoporosis as a condition characterized by low bone mass and microarchitectural deterioration, resulting in increased fracture risk [5]. Osteoporosis in COPD patients is higher due to multiple factors, such as age, smoking, inflammatory cytokine production, vitamin D deficiency, physical inactivity, and the use of steroids, with a high prevalence of 36% to 60% as reported across the globe, whereas the prevalence of osteopenia is 35% to 72% [6].

Osteoporosis can be measured using Quantitative Ultrasound (QUS), a portable, non-invasive, and affordable option that allows radiation-free assessment of bone status [6]. In this study, we evaluated the prevalence of osteopenia and osteoporosis in patients with COPD using an ultrasonic bone densitometer (a type of QUS) and assessed the correlation between various risk factors for osteopenia and osteoporosis in COPD, including Body Mass Index (BMI), Age, Smoking, and Steroid use.

Materials and Methods

A cross-sectional study was conducted over 2 years in the Department of Respiratory Medicine at Malla Reddy Institute of Medical Sciences, Hyderabad. One hundred patients with COPD were recruited using a consecutive sampling method from both outpatient and inpatient services following confirmatory diagnosis of COPD by Spirometry using the RMS Helios 401 model in accordance with the American Thoracic Society (ATS) guidelines and Global Initiative for Obstructive Lung Disease (GOLD) guidelines 2023 [7].

COPD patients were grouped into A, B, and E categories based on their COPD assessment test (CAT) score, mMRC (Modified British Medical Research Council) dyspnoea grade, and history of exacerbations and hospitalizations, as per the GOLD guidelines 2023 [7].

The details on the inhaled and systemic steroids used by the COPD patients (cumulative dose of systemic steroids - prednisolone equivalent) in the last 3 years were noted. Bone mineral density (BMD) was assessed in COPD patients using an ultrasound bone densitometer (Sunlight Mini Omni), targeting the left calcaneus (heel bone). The T-score, calculated by the system software, compares a patient's BMD with the mean BMDs of healthy young adults of the same sex, using a single reference population.

We excluded patients who had conditions that could independently affect BMD or require long-term systemic steroid treatment. This included pregnant women, individuals with chronic systemic illnesses causing prolonged immobilization, unstable COPD patients, those with connective tissue disorders, endocrine disorders affecting calcium metabolism, and individuals already receiving treatment for osteoporosis.

According to WHO criteria, a T-score within ±1 standard deviation (SD) of the young adult mean (−1 to +1) is considered normal. A T-score between −1 and −2.5 indicates osteopenia, while a score below −2.5 SD signifies osteoporosis [5,6]. The objective was to assess BMD and its association with risk factors among COPD patients. In addition to measuring BMD, our study examined the correlation between BMD and various risk factors for bone loss in COPD patients.

Statistical analysis

All analyses were performed using IBM SPSS Statistics Version 31.0 (SPSS Inc., USA) and Microsoft Excel 365. Descriptive statistics were computed for quantitative variables, while proportions and ratios were calculated for qualitative data. Associations between categorical variables were evaluated using the chi-square test. Correlation coefficients were calculated to examine relationships between quantitative variables. A p-value <0.05 was considered statistically significant.

Results

A total of 100 individuals were enrolled in the study. There were 65 male patients (65.0%) and 35 female patients (35.0%). The age of the study participants ranged from 43 to 86 years. The mean age of the male patients was 64.9 ± 11.04 years, and that of the female patients was

65.1 ± 10.35 years. The average duration of COPD in our study population was 6.7±3.3 years. A total of 69 patients (69.0%) had osteoporosis, 19 patients (19.0%) had osteopenia, and the remaining 12 patients (12.0%) had normal bone densitometry. Osteoporosis was observed in 68% of patients aged over 55 years. However, as this age group accounted for most of our study population (78 patients), the significance of this high prevalence is inconclusive for determining an independent age-related risk. Eight patients had complications like congestive cardiac failure, respiratory failure requiring intubation, and mechanical ventilation. The gender distribution of study participants by BMD is shown in Table 1.

