RESEARCH PAPER

Cross Sectional Magnetic Resonance Imaging-Based Vertebral Bone Quality Score and Dual-Energy X-Ray Absorptiometry Bone Mineral Density Measurement in Post Menopausal Women in South Indian Population with or Without Fragility Fracture

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Received: 28th Feb, 2026; Revised: 6th March 2026; Accepted: 7th April, 2026; Available Online: 20th April, 2026

ABSTRACT
Background: The prevalence of osteoporosis in postmenopausal women is one out of every three women, according to recent studies. Awareness and management of osteoporosis are underrated. Objective: This cross-sectional study aimed to emphasise the importance of early detection of osteoporosis in post menopausal females. Methodology: In the present study, 70 Postmenopausal women (35 women with and 35 women without fracture fragility) who fulfilled the inclusion criteria were enrolled. A MRI and DEXA-based VBQ score was analyzed for all the particupating individuals. It was observed that the correlation exibhit between these two scores. Results: The observation found an individual age of 67.6 years, T-scores mean of 1.9, Z-scores of -0.6, and VBQ scores of 3.4, determining bone density in osteoporotic individuals. These outcomes explains the need for early osteoporosis detection to evade the chances of fractures. The VBQ-fracture correlation análisis determines its value is complementing DEXA for upgraded osteoporosis risk detection. Discussion: The current study revealed significant vertebral fracture categorization in older adults. The equal categorization of fractures (50%) and their improved correlation with signal intensity radiating pain VBQ scores and DEXA scores indicate that these variables may be useful in predicting fracture risk. Conclusion: These results highlight the need for a thorough method that incorporates imaging bone density measurements and clinical indicators in order to determine fractures.
Keywords: Dual energy X-ray absorptiometry; Fracture; MRI; Osteoporosis; Postmenopausal women; VBQ score
How to cite this article: Udaya Shankar SR, Shangamithra S, Sirohi V, Arun Kumar KV, Mohideen S, Manoj Kumar R, Elangovan P. Cross Sectional Magnetic Resonance Imaging-Based Vertebral Bone Quality Score and Dual-Energy X-Ray Absorptiometry Bone Mineral Density Measurement in Post Menopausal Women in South Indian Population with or Without Fragility Fracture. Int J Drug Deliv Technol. 2026;16(61s): 373-388. DOI: 10.25258/ijddt.16.61s.41
Source of support: Nil.
Conflict of interest: None

1. INTRODUCTION

Menopausal women frequently experience serious health issues primarily with regard to the strength and health of their bones. Inadequate calcium intake low vitamin D levels and unhealthy lifestyle choices are some of the contributing factors to this increased risk [1]. Frangibility fractures which typically result from a marginal effect involving an easy fall from a straight position are a major concern for postmenopausal women [2]. A major factor responsible for fall is estrogen content after menopause, which speed up the bone loss by reducing the production of new elements of bone and encourage resorption. Poor diet, mainly deficiency of vitamin D and calcium, further debilitate bones [3]. Furthermore, genetic changes such as a family history of osteoporosis can raise the risk of the condition. In the southern region of India osteoporosis is a public health concern particularly for postmenopausal women [4].

According to recent research one in three postmenopausal women experience osteoporosis a condition characterized by weak brittle bones. Treatments and preventative measures for osteoporosis remain insufficient despite the diseases high incidence and serious findings [5].

Bone mineral density (BMD) analyzed by dual-energy X-ray absorptiometry (DEXA) technique is the global standard control for detecting the problem of osteoporosis. While this broadly utilized, DEXA has some limitations

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also—it often underrates the probability of fracture, possibly leaving many females without the proactive care they require at that specific time [6]. Ability of DEXA for analyzing bone mass in the spine and hip region while avoiding other vulnerable areas like wrist or ankle presents a remarkable challenge. Additionally, DEXA also ignores other important risk factors that plays a role in developing osteoporosis , such as lifestyle , age and genetics [7]. The lower BMD values has a higher risk of fractures and weaker bones emphasizing the need for a more thorough approach to osteoporosis analysis and prevention [8].

Researchers have begun examining the use of magnetic resonance imaging (MRI) to assess bone health in an effort to limit the limitations of traditional bone density analysis. Although MRI has primarily been used to identify soft tissue damage and disc abnormalities technological advancements have now made it feasible to assess bone strength as well. By examining bone microarchitecture and its composition MRI offers a more comprehensive assessment of bone mass than DEXA which only focuses on bone mineral health [9]. This method is based on examining changes in signal depth from T1-weighted MRI scans of the lumbar vertebrae and cerebrospinal fluid. The VBQ score offers a precise measurement of general well-being by assessing these variabilities [10].

Researchers have demonstrated a robust correlation between the VBQ score and aging establishing it as a reliable marker for identifying osteopenia and osteoporosis. The VBQ score aids in more accurately identifying fragile fractures since bone strength decreases with age. Because of this it is a helpful tool for identifying females who are more vulnerable enabling suitable intervention and pertinent treatments to postpone serious problems [11]. The VBQ score's reliability and usefulness in medical analysis are further enhanced by its compatibility and consistency across various MRI scans. Because of its reproducibility wellness providers can rely on the VBQ score to identify changes in bone quality over time or assess the effectiveness of therapeutic approaches [12].

Osteoporosis is frequently referred to as a silent ailment because it is not noticeable until a fracture happens. These fractures can cause major issues for postmenopausal women including excruciating pain diminished autonomy and a potential change in death rates. Researchers found that women who experience osteoporotic fractures are more likely to die within the first year than women who do not have fractures [13]. Early detection and proactive management can play a crucial role in preventing fractures and their complications. But for women to receive timely and effective treatment, they first need to be aware of their risk for osteoporosis. This is where the importance of management and raising awareness comes into play [14]. Thus, this study aims to measure the magnetic resonance imaging-based vertebral bone quality score and dual-energy x-ray absorptiometry bone mineral density in postmenopausal women. To determine the predictive value of the VBQ score for the prevalence of osteoporosis in postmenopausal women with no fragility fracture.

