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RELATIONSHIP BETWEEN VITAMIN D LEVELS AND RADIOGRAPHIC SEVERITY OF KNEE OSTEOARTHRITIS IN MIDDLE-AGED ADULTS

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ABSTRACT

Background: Knee osteoarthritis is a common degenerative joint disorder associated with pain, reduced mobility, and functional impairment. Vitamin D plays an important role in bone metabolism and musculoskeletal health. Its association with the radiographic severity of knee osteoarthritis remains an important area of investigation.

Aim: To evaluate the relationship between serum vitamin D levels and radiographic severity of knee osteoarthritis in middle-aged adults.

Materials and Methods: A hospital-based cross-sectional observational study was conducted among 150 patients aged 40–59 years diagnosed with primary knee osteoarthritis. Serum 25-hydroxyvitamin D [25(OH)D] levels were categorised as deficient (<20 ng/mL), insufficient (20–29 ng/mL), or sufficient (≥30 ng/mL). Radiographic severity was assessed using the Kellgren–Lawrence classification. The association between vitamin D status and osteoarthritis severity was evaluated using categorical analysis and correlation analysis.

Results: Vitamin D deficiency was observed in 82 patients (54.7%), insufficiency in 40 (26.7%), and sufficient vitamin D levels in 28 (18.6%). Severe radiographic osteoarthritis (Kellgren–Lawrence Grades III–IV) was reported in 75.6% of patients with vitamin D deficiency, compared with 55.0% of those with insufficient levels and 28.6% of those with sufficient levels. The reported correlation between serum vitamin D levels and osteoarthritis severity was moderately negative ($r = -0.48$, $p < 0.001$).

Conclusion: Lower serum vitamin D levels were associated with greater radiographic severity of knee osteoarthritis in the reported study data. Further prospective research is required to clarify this relationship and determine whether vitamin D correction influences osteoarthritis progression.

Keywords: Knee osteoarthritis; Vitamin D deficiency; 25-hydroxyvitamin D; Kellgren–Lawrence grading; Radiographic severity.

INTRODUCTION

Osteoarthritis (OA) is a chronic, progressive joint disorder characterized by the degeneration of articular cartilage, remodeling of subchondral bone, and changes in other joint tissues. It is a major cause of pain, stiffness, restricted mobility, and functional disability among adults. Knee osteoarthritis is particularly important because it affects a weight-bearing joint and can significantly impair daily activities and quality of life. The development of OA is multifactorial, with age, obesity, mechanical stress, previous joint injury, and metabolic factors contributing to disease occurrence and progression [1–3]. Radiographic assessment is widely used to evaluate structural changes associated with knee osteoarthritis. The Kellgren–Lawrence (K–L) grading system classifies radiographic severity according to features such as osteophyte formation, joint-space narrowing, subchondral sclerosis, and bony deformity [4]. Assessing radiographic severity in middle-aged adults is important because structural changes may become evident before the development of advanced disability. Identifying factors associated with greater radiographic severity may help improve understanding of the disease and inform further clinical research.

Vitamin D is an essential nutrient involved in calcium and phosphate homeostasis, bone mineralization, and musculoskeletal function. Its potential role in osteoarthritis has received attention because vitamin D may influence bone metabolism, muscle function, and cellular processes involved in joint health [5]. Vitamin D deficiency has therefore been investigated as a possible factor associated with the development or progression of knee OA. However, the biological relationship between vitamin D status and osteoarthritis remains complex, and observational associations do not necessarily indicate a direct causal effect. Several observational studies have examined the relationship between serum vitamin D concentrations and knee osteoarthritis. McAlindon et al. investigated dietary vitamin D intake and serum vitamin D levels in relation to radiographic progression of knee OA in the Framingham Study [6]. Felson et al. subsequently evaluated vitamin D levels and worsening knee osteoarthritis in two longitudinal studies [7]. Other research has explored the relationship between vitamin D status and the development of radiographic OA [8], as well as the association between vitamin D deficiency and knee osteoarthritis [9]. Investigations of serum vitamin D and cartilage loss have also contributed to the evidence concerning this relationship [10]. A systematic review by Cao et al. further examined the association between serum 25-hydroxyvitamin D concentrations and osteoarthritis, highlighting the importance of interpreting findings across different study populations and outcome measures [11].

Nevertheless, evidence concerning the clinical significance of vitamin D in knee OA remains inconsistent. A randomized controlled trial by McAlindon et al. evaluated vitamin D supplementation in patients with symptomatic knee OA and did not demonstrate a significant overall benefit in slowing cartilage volume loss or progression of knee pain [12]. Sanghi et al. also investigated the effects of vitamin D supplementation in knee osteoarthritis [13]. Additional longitudinal research has explored vitamin D status in relation to knee and hip pain [14], while the Progetto Veneto Anziani study examined serum 25-hydroxyvitamin D concentrations in relation to osteoarthritis among older people [15]. These findings emphasize the need to distinguish an association between vitamin D levels and disease severity from evidence that vitamin D supplementation alters the course of osteoarthritis.