In our study, the majority of patients with osteoporosis were classified under GOLD Groups B and E of COPD (69%). Conversely, patients in GOLD Group A had a lower prevalence of osteopenia, with no cases of osteoporosis. It was observed that with the increasing severity of COPD, the risk of osteoporosis also increased. The association between COPD GOLD groups and BMD was observed to be statistically significant ($p<0.05$) (Table 2). Various risk factors that lead to osteoporosis in COPD, apart from the disease process itself, such as BMI, smoking, number of exacerbations, and the use of inhaled and oral corticosteroids, were analyzed.

BMI did not show any significant correlation with the BMD in our study. It was observed that patients with normal (18.5 to 24.9 kg/m^2) and low BMI (<18.5 kg/m^2) had a higher prevalence of osteoporosis (n=30 and n=23, respectively) as compared to overweight (BMI: 25-29.9 kg/m^2) and obese (>30kg/m^2) individuals. Obese individuals showed reduced risk of developing osteoporosis (n=5). In our study, smoking was the predominant risk factor among the male cohort (n=65), with 60 of the men being smokers. In contrast, most female patients (n=35) reported a history of biomass fuel exposure, which is a likely cause of COPD in this group.

Osteoporosis was observed in 23 of the 35 female patients (65.7%). Among males, 45 of 60 smokers had osteoporosis, a difference that was statistically significant ($p < 0.05$). A strong correlation was observed between heavy smoking and osteoporosis in our patient cohort. Of the n=60 smokers, 44 individuals had a smoking history of ≥20 pack-years. Within this high-exposure group, 36 patients developed osteoporosis. In contrast, among the 16 patients with smoking history (<20 pack-years), only 9 developed osteoporosis (Figure 1).

The effect of COPD exacerbation severity on BMD was also calculated. Among 41 patients with severe exacerbation, 34 had osteoporosis. Among 46 patients with moderate exacerbation, 30 had osteoporosis; the prevalence of osteoporosis was lower in patients with mild and no exacerbations.

COPD management typically involves bronchodilators (long-acting beta 2 agonists and long-acting muscarinic antagonists) and inhaled corticosteroids (ICS) based on COPD groups, with oral corticosteroids (OCS) reserved for exacerbations. All the COPD patients were categorized as those not on any steroids and using only bronchodilators, those who were using only ICS, and those who used both systemic and inhaled steroids. Systemic corticosteroids were further categorized as those using <1000 mg oral steroids (prednisolone equivalent) or >1000 mg oral steroids (prednisolone equivalent) in the last 3 years.

Most of the COPD patients in our study belonged to Group E (n=85) of COPD and were observed to be using ICS for disease control and systemic steroids during exacerbation episodes to improve lung function and prevent further exacerbations. Among the 10 patients who used only ICS, 3 patients developed osteoporosis. The risk of osteoporosis was found to be remarkably elevated (n=46) in the subgroup that used ICS along with systemic steroids (>1000mg) (prednisolone equivalent), and it was statistically significant (p=0.0019) (Figure 2).

Discussion

COPD is a systemic inflammatory condition primarily affecting the lungs, but it is also associated with multiple comorbidities. Among its extrapulmonary complications, osteoporosis is a significant concern, leading to reduced bone density [4,7].

Both trabecular and cortical bones are affected by an imbalance between bone formation and resorption. The OPG/RANK/RANKL axis and pro-resorptive cytokines such as IL-1, IL-7, IL-17, and TNF-α upregulate the RANKL pathway, which plays a critical role in the pathogenesis of osteoporosis [4-6].

Several studies conducted in India have highlighted the high prevalence of reduced BMD among patients with COPD. HattiHoli et al. reported osteoporosis and osteopenia in 66.7% and 19.6% of COPD patients, respectively [6]. Similarly, Ramachandran et al., in a study conducted at a tertiary care hospital in Southern India, observed that 67% of COPD patients had osteopenia or osteoporosis, with reduced BMD showing significant associations with disease severity, smoking, advancing age, and cumulative tobacco exposure [8]. Overall, the occurrence of osteoporosis among individuals with COPD and smokers was significantly higher—ranging from 14% to 66%—compared to healthy controls and non-smokers [9,10]. Nayyar et al. used a dual-energy X-ray absorptiometry (DEXA) scan of the lumbar spine and showed a greater burden of reduced BMD, with 86.9% affected (45.2% with osteoporosis and 41.6% with osteopenia). In their study, the prevalence of low bone density was approximately

4 times higher in COPD patients than in controls [11]. The prevalence of osteoporosis was found to be 69% in our study. The study participants who were smokers with a pack year of > 20 (n=36, 81.8%) had more osteoporosis compared to smokers with <20 pack years (n=9, 56.2%).