2. MATERIALS AND METHODS

2.1 STUDY TYPE, METHODOLOGY, AND DESIGN:

Descriptive, Mixed-Method (Qualitative and quantitative) and cross-sectional observational investigation.

2.2 Ethical Approval

The ethical authorization (IHEC-I/3150/24) was secured from the Institutional Human Ethics Committee (CARE-IHEC-I), Chettinad Academy of Research and Education, India, and written permission was obtained following a comprehensive explanation of the research methodology.

2.3 Study Setting

Department of Orthopaedics, Chettinad Hospital and Research Institute, Kelambakkam.

2.4 Duration Of Study

2 years (2023-2025)

2.5 Study Group

Who fulfil the inclusion criteria and exclusion criteria has been included in the study

2.6 Sample Size

70 postmenopausal women, with 35 women in each group who fulfil the inclusion and exclusion criteria, shall be included in the study

2.7 Study Design

The research is based on peer-reviewed articles published in English and indexed in various databases, including Google Scholar, NCBI, Scopus, ScienceDirect, Web of Science, and PubMed. The keywords that are utilized to search the information are as follows: modified Rasmussen score, osteosynthesis, Schatzker type, and tibial plateau fracture. The aforementioned databases were selected to compile the discussion of the present article

2.7.1 Inclusion Criteria

- Postmenopausal women
- Osteoporotic vertebral fractures
- Age greater than 60 years
- Chronic low back pain for more than 4 weeks

2.7.2 Exclusion Criteria

- Individuals with metabolic bone disorders like Paget's disease, fibrous dysplasia, osseous neoplasms, or osteogenesis imperfecta
- Those with metastatic spine disease or a family history of spinal radiation
- Patients with congenital spinal anomalies.
- History of lumbar spine surgery

2.8 Participant Information And Variables

All participants were informed in their local language about the study's purpose, procedure, benefits, risks, potential complications, and confidentiality measures.

Informed consent was obtained from participants who were willing to participate. Additionally, permission was secured to reproduce their investigation results and imaging films, as well as to use clinical evaluation data for publication in indexed journals, while ensuring confidentiality.

2.9 Study Procedure

This study was conducted on patients from the Chettinad Hospital and Research Institute Orthopaedics outpatient or emergency department who met the eligibility criteria. Written informed consent was obtained. Comprehensive demographic data, medical history and clinical examinations were recorded for all patients. Dual-energy X-ray absorptiometry (DEXA) was used to measure bone mineral density and an MRI-based vertebral bone quality score was assessed.

2.10 Vertebral Bone Quality (Vbq) Score Calculation

To determine the VBQ score a non-contrast, T1-weighted MRI of the lumbar spine was used . The median signal intensity (SI) of the trabecular bone in the L1–L4 vertebrae was measured using a mid-sagittal section. A relative vertebral body SI was then calculated by dividing the median SI of these vertebrae by the SI of the cerebrospinal fluid (CSF). At the L3 level, CSF SI was measured inside a region of interest (ROI). The ROI was measured at L2 or L4 if nerve roots blocked the L3 CSF space.

VBQ Score

VBQ score = SI(L1L4) / SI(CSF)

2.11 Data Analysis And Statistical Methods

DEXA and VBQ scores were compared between patients with and without fragility fractures. The data obtained were analyzed and compared between the two groups using appropriate statistical tools.

3. RESULTS

The following Table 1 and Figure 1, and 2 illustrate the relationship between MRI-based Vertebral Bone Quality (VBQ) scores and DEXA-derived Bone Mineral Density (BMD) in postmenopausal Women from South India who have fragility fractures or do not. The primary goal of the study is to assess VBQ's predictive scores in diagnosing osteoporosis in women without fractures and to analyze the clinical correlation between VBQ scores, BMD, and new-onset fragility fractures. By the integration of these imaging approaches, the investigations aim to improve the diagnosis and control of early osteoporosis, majorly decreasing the chances of fragility fractures in this broader-risk population.

Fig. (1). MRI illustrations of osteoporotic female individual without vertebral fracture. a. 70-year-old; and b. 74-year-old female patients.

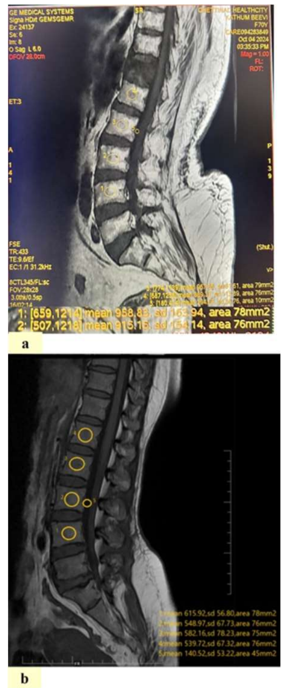

Fig. (2). MRI images of osteoporotic female patients with vertebral fracture. a. 70-year-old; and b. 67-year-old female patients.

3.1 Socio-Demographic Profile

3.1.1 Age Distribution

Table 1 revealed the categorization of individuals across variable age groups in the present investigation. Most individuals, 55.71%, lie within the 60-65 years of age range, forming this the greatest group with 39 individuals. The 66-70 years age group comprises 18.57% of the total, with 13 patients. Lastly, those over 70 years make up 25.71% of the patients, totalling 18 individuals. In summary, the study population is predominantly aged 60-65 years, followed by those over 70 years, and finally those aged 66-70 years (Figure 3a).

3.1.2 Distribution Of Occupation

Table 1 illustrates the distribution of patients by occupation. The majority of patients, 64.29%, are housewives, comprising 45 individuals. Daily wagers constitute the second-largest group, representing 28.57% of the total, with 20 patients. Attenders make up 5.71% of the patients, totaling 4 individuals, and there is one teacher, accounting for 1.43% of the total. In summary, housewives are the predominant occupational group in the study, followed by daily wage earners, attendants, and teachers (Figure 3b).