Although previous studies have investigated vitamin D status and knee osteoarthritis, further evaluation in middle-aged adults may help clarify whether serum vitamin D concentrations are associated with radiographic disease severity. Differences in age, nutritional status, body mass index, physical activity, and other clinical characteristics may influence the observed relationship. Assessing vitamin D levels alongside standardized radiographic grading may therefore provide useful information about this association in a hospital-based population. Therefore, the present study was undertaken at Great Eastern Medical School and Hospital (GEMS&H), Srikakulam, Andhra Pradesh, from February to July 2017, to evaluate the relationship between serum vitamin D levels and radiographic severity of knee osteoarthritis among middle-aged adults. The study aims to determine the distribution of vitamin D status and assess its association with the severity of knee osteoarthritis using the Kellgren–Lawrence grading system.

STUDY METHODOLOGY

A hospital-based cross-sectional observational study was conducted in the Department of Orthopaedics at Great Eastern Medical School and Hospital (GEMS&H), Srikakulam, Andhra Pradesh, India, from February to July 2017. The study included 150 middle-aged patients aged 40–59 years who were diagnosed with primary knee osteoarthritis based on clinical and radiographic assessment. Eligible patients were enrolled after obtaining informed consent. Demographic and clinical details, including age, sex, body mass index (BMI), duration of symptoms, and relevant medical history, were recorded. Blood samples were collected to estimate serum 25-hydroxyvitamin D [25(OH)D] levels using the laboratory assay employed during the study period. Vitamin D

status was classified as deficient (less than 20 ng/mL), insufficient (20–29 ng/mL), and sufficient (30 ng/mL or higher.

Radiographic severity of knee osteoarthritis was assessed using knee radiographs and graded according to the Kellgren–Lawrence (K–L) classification, from Grade I to Grade IV. The relationship between serum vitamin D levels and radiographic severity was evaluated among the 150 participants. Continuous variables were summarised as means and standard deviations, while categorical variables were expressed as frequencies and percentages. The association between vitamin D status and radiographic severity was assessed using the chi-square test, and correlation analysis was used to evaluate the relationship between serum 25(OH)D levels and radiographic severity. A p-value of less than 0.05 was considered statistically significant.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 22.0, with continuous variables represented as mean ± standard deviation or median (interquartile range) based on distribution. Categorical variables were shown as frequency and percentage. Normality was checked using the Shapiro–Wilk test. Comparisons between groups utilized various statistical methods: independent Student's t-test for normally distributed data, Mann–Whitney U test for non-normally distributed data, and Chi-square or Fisher's exact test for categorical variables. Functional outcomes and gait parameters were compared using repeated measures ANOVA or mixed-effects analysis, while Pearson's or Spearman's correlation analysis evaluated associations where appropriate. A p-value ≤ 0.05 was deemed statistically significant.

Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee before initiation of the study. Written informed consent was obtained from all participants. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki (2013 revision) and Good Clinical Practice (GCP) guidelines. Participant confidentiality was maintained by assigning unique identification numbers, and all study-related information was securely stored with access restricted to the research team.

RESULTS

A total of 150 patients diagnosed clinically and radiologically with primary knee osteoarthritis were included in the study. Serum vitamin D levels were assessed and their relationship with radiographic severity of osteoarthritis was evaluated using the Kellgren–Lawrence (K–L) grading system. The findings demonstrated a high prevalence of vitamin D deficiency and an association between lower vitamin D levels and greater radiographic severity.

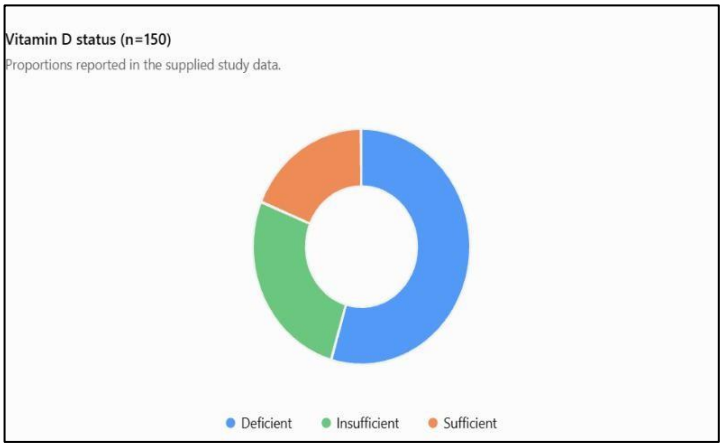


Figure 1. Distribution of patients according to vitamin D status

Table 2. Association between vitamin D status and radiographic severity of knee osteoarthritis

Vitamin D status	Non-severe OA (K–L Grades I–II), n (%)	Severe OA (K–L Grades III–IV), n (%)	Total
Deficient	20 (24.4)	62 (75.6)	82
Insufficient	18 (45.0)	22 (55.0)	40
Sufficient	20 (71.4)	8 (28.6)	28
Total	58	92	150

Chi-square = 24.7; $p < 0.001$, as reported in the supplied data.