The presence of multiple risk factors in the COPD population further exacerbates their susceptibility to osteoporosis. Low BMI has been identified as a significant predictor of osteoporosis in individuals with COPD [6]. COPD patients with low BMI are more prone to fractures, especially on regular use of systemic steroids and long-term high doses of ICS. Underweight individuals have been shown to have a higher risk of osteoporosis in multiple studies [6,10,12]. Our findings were consistent with these observations. Underweight individuals (n=23) and patients with normal BMI (n=30) were observed to have comparatively more osteoporosis than obese and overweight participants.

COPD severity is linked to a heightened risk of developing osteoporosis. Factors such as anemia, advanced age, smoking status, pack years, disease stage, frequent exacerbations, and prolonged glucocorticoid use have been identified as independent risk contributors to osteoporosis among COPD patients in multiple studies [6,8,11].

Patients in the COPD Group E had a higher prevalence of osteoporosis and osteopenia than those in COPD Groups A and B in our study. This elevated risk is likely attributable to the repeated exacerbations characteristic of Group E, which necessitate frequent hospitalizations and the use of systemic corticosteroids. The overall increasing prevalence of bone density loss in this group strongly correlates with uncontrolled disease activity and the cumulative exposure to steroids.

Glucocorticoids remain a cornerstone of effective COPD management. Although ICS can reduce the risk of exacerbation in COPD patients, it increases the risk of adverse events, such as pneumonia and upper respiratory infection [4]. Glucocorticoids also promote osteoblast apoptosis, inhibit osteoblast precursor differentiation, and osteoblast maturation, leading to osteoporosis [5,6]. However, studies examining the impact of glucocorticoid use in COPD patients have shown inconsistent findings. While some studies have demonstrated an association between glucocorticoid use and reduced BMD along with an increased risk of fractures, others have found no significant impact on BMD [13,14].

A systematic review and meta-analysis by Peng S et al. [13], registered with PROSPERO, included 44 RCTs involving 87,594 patients. Inhaled therapy containing ICS, especially ICS/LABA and triple therapy, was significantly associated with increased fracture risk in COPD

patients when compared with inhaled therapy without ICS. Subgroup analyses showed that the treatment duration of ≥ 12 months with budesonide or fluticasone furoate therapy in study participants aged ≥ 65 years and GOLD stage III was significantly associated with an increased risk of fractures [13].

Similar results were observed by Loke et al in their meta-analysis [15]. The study indicates that prolonged exposure to ICS, specifically fluticasone and budesonide, is significantly associated with an increased risk of fractures in individuals with COPD [15]. Bone parenchymal damage can begin as early as 3 to 6 months after initiating glucocorticoid therapy and tends to worsen with increasing cumulative steroid doses [16]. It has been observed that high doses of ICS administered for a prolonged period increase the risk of osteoporosis [17,18].

Conversely, certain studies propose that the elevated fracture risk in COPD patients is primarily associated with the underlying chronic respiratory condition rather than the use of ICS.

A study by Grosso et al did not show any significant association between long-term ICS use and self-reported diagnosis of osteoporosis in subjects aged >55 years. Osteoporosis was identified in 16 subjects (6.5%) in the ICS group and 167 subjects (6.1%) in the non-exposed group. The risk of developing osteoporosis among individuals who used ICS for >12 months and >36.5 months was not significantly different from that of individuals not exposed to ICS (OR = 1.02, 95% CI: 0.51, 2.03). Thus, the history of COPD, use of long-term ICS, OCS, BMI, smoking, and physical activity were not considered risk factors for osteoporosis as per the above study [14].