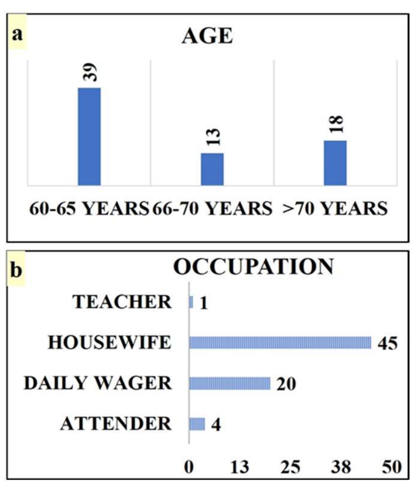

Fig. (3). Socio-demographic profile in post-menopausal women in the south Indian population. a. Age, and b. Occupation.

3.1.3 Distribution Of Co-Morbidities

Table 1 shows the distribution of co-morbidities among the patients. A significant majority, 71.43% (50 patients), reported having no comorbidities. Among those with co-morbidities, 12.86% (9 patients) were diagnosed with diabetes, while 11.43% (8 patients) had hypertension. A smaller percentage, 2.86% (2 patients), had hyperlipidemia, and 1.43% (1 patient) had both hypertension and diabetes (Figure 4a).

3.1.4 Distribution Of Symptoms

Table 1 lists the symptoms presented by the patients, including low back pain. The number of patients who reported the symptom of "Low Back Pain" is 70, indicating that **every patient in the sample experienced this symptom.**

3.1.5 Distribution Of Radiating Pain

The majority of patients (68.57%) do not report radiating pain. About one-third of patients (31.43%) experienced radiating pain in either the right or left lower limb, or in both (Figure 4b).

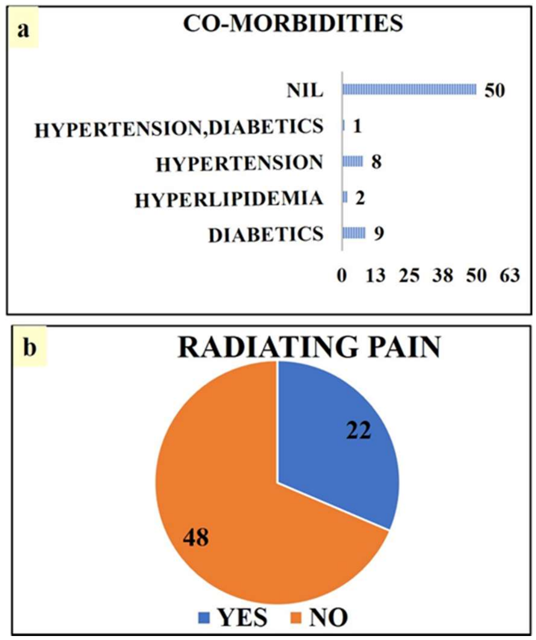

Fig. (4). Socio-demographic profile in post-menopausal women in the south Indian population. a. Co-morbidities, and b. Radiating pain.

3.1.6 Distribution Of Neurological Deficits

Table 1 presents the distribution of neurological deficits among the patients. The vast majority, 87.14% (61 patients), reported no neurological deficits. Among those with deficits, 4.29% (3 patients) had reduced sensations over the L4 region, and 2.86% (2 patients) had reduced sensations over the Extensor hallucis longus (EHL) and L4L5, respectively (Figure 5a).

3.1.7 Presence/Absence Of Vertebral Body Fractures

Table 1 below indicates an equal distribution of vertebral body fractures among the patients. Out of 70 patients, 50% (35 patients) were found to have vertebral body fractures, while the other 50% (35 patients) did not. This suggests that half of the study population experienced vertebral body fractures, highlighting the prevalence of this condition within the group.

3.1.8 Vertebrae Level Csf Signal Intensity

Table 1 below displays the distribution of cerebrospinal fluid (CSF) signal intensity at different vertebral levels among the 70 patients studied. The overwhelming majority, 88.57% (62 patients), showed CSF signal strength at the L3 vertebral level. A smaller group, comprising 10% (7 patients), exhibited CSF signal strength at the L2 level, and only 1.43% (1 patient) had CSF signal strength at the L4 level. This indicates that L3 is the most common vertebral level for CSF signal intensity in this patient population (Figure 5b).

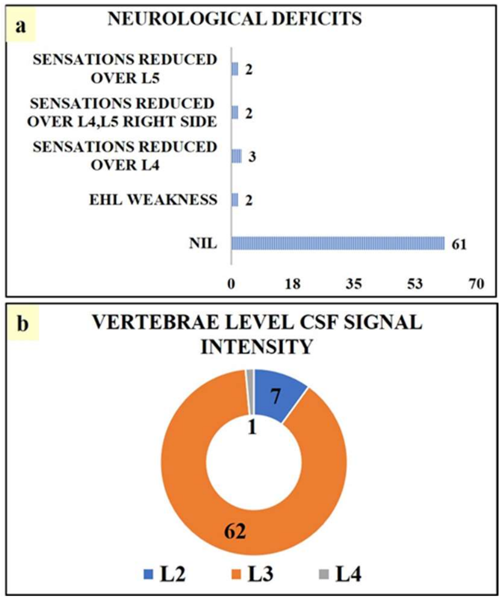

Fig. (5). Socio-demographic profile in post-menopausal women in the South Indian population. a. Neurological deficits; and b. Vertebrae level CSF signal intensity

Table 1. Socio-demographic profile in post-menopausal women in the South Indian population