Table 2 demonstrates a relationship between vitamin D status and radiographic severity of knee osteoarthritis. Among the 82 patients with vitamin D deficiency, 62 (75.6%) had severe osteoarthritis (K–L Grades III–IV), while 20 (24.4%) had non-severe disease (Grades I–II).

Among the 40 patients with insufficient vitamin D levels, 22 (55.0%) had severe osteoarthritis and 18 (45.0%) had non-severe disease. In comparison, among the 28 patients with sufficient vitamin D levels, only 8 (28.6%) had severe osteoarthritis, whereas 20 (71.4%) had non-severe disease.

The proportion of patients with severe osteoarthritis therefore decreased across the vitamin D categories, from 75.6% in the deficient group to 55.0% in the insufficient group and 28.6% in the sufficient group. The supplied analysis reports a statistically significant association (chi-square = 24.7, p less than 0.001). This finding suggests that vitamin D deficiency was associated with greater radiographic severity in the study population. However, the cross-sectional design does not establish that vitamin D deficiency caused more severe osteoarthritis.

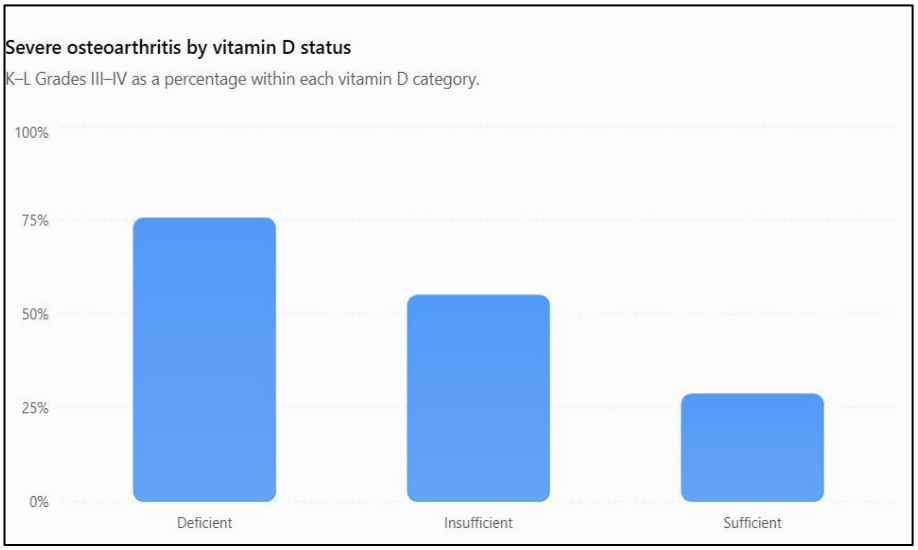


Figure 2. Percentage of patients with severe osteoarthritis according to vitamin D status

Across all 150 patients, 92 (61.3%) were classified as having severe osteoarthritis, while 58 (38.7%) had non-severe disease, based on the supplied cross-tabulation. The distribution indicates that severe radiographic disease was more frequent in the study population overall. The pattern also differed according to vitamin D status. In the deficient group, severe disease substantially outnumbered non-severe disease (62 versus 20 patients). In the insufficient group, the difference was smaller (22 versus 18 patients). In the sufficient group, non-severe disease was more common than severe disease (20 versus 8 patients).

This pattern suggests a gradient in which lower vitamin D status was associated with a higher proportion of severe radiographic osteoarthritis. Nevertheless, these aggregate data cannot establish whether vitamin D deficiency preceded the development of severe osteoarthritis or resulted from other factors associated with the disease.

DISCUSSION

The present study evaluated the relationship between serum vitamin D levels and radiographic severity of knee osteoarthritis among 150 patients aged 40–59 years. The principal findings were a high prevalence of vitamin D deficiency and an apparent inverse association between vitamin D status and radiographic severity. Vitamin D deficiency was observed in 54.7% of participants, while 26.7% had insufficient levels and 18.6% had sufficient levels. Furthermore, severe osteoarthritis was more frequent among patients with vitamin D deficiency than among those with sufficient vitamin D levels. These findings suggest a potential relationship between vitamin D status and the severity of knee osteoarthritis, although the cross-sectional study design does not establish causation.