Similarly, both the ICS and the non-corticosteroid bronchodilator groups showed higher fracture rates compared to controls, with no significant difference between the two treatment groups in a study by Staa et al [19]. Parallel outcomes were observed by de Vries et al., and fracture risk was comparable between ICS users and nonusers [20].

Two prominent clinical trials, TORCH (2007) and SUMMIT (2016), investigated the effects of ICS on patients with COPD. Despite their large scale, these trials suggested no significant difference in fracture risk between patients treated with ICS and those in non-ICS or placebo groups. This further supports the notion that the disease per se is a primary driver of osteoporosis and osteopenia [21,22].

The National Osteoporosis Foundation recommends osteoporosis screening for patients receiving 7.5 mg or more of prednisone per day (or its equivalent) for more than 1 month, given the rising incidence of glucocorticoid-associated osteoporosis [14].

Many patients in our study belonged to COPD Group E and showed a high incidence of repeated exacerbations, necessitating increased dependence on systemic steroids alongside ICS. This pattern may be linked to the challenges faced by patients from the nearby rural communities who visit our hospital. The observed lack of adherence to treatment and lack of regular follow-up, coupled with continued smoking, results in uncontrolled disease and prolonged, indefinite use of both inhaled and systemic steroids, demonstrating a high prevalence of osteoporosis. This outcome underscores an urgent need for intervention by healthcare providers.

We must implement strategies to monitor and regulate COPD treatment, emphasizing regular follow-up visits and patient counseling. The primary goal should be to strictly limit the duration of systemic steroid use and taper all steroids to the minimal effective dose to mitigate severe adverse effects like BMD loss.

COPD patients often have poor dietary habits and decreased sun exposure, leading to Vitamin D deficiency. Glucocorticoids enhance vitamin D metabolism, which can lead to osteoporosis [9]. Vitamin D and Calcium levels should be routinely checked in COPD patients and treated accordingly, but this was unfortunately not possible in our study due to financial constraints among patients.

The BMD in our patients was measured using a bone densitometer, which is not a gold standard, rather than a DEXA scan. The sample size in our study is small, and further studies are required to assess the effects of systemic and different types of ICS available for COPD management on BMD. Also, detailed studies on the dosage and duration of steroids that initiate bone loss are also a need of the hour.

Routine BMD assessment in all COPD patients, irrespective of disease severity, can help detect osteoporosis and osteopenia early and prevent silent fractures through timely management.

Conclusions

The primary focus of the pulmonologist in a COPD patient is to manage symptoms, prevent further exacerbations, and preserve respiratory function, but it is equally important to address complications of COPD, such as Osteoporosis. Routine screening for BMD in patients with COPD is warranted to enable early detection of osteoporosis. Along with BMD screening, evaluating nutritional status, correcting calcium and vitamin D deficiencies, and pulmonary rehabilitation involving aerobic and resistance exercises can improve BMD and lower fracture risk in COPD patients.

References

1. Celli BR, Fabbri LM, Criner GJ, et al. Definition and nomenclature of chronic obstructive pulmonary disease: time for its revision. Am J Respir Crit Care Med 2022;206:1317-25.
2. Doke PP. Chronic respiratory diseases: a rapidly emerging public health menace. Indian J Public Health 2023;67:192-6.
3. Salvi S, Ghorpade D. What is the true burden of chronic obstructive pulmonary disease in India and what are its implications at a national level? Lung India 2021;38:503-5.
4. Global Initiative for Chronic Obstructive Lung Disease. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: 2026 report. GOLD; 2026. Available from: https://goldcopd.org/wp-content/uploads/2026/01/GOLD-REPORT-2026-v1.3-8Dec2025_WMV2.pdf
5. Sarkar M, Bhardwaj R, Madabhavi I, Khatana J. Osteoporosis in chronic obstructive pulmonary disease. Clin Med Insights Circ Respir Pulm Med 2015;9:5-21.
6. Hattiholi J, Gaude GS. Prevalence and correlates of osteoporosis in chronic obstructive pulmonary disease patients in India. Lung India 2014;31:221-7.
7. Global Initiative for Chronic Obstructive Lung Disease. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: 2023 report. GOLD; 2023. Available from: https://goldcopd.org/wp-content/uploads/2023/03/GOLD-2023-ver-1.3-17Feb2023_WMV.pdf
8. Ramachandran K, Mani SK, Gopal GK, Rangasami S. Prevalence of bone mineral density abnormalities and factors affecting bone density in patients with chronic obstructive pulmonary disease in a tertiary care hospital in southern India. J Clin Diagn Res 2016;10:OC32-4.
9. Bitar AN, Syed Sulaiman SA, Ali IAH, et al. Osteoporosis among patients with chronic obstructive pulmonary disease: systematic review and meta-analysis of prevalence, severity, and therapeutic outcomes. J Pharm Bioallied Sci 2019;11:310-20.
10. Graat-Verboom L, Wouters EF, Smeenk FW, et al. Current status of research on osteoporosis in COPD: A systematic review. Eur Respir J 2009;34:209-18.
11. Nayyar N, Sood RG, Sarkar M, et al. Prevalence of osteoporosis and osteopenia in stable patients of chronic obstructive pulmonary disease in Sub-Himalayan region of Himachal Pradesh, India. J Family Med Prim Care 2017;6:595-9.