Age	No. of patients	Percentage (%)
60-65 years	39	55.71
66-70 years	13	18.57
>70 years	18	25.71
Total	70	100
Occupation	**No of patients**	**Percentage (%)**
Attender	4	5.71
Daily wager	20	28.57
Housewife	45	64.29
Teacher	1	1.43
Total	70	100
Co-morbidities	**No of patients**	**Percentage (%)**
Diabetics	9	12.86
Hyperlipidemia	2	2.86
Hypertension	8	11.43
Hypertension, diabetes	1	1.43
Nil	50	71.43
Total	70	100
Symptoms	**No of patients**	**Percentage (%)**
Low back ache	70	100
Total	70	100
Radiating pain	**No of patients**	**Percentage (%)**
Yes	22	31.43
No	48	68.57
Total	70	100
Neurological deficits	**No of patients**	**Percentage (%)**
Ehl weakness	2	2.86
Sensations reduced over l4	3	4.29
Sensations reduced over l4,l5	2	2.86
Sensations reduced over l5	2	2.86
Nil	61	87.14
Total	70	100
Presence of vertebral body fractures	**No of patients**	**Percentage (%)**
Yes	35	50

No	35	50
Total	70	100
Vertebrae level CSF signal intensity	**No of patients**	**Percentage (%)**
L2	7	10
L3	62	88.57
L4	1	1.43
Total	70	100

3.2 Mean Socio-Demographic Profile

3.2.1 Mean Distribution Of Age

Table 2 presents the age distribution of 70 patients included in the study. The average age is 67.6 years, with a standard deviation of 6.7 years. This suggests that most patients are approximately 67.6 years old, with an age variation of around 6.7 years. The standard deviation indicates a moderate spread, meaning the majority of participants fall within a relatively narrow age range around the mean.

3.2.2 Mean Distribution Of Signal Intensity At L1

Table 2 below provides data on the mean signal intensity at the L1 vertebral level for 70 patients. The mean signal intensity is 657.3, with a standard deviation of 122. This indicates that, on average, the signal intensity at L1 is 657.3 units, with the values typically varying by 122 units around this mean. The standard deviation suggests there is some variability in signal intensity levels, but most values cluster around the mean.

3.2.3 Mean Distribution Of Signal Intensity At L2

Table 2 showcase values on the mean signal intensity at the L2 vertebral level for 70 individuals. The mean signal intensity is 670.5, with a standard deviation of 129.7. This revealed that, accordingly, the signal intensity at L2 is 670.5 units, with the data commonly varying by 130 units around this mean. The standard deviation revealed there is some variation in signal intensity levels, but major data gather around the mean.

3.2.4 Mean Distribution Of Signal Intensity At L3

The mean signal intensity is 669.3, with a standard deviation of 119. This revealed that, accordingly, the signal intensity at L3 is 669.3 units, with the data commonly varying by 119 units around this mean. The standard deviation showcases that there is some variation in signal intensity levels, but major data is close to the mean (Table 2).

3.2.5 Mean Distribution Of Signal Intensity At L4

The mean signal intensity is 673.6, with a standard deviation of 124.4. This revealed that, accordingly, the signal intensity at L4 is 673.6 units, with the data commonly varying by 124.4 units surrounding this mean. The standard deviation suggests some variability in signal intensity levels, but most values are close to the mean (Table 2).

3.2.6 Median Signal Intensity Of L1-L4

Table 2 below presents median signal intensity measurements from vertebral levels L1 to L4 for 70 patients. The median signal intensity is 654.5, with a standard deviation of 115.4. This means that the central value of signal intensities at these vertebral levels is 654.5 units, with typical variations of around 115.4 units. While there is some variability, the standard deviation indicates that most values remain relatively close to the median.

3.2.7 Csf Signal Intensity

The mean signal intensity is 182.6, with a standard deviation of 38. This indicates that, on average, the CSF signal intensity is 182.6 units, with the values typically varying by 38 units around this mean. The standard deviation suggests some variability in signal intensity levels, but most values are close to the mean (Table 2).

3.2.8 Dexa T-Score

The mean T-score is -1.9, with a standard deviation of 1.2, indicating that, on average, patients have low bone mass or osteopenia. The standard deviation suggests some variation in T-scores among patients, but most values remain relatively close to the mean (Table 2).

3.2.9 Dexa Z-Score

Table 2 presents the DEXA Z-scores for 70 patients, with a mean Z-score of -0.6 and a SD of 1. This suggests that, on average, People have slightly lower bone density compared to their age group. The standard deviation indicates some variation, but most Z-scores remain close to the mean (Table 2).

3.2.10 Vbq Score=Si(L1-L4)/Si (Csf)

Table 2 presents the Vertebral Bone Quality (VBQ) scores for 70 patients, analyzed as the ratio of signal strength from L1 to L4 to the cerebrospinal fluid (CSF) signal intensity. The mean VBQ score is 3.4, with a standard deviation of 0.8. This indicates that, on average, patients have a VBQ score of 3.4, with typical variations of 0.8 units. While there is some variability, most scores remain close to the mean.

Table 2. Mean socio-demographic profile in post-menopausal women in the South Indian population

Variable	N	Mean	Std. Dev.
Age	70	67.6	6.7
Mean signal intensity at L1	70	657.3	122
Mean signal intensity at L2	70	670.5	129.7
Mean signal intensity at L3	70	669.3	119
Mean signal intensity at L4	70	673.6	124.4
Median signal intensity of L1-L4	70	654.5	115.4

Csf signal intensity	70	182.6	38
Dexa T-score	70	-1.9	1.2
Dexa Z-score	70	-0.6	1
Vbq score=si(L1-L4)/si (CSF)	70	3.4	0.8

3.3 Socio-Demographic Factors And Fractures

3.3.1 Distribution Of Age And Fracture

Table 3 and Figure 6a present the distribution of fractures among different age groups of the 70 patients, along with the associated p-value:

- 60-65 Years: 21 patients (60%) had fractures, and 18 patients (51.4%) did not, making this the largest age group with a total of 39 patients (55.7%).
- 66-70 Years: 4 patients (11.4%) had fractures, while 9 patients (25.7%) did not, totaling 13 patients (18.6%).
- >70 Years: 10 patients (28.6%) had fractures, and 8 patients (22.9%) did not, summing up to 18 patients (25.7%).