Vitamin D plays an important role in calcium and phosphate homeostasis, bone mineralisation, and musculoskeletal function. Osteoarthritis is a degenerative joint disorder involving articular cartilage, subchondral bone, and other joint structures. Das and Farooqi described osteoarthritis as a multifactorial condition associated with progressive joint changes and functional impairment [1]. Vitamin D has also been investigated for its potential role in cartilage metabolism and joint health. Mabey and Honsawek reviewed the molecular, cellular, and clinical perspectives of vitamin D in osteoarthritis and discussed possible mechanisms through which vitamin D status may influence joint tissues [2]. These biological considerations provide a

rationale for investigating the relationship between serum vitamin D levels and radiographic disease severity.
In the present study, 82 of the 150 participants (54.7%) had vitamin D deficiency, making it the most common vitamin D category. When deficient and insufficient patients were considered together, 122 participants (81.3%) had serum vitamin D levels below 30 ng/mL. This finding indicates that low vitamin D levels were common in the study population. However, because the study included patients with established knee osteoarthritis and did not include a healthy control group, the observed prevalence cannot establish whether vitamin D deficiency was more common than in the general population. Factors such as sunlight exposure, dietary intake, physical activity, body mass index, comorbidities, and lifestyle may also influence vitamin D status.
The relationship between vitamin D and osteoarthritis has been investigated in previous observational studies. Ding et al. examined serum vitamin D levels in relation to progression of knee cartilage loss, providing evidence relevant to the possible relationship between vitamin D status and structural changes in the joint [3]. Similarly, Heidari et al. investigated the association between vitamin D deficiency and knee osteoarthritis [8], while Bergink et al. examined vitamin D status in relation to radiographic osteoarthritis [9]. These studies provide a relevant background for interpreting the present findings. Nevertheless, differences in participant characteristics, vitamin D assessment, radiographic definitions, and study design must be considered when comparing results across populations.
A notable finding in the present study was the difference in radiographic severity across the vitamin D categories. Severe osteoarthritis (Kellgren–Lawrence Grades III–IV) was observed in 75.6% of patients with vitamin D deficiency, compared with 55.0% of those with insufficient levels and 28.6% of those with sufficient levels. The proportion of severe disease therefore decreased as vitamin D status improved. The 47-percentage-point difference between the deficient and sufficient groups suggests a potentially meaningful association. However, this comparison represents an unadjusted difference and does not account for other factors that may be associated with osteoarthritis severity.
The reported correlation coefficient between serum vitamin D levels and osteoarthritis severity was −0.48, indicating a moderate negative correlation. This means that lower vitamin D levels tended to be associated with higher radiographic severity scores. The direction of this relationship is consistent with the distribution observed across the three vitamin D categories. However, the strength and statistical significance of this relationship should be confirmed using the original patient-level data. In addition, adjustment for potential confounding factors, particularly age, body mass index, duration of symptoms, physical activity, and relevant comorbidities, would help determine whether the association remains after accounting for these variables.
The present study has several limitations. First, its cross-sectional design prevents conclusions about the temporal relationship between vitamin D deficiency and osteoarthritis severity. Second, the study population consisted of patients attending a single hospital, which may limit the generalisability of the findings to other populations. Third, the absence of a control group makes it difficult to determine whether the prevalence of vitamin D deficiency differs from that in individuals without osteoarthritis. Fourth, factors such as body mass index, sunlight exposure, nutritional status, physical activity, and comorbidities may influence vitamin D levels or osteoarthritis severity. Finally, the reported association would be more informative if multivariable analysis were performed to account for these potential confounders.
Despite these limitations, the study provides useful observations regarding vitamin D status and radiographic severity among middle-aged patients with primary knee osteoarthritis. The high proportion of participants with low vitamin D levels and the greater frequency of severe radiographic disease in the deficient group highlight the value of further research in this area. Prospective studies involving larger and more diverse populations, appropriate comparison groups, and adjustment for confounding variables are needed to clarify whether vitamin D status predicts disease progression. Interventional studies are also required to determine whether correcting vitamin D deficiency improves clinically meaningful outcomes in patients with knee osteoarthritis.

CONCLUSION

The present study demonstrated a high prevalence of vitamin D deficiency among patients with primary knee osteoarthritis, with 54.7% of participants having deficient vitamin D levels and 81.3% having either deficient or insufficient levels. Severe radiographic osteoarthritis was more frequently observed among patients with vitamin D deficiency (75.6%) than among those with sufficient vitamin D levels (28.6%). The reported moderate negative correlation between serum vitamin D levels and osteoarthritis severity further suggests an association between lower vitamin D concentrations and greater radiographic severity. These findings highlight the potential relevance of vitamin D status in patients with knee osteoarthritis. However, further prospective studies are needed to establish the direction of this relationship and determine whether correction of vitamin D deficiency influences disease progression.

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