12. Ali MA, Salve VT. Measurement of bone mineral density in stable COPD patients using ultrasound densitometry: prevention is better than cure. Int J Community Med Public Health 2017;4:3554.60.
13. Peng S, Tan C, Du L, et al. Effect of fracture risk in inhaled corticosteroids in patients with chronic obstructive pulmonary disease: a systematic review and meta-analysis. BMC Pulm Med 2023;23:304.
14. Grosso A, Cerveri I, Cazzoletti L, et al. Inhaled corticosteroids and risk of osteoporosis in late-middle-aged subjects: a multicenter European cohort study. Minerva Med 2023;114:15-21.
15. Loke YK, Cavallazzi R, Singh S. Risk of fractures with inhaled corticosteroids in COPD: systematic review and meta-analysis of randomised controlled trials and observational studies. Thorax 2011;66:699-708.
16. Suzuki Y, Sato S. Secondary osteoporosis update. Clinical significance of glucocorticoid-induced osteoporosis. Clin Calcium 2010;20:645-53. [Article in Japanese].
17. Duckers JM, Evans BA, Fraser WD, et al. Low bone mineral density in men with chronic obstructive pulmonary disease. Respir Res 2011;12:101.
18. Chiu KL, Lee CC, Chen CY. Evaluating the association of osteoporosis with inhaled corticosteroid use in chronic obstructive pulmonary disease in Taiwan. Sci Rep 2021;11:724.
19. Van Staa TP, Leufkens HG, Cooper C. Use of inhaled corticosteroids and risk of fractures. J Bone Miner Res 2001;16:581-8.
20. de Vries F, van Staa TP, Bracke MS, et al. Severity of obstructive airway disease and risk of osteoporotic fracture. Eur Respir J 2005;25:879-84.
21. Vestbo J, Anderson JA, Brook RD, et al. Fluticasone furoate and vilanterol and survival in chronic obstructive pulmonary disease with heightened cardiovascular risk (SUMMIT): a double-blind randomised controlled trial. Lancet 2016;387:1817-26.
22. Ferguson GT, Calverley PM, Anderson JA, et al. Prevalence and progression of osteoporosis in patients with COPD: Results from the towards a revolution in COPD Health Study. Chest 2009;136:1456-65.

Table 1. Gender Distribution of study participants according to T-score.

Gender	Normal (T-score ≥-1 SD)	Osteopenia (T-score -1 to -2.5 SD)	Osteoporosis (T-score < -2.5 SD)	Total	p
	n (%)	n (%)	n (%)	n (%)	
Male	9 (13.85)	10 (15.38)	46 (70.77)	65 (100)	0.3888 (NS)
Female	3 (8.57)	9 (25.71)	23 (65.71)	35 (100)	
Total	12 (12.0)	19 (19.0)	69 (69.0)	100 (100)	

Statistical analysis: Chi-square test; Statistically significant if p<0.05; NS: Not statistically significant

Table 2. Distribution of Study participants according to COPD GOLD Groups and T-score.