A p-value of 0.305 shows that there is no statistically important difference in fracture distribution across different age groups. This suggests that age may not be a key factor influencing fracture occurrence in this study population.

3.3.2 Distribution Of Occupation And Fracture

Table 3 and Figure 6b display the distribution of fractures among patients with different occupations, along with the associated p-value:

- **Attender:** Both with and without fractures make up 5.7% (2 patients each) of the total, resulting in a total of 4 patients (5.7%).
- **Daily Wager:** Patients with fractures are 31.4% (11 patients) and those without are 25.7% (9 patients), totalling 20 patients (28.6%).
- **Housewife:** The largest group, with 62.9% (22 patients) having fractures and 65.7% (23 patients) not having fractures, for a total of 45 patients (64.3%).
- **Teacher:** No patients with fractures, with only 1 patient (2.9%) without fractures, totalling 1 patient (1.4%)

The p-value of 0.919 suggests no statistically significant difference in the distribution of fractures among the different occupational groups.

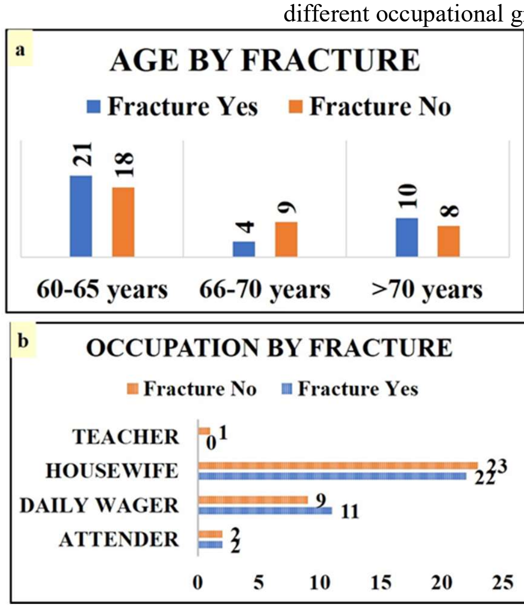

Fig. (6). Mean socio-demographic profile in post-menopausal women in the South Indian population. a. Age by fracture; and b. Occupation by fracture.

3.3.3 Distribution Of Co-Morbidities And Fracture

Table 3 and Figure 7a shows the distribution of co-morbidities among patients with and without fractures, along with the associated p-value:

- **Diabetics:** 11.4% (4 patients) with fractures and 14.3% (5 patients) without fractures, totalling 12.9% (9 patients).
- **Hyperlipidemia:** Both with and without fractures make up 2.9% (1 patient each), resulting in 2.9% (2 patients) of the total.
- **Hypertension:** 14.3% (5 patients) with fractures and 8.6% (3 patients) without fractures, totalling 11.4% (8 patients).
- **Hypertension, Diabetics:** No patients with fractures and 2.9% (1 patient) without fractures, making up 1.4% (1 patient).

- **No Co-morbidities (NIL):** Both with and without fractures constitute 71.4% (25 patients each), totalling 50 patients.

A p-value of 0.922 indicates that there is no statistically significant difference in fracture distribution among the different co-morbidity groups. This suggests that the presence of co-morbidities does not have a notable impact on fracture occurrence in this study population.

3.3.4 Distribution Of Radiating Pain And Fracture

Table 3 and Figure 7b present the distribution of fractures among patients with and without radiating pain, along with the associated p-value:

- **Patients with Radiating Pain:** 14.3% (5 patients) had fractures, while 48.6% (17 patients) did not, totaling 31.4% (22 patients).
- **Patients without Radiating Pain:** 85.7% (30 patients) had fractures, and 51.4% (18 patients) did not, making up 68.6% (48 patients).

A p-value of 0.002 indicates statistically significant differences in fracture distribution between patients with and without radiating pain. This suggests that radiating pain may be an essential factor associated with fracture occurrence in this study population.

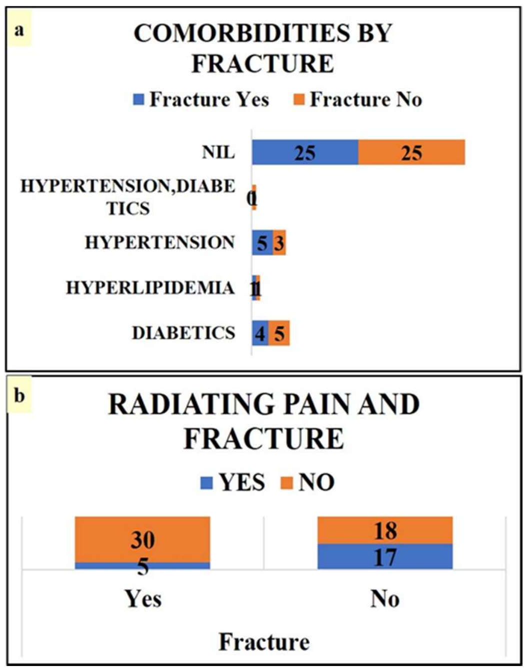

Fig. (7). Mean socio-demographic profile in post-menopausal women in the South Indian population. a. Comorbidities by fracture; and b. Radiating pain and fracture.

3.3.5 Distribution Of Neurological Deficits And Fracture

Table 3 and Figure 8a present the distribution of fractures among patients with different neurological deficits, along with the associated p-value:

- **EHL Weakness:** No patients with fractures, while 5.7% (2 patients) had fractures, totaling 2.9% (2 patients).
- **Reduced Sensations Over L4:** No patients with fractures, and 8.6% (3 patients) without fractures, making up 4.3% (3 patients).
- **Reduced Sensations Over L4, L5 (Right Side):** 5.7% (2 patients) with fractures, and no patients without fractures, totaling 2.9% (2 patients).
- **Reduced Sensations Over L5:** 2.9% (1 patient) with fractures, and 2.9% (1 patient) without fractures, summing up to 2.9% (2 patients).
- **No Neurological Deficits (NIL):** 91.4% (32 patients) with fractures, and 82.9% (29 patients) without fractures, making up the majority at 87.1% (61 patients).

A p-value of 0.092 suggests no significant link between neurological deficits and fracture occurrence.

3.3.6 Distribution of Vertebrae Level Csf Signal Intensity At Different Vertebral Levels

Table 3 and Figure 8b present the distribution of cerebrospinal fluid (CSF) signal intensity at different vertebral levels among patients with and without fractures, along with the associated p-value:

- **L2:** 14.3% (5 patients) with fractures and 5.7% (2 patients) without fractures, totaling 10.0% (7 patients).
- **L3:** 82.9% (29 patients) with fractures and 94.3% (33 patients) without fractures, making up 88.6% (62 patients).

- **L4:** 2.9% (1 patient) with fractures and no patients without fractures, accounting for 1.4% (1 patient).

A p-value of 0.259 indicates no significant difference in CSF signal intensity between patients with and without fractures.

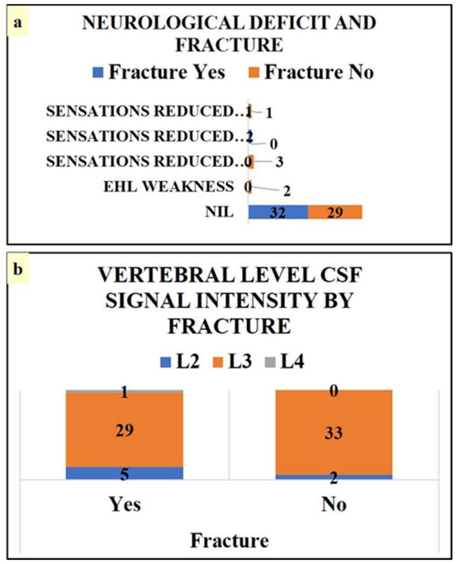

Fig. (8). Mean socio-demographic profile in post-menopausal women in the South Indian population. a. Neurological deficit and fracture; and b. Vertebral level CSF signal intensity by fracture.

3.3.7 Mean Signal Intensity At L1 And Fracture Data

Table 3 provides data on the mean signal intensity at the L1 vertebral level for patients with and without fractures, along with the associated p-value:

- **Patients with Fractures:** The mean signal intensity at L1 is 713.9, with a standard deviation of 126.4.
- **Patients without Fractures:** The mean signal intensity at L1 is 600.6, with a standard deviation of 87.1.

A p-value of <0.001 indicates a significant difference in L1 signal intensity between patients with and without fractures, suggesting that higher intensity is associated with the presence of fractures.

3.3.8 Men Signal Intensity At L2 And Fracture Data

Table 3 provides data on the mean signal intensity at the L2 vertebral level for patients with and without fractures, along with the associated p-value:

- **Patients with Fractures:** The mean signal intensity at L2 is 723.4, with a standard deviation of 137.4.
- **Patients without Fractures:** The mean signal intensity at L2 is 617.5, with a standard deviation of 97.4.

A p-value of <0.001 shows a minor change in L2 signal intensity between patients with and without fractures.

3.3.9 Mean Signal Intensity At L3 And Fracture Data

Table 3 provides data on the mean signal intensity at the L3 vertebral level for patients with and without fractures, along with the associated p-value:

- **Patients with Fractures:** The mean signal intensity at L3 is 712.1, with a standard deviation of 119.7.
- **Patients without Fractures:** The mean signal intensity at L3 is 626.5, with a standard deviation of 103.3.

A p-value of 0.002 shows changes in L3 signal intensity between patients with and without fractures.

3.3.10 Mean Signal Intensity At L4 And Fracture Data

The mean signal intensity at the L4 vertebral level for people with and without fractures is shown in Table 3 along with the corresponding p-value:

- **Patients with Fractures:** The mean signal intensity at L4 is 708.9, with a standard deviation of 131.5.
- **Patients without Fractures:** The mean signal intensity at L4 is 638.3, with a standard deviation of 107.4.

A correlation between fracture occurrence and higher intensity is revealed by a p-value of 0. 016 which highlights an exceptionally significant variation in L4 signal intensity.

3.3.11 Median Signal Intensity From L1 To L4 And Fracture Data

The median signal intensity for patients with fractures was 717. 3 (SD: 119. 6) whereas the median signal intensity for patients without fractures was 591. 8 (SD: 68. 1). A significant difference is indicated by a p-value of less than 0. 001 which connects fractures with higher signal intensity.

3.3.12 Csf Signal Intensity And Fracture Data

Table 3 provides data on signal strength for cerebrospinal fluid (CSF) in sufferers with and without fractures, along with the associated p-value:

- **Patients with Fractures:** The mean CSF signal intensity is 193.2, with a standard deviation of 47.5.
- **Patients without Fractures:** The mean CSF signal intensity is 172, with a standard deviation of 20.9.

A p-value of 0.018 indicates minor differences in mean CSF signal intensity between patients with and without fractures, suggesting a potential link between higher CSF signal intensity and fractures.

3.3.13 Dexa T-Score And Fracture Data

Table 3 provides data on the DEXA T-scores for patients with and without fractures, along with the associated p-value:

A p-value of 0.001 shows a significant change in mean T-scores between patients with and without fractures, suggesting that lower DEXA T-scores (lower bone density) are linked to a higher risk of fractures.

3.3.14 Dexa Z-Score And Fracture Data

Table 3 provides data on the DEXA Z-scores for patients with and without fractures, along with the associated p-value:

- **Patients with Fractures:** The average Z-score is -0.9, with a standard difference of 1.1.

A p-value of 0.008 revealed a critical variation in average Z-scores among individuals without and with fractures, revealing that lower value of DEXA Z-scores (decrease bone health relative to age standards) are associated to a greater risk of fractures.

3.3.15 Vbq Score And Fracture Data

Table 3 provides data on the Vertebral Bone Quality (VBQ) ratings for those who have and have not cracks, determined by dividing the signal amplitude from L1 to L4 by the signal level in cerebrospinal fluid (CSF), along with the associated p-value:

- **Patients with Fractures:** The mean VBQ score is 3.8, with a standard deviation of 0.9.

A p-value of <0.001 revealed a major significance in mean VBQ scores among individuals without and with fractures, revealed that higher value of VBQ scores are associated to a greater chance of fractures in this investigation population.

Table 3. Correlation of socio-demographic profile in post-menopausal women with the fracture in the South Indian population

Age	**Fracture**			
	Yes	**No**	**Total**	**p-value**
60-65 years	21 (60.0%)	18 (51.4%)	39 (55.7%)	0.305
66-70 years	4 (11.4%)	9 (25.7%)	13 (18.6%)	
>70 years	10 (28.6%)	8 (22.9%)	18 (25.7%)	
Total	35 (100.0%)	35 (100.0%)	70 (100.0%)	
Occupation	**Fracture**			
	Yes	**No**	**Total**	**p-value**
Attender	2 (5.7%)	2 (5.7%)	4 (5.7%)	0.919
Daily wager	11 (31.4%)	9 (25.7%)	20 (28.6%)	
Housewife	22 (62.9%)	23 (65.7%)	45 (64.3%)	
Teacher	0 (0.0%)	1 (2.9%)	1 (1.4%)	
Total	35 (100.0%)	35 (100.0%)	70 (100.0%)	
Co-morbidities	**Fracture**			
	Yes	**No**	**Total**	**p-value**
Diabetics	4 (11.4%)	5 (14.3%)	9 (12.9%)	0.922
Hyperlipidemia	1 (2.9%)	1 (2.9%)	2 (2.9%)	
Hypertension	5 (14.3%)	3 (8.6%)	8 (11.4%)	
Hypertension, diabetes	0 (0.0%)	1 (2.9%)	1 (1.4%)	
Nil	25 (71.4%)	25 (71.4%)	50 (71.4%)	
Total	35 (100.0%)	35 (100.0%)	70 (100.0%)	
Radiating pain	**Fracture**			
	Yes	**No**	**Total**	**p-value**
Yes	5 (14.3%)	17 (48.6%)	22 (31.4%)	0.002
No	30 (85.7%)	18 (51.4%)	48 (68.6%)	
Total	35 (100.0%)	35 (100.0%)	70	

			(100.0%)	
Neurological deficits	**Fracture**			
	Yes	**No**	**Total**	**p-value**
EHL weakness	0 (0.0%)	2 (5.7%)	2 (2.9%)	0.092
Sensations reduced over L4	0 (0.0%)	3 (8.6%)	3 (4.3%)	
Sensations reduced over L4,L5 right side	2 (5.7%)	0 (0.0%)	2 (2.9%)	
Sensations reduced over L5	1 (2.9%)	1 (2.9%)	2 (2.9%)	
Nil	32 (91.4%)	29 (82.9%)	61 (87.1%)	
Total	35 (100.0%)	35 (100.0%)	70 (100.0%)	
Vertebrae level CSF signal intensity	**Fracture**			
	Yes	**No**	**Total**	**p-value**
L2	5 (14.3%)	2 (5.7%)	7 (10.0%)	0.259
L3	29 (82.9%)	33 (94.3%)	62 (88.6%)	
L4	1 (2.9%)	0 (0.0%)	1 (1.4%)	
Total	35 (100.0%)	35 (100.0%)	70 (100.0%)	
Fracture	**Mean signal intensity**			
	N	**ATL1**		**p-value**
		Mean	**SD**	
Yes	35	713.9	126.4	<0.001
No	35	600.6	87.1	
Fracture	**Mean signal intensity**			
	N	**ATL2**		**p-value**
		Mean	**SD**	
Yes	35	723.4	137.4	<0.001
No	35	617.5	97.4	
Fracture	**Mean signal intensity**			
	N	**ATL3**		**p-value**
		Mean	**SD**	
Yes	35	712.1	119.7	0.002
No	35	626.5	103.3	
Fracture	**Mean signal intensity**			
	N	**ATL4**		**p-value**
		Mean	**SD**	
Yes	35	708.9	131.5	0.016
No	35	638.3	107.4	
Fracture	**Mean signal intensity**			
	N	**Intensity of L1-L4**		**p-value**
		Mean	**SD**	
Yes	35	717.3	119.6	<0.001
No	35	591.8	68.1	
Fracture	**CSF signal intensity**			
	N	**Mean**	**SD**	**p-value**
Yes	35	193.2	47.5	0.018
No	35	172	20.9	
Fracture	**DEXA T-score**			
	N	**Mean**	**SD**	**p-value**
Yes	35	-2.4	1.2	0.001
No	35	-1.4	1.2	
Fracture	**DEXA Z-score**			
	N	**Mean**	**SD**	**p-value**
Yes	35	-0.9	1.1	0.008
No	35	-0.3	0.8	
Fracture	**VBQ score=SI(L1-L4)/SI (CSF)**			
	N	**Mean**	**SD**	**p-value**

Yes	35	3.8	0.9	<0.001
No	35	2.9	0.3	

4. DISCUSSION

Current investigations showcase the value of MRI-based Vertebral Bone Quality (VBQ) scores as an important strategy for determining bone health in postmenopausal females. A study by Chen et al. (2023) reported a moderate correlation analysis ($r = 0.4$, $p < 0.05$) between lumbar BMD and VBQ scores analyzed by DEXA, revealing that VBQ can upgrade conventional bone density measurements and help in the detection of osteoporosis [15].

Age distribution is valuable as bone health tends to fall more gradually after menopause, forming this demographic specifically vulnerable to osteoporosis and associated fractures. Investigations reveals that fragility fractures and osteoporosis are more common in elder postmenopausal females [16]. Age remarkably affects the relation between VBQ scores and BMD, as trabecular bone health falls with raised fat infiltration in the bone marrow. This damage is more common in postmenopausal female, resulting to a raised fracture risk [17]. In this investigation, the percentage of individuals who reported the symptom "Low Back Ache" is 100%, indicating that every patient in the sample experienced this symptom. Low back ache (LBA) is a major problem among postmenopausal females, often resulting to reduced locomotion and durability. Around 31.43% of individuals encounter radiating pain, whereas the majority (68.57%) do not. Radiating pain in postmenopausal females may reveal degenerative spine alterations [18]. In this investigation, 50% (35 patients) of the 70 individuals were observed to have vertebral body fractures, whereas the other 50% (35 patients) did not. Previous investigations have revealed a greater likelihood of vertebral body fractures (62%) among the postmenopausal females, which emphasize the requirement for successful detection and screening tools. For assessing and identifying the likelihood of fracture and bone health MRI-based VBQ scores offer a promising substitute for DEXA [19]. In this study 88. 57 percent of subjects had CSF signal intensity at L3 10 percent at L2 and 1. 43 percent at L4. A measure of bone health is the VBQ score derived from the trabecular bone-to-CSF signal ratio. The results of the investigation show a moderate relationship between lumbar BMD and VBQ scores supporting the use of VBQ to predict the likelihood of osteoporosis. The VBQ score is a non-invasive non-ionizing method that is easier to use quicker and compatible with a variety of MR scanners. It has been shown to be useful in identifying fragility fractures and assessing bone health in degenerative spinal states [20].

With mean values of 657. 3 (L1) 670. 5 (L2) 669. 3 (L3) and 673. 6 (L4) this analysis reveals variation in signal intensity across L1-L4. A balanced distribution is shown by the nearly assembled median and mean signal intensity for L1-L4 (654. 5). The current study demonstrates the usefulness of VBQ scores in assessing bone quality. According to investigations VBQ scores outperform DXA in identifying osteoporosis and have a strong correlation with T-scores and BMD [20].

The T-score is an important and valuable method for detecting osteoporosis and osteopenia. A T-score of -1.9 in the investigational group reveal a higher chance of osteoporosis, determining the need for preventive care (Serota CA et al., 2022). The Z-score which measures bone health in relation to peers of the same age is -0. 6 indicating slightly below-average bone health that may be influenced by health stage genetics or standard of living [21].

Additionally, MRI-based VBQ scores determined to be valuable in assessing bone health, predicting fracture risk, and their surgical results. These scores demonstrate the quality of trabecular bone and fat infiltration using T1-weighted MRI [22]. With a standard deviation of 0. 8 and a mean score of 3. 4 VBQ exhibits moderate variation around the mean. According to research osteoporosis or osteopenia is indicated by VBQ scores greater than three [23]. Furthermore studies conducted by Yokota et al. (2024) found high interrater reliability (ICC = 0. 819) which supports the VBQ scores stability and clinical advantages across different examiners [24].

5. ASSOCIATION BETWEEN STUDY VARIABLES AND FRACTURES

This investigation challenges the widely held notion that postmenopausal women's fracture risk typically rises with age. The p-value of 0. 305 indicates that there are no noteworthy significant differences in fracture types between age groups suggesting that comorbidities lifestyle choices and genetics may play a significant role in fracture risk analysis [25].

Similarly, the p-value of 0.919 revealed that there are no remarkable significant alterations in fracture categorization across occupational groups. The statistical assessment determines potential awareness into the relation between fractures & various clinical parameters in postmenopausal females. Absence of a remarkably significant variation in fracture categorization among various comorbidity groups ($p = 0.922$) line up with investigations while type 2 diabetes mellitus is related with greater bone mineral density (BMD), the likelihood of vertebral cracks continues to be considerable due to complicated bone quality. On the other hand, the appearance of radiating pain ($p = 0.002$) is linked with fractures, confirming the investigations that MRI-based Vertebral Bone Quality (VBQ) scores can successfully transform osteoporotic condition and may complement conventional DEXA scans. No remarkable correlation was revealed between fractures and neurological deficiency ($p = 0.092$) or CSF signal intensity categorization ($p = 0.259$), though prior investigation highlights the importance of VBQ scores in early osteoporosis analysis.

Significantly, the investigation verifies an association between lower BMD and fractures, as detected by remarkable significant changes in T-scores ($p = 0.001$) and Z-scores ($p = 0.008$), strengthening the requirement for complete bone health assessments. These observations demonstrate the value of combining DEXA and VBQ scores to enhance precision of osteoporosis detection and fracture risk assessment in postmenopausal women [26].

The mean VBQ scores of participants with and without fractures varied significantly (p 0. 001) which is consistent with numerous studies on MRI-based VBQ scores and fracture risk in postmenopausal women. The correlation between higher VBQ scores and increased bone marrow adiposity provides a plausible explanation for this association. This condition throws off the equilibrium between bone formation and resorption which is linked to lower BMD and an increased risk of fracture. Although DXA-based BMD analysis is still the gold standard for determining osteoporosis VBQ scores may offer useful information by examining subtle changes in bone microarchitecture that might not be visible on DXA scans potentially improving the prediction of fracture chances in postmenopausal women [27].

6. NEED FOR THE STUDY

This study assesses the significance of using various imaging techniques to reveal bone strength. However, the gold standard for identifying osteoporosis is still DEXA BMD assessment. The use of the MRI-based VBQS score can offer a more thorough examination of bone health. This analysis provides important information for the early diagnosis and management of osteoporosis and fragility fractures in postmenopausal women. It also reveals the need for further research on bone imaging techniques. Ongoing research is helpful in improving osteoporosis detection and management because new opportunities for early detection of bone damage arise as techniques advance.

7. LIMITATIONS AND RECOMMENDATIONS

Problems include: (i) Research