GOLD Group	Normal (-1 SD)	Osteopenia (-1 to -2.5 SD)	Osteoporosis (<-2.5 SD)	Total	p
	N (%)	N (%)	N (%)	N (%)	
A	1 (33.33%)	2 (66.67%)	0 (0.0%)	3 (100.0%)	
B	2 (16.67%)	4 (33.33%)	6 (50.0%)	12 (100.0%)	0.04 (S)
E	9 (10.59%)	13 (15.29%)	63 (74.12%)	85 (100.0%)	
Total	12 (12.0%)	19 (19.0%)	69 (69.0%)	100 (100.0%)	

Statistical analysis: Chi-square test. Statistically significant (S) if p<0.05.

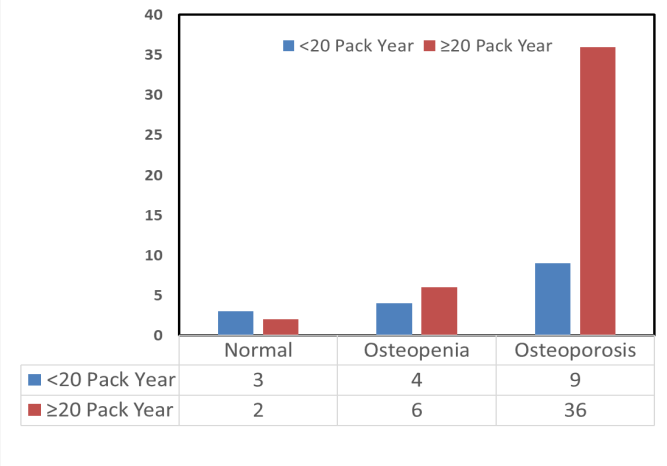

Figure 1. Relationship between smoking exposure and bone mineral density.

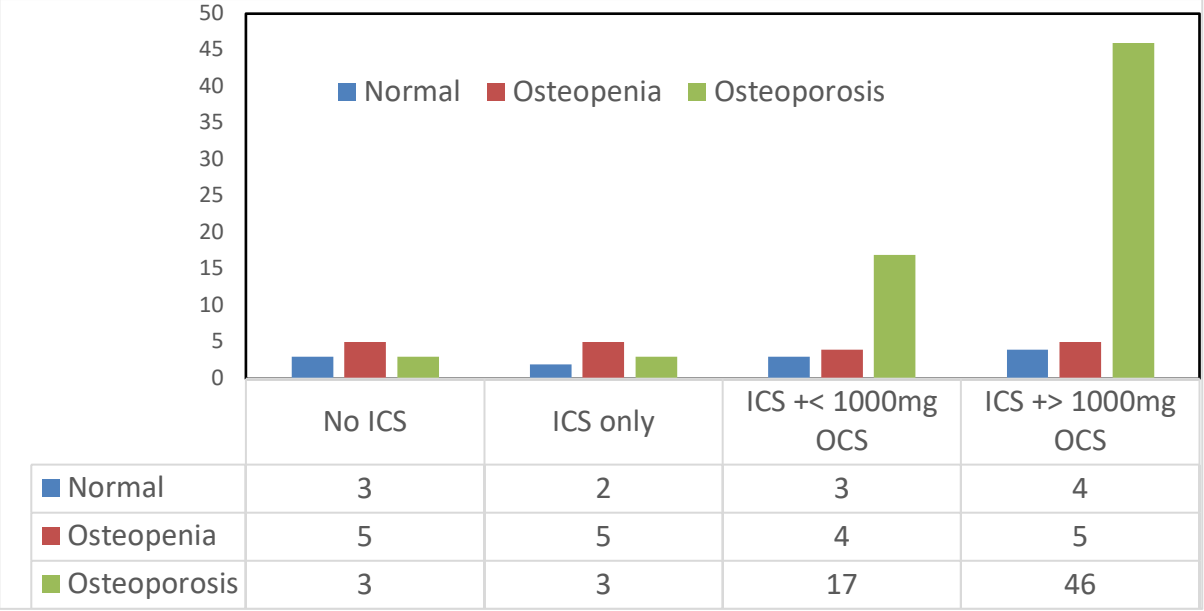

Figure 2. Effect of inhaled and systemic steroids on bone mineral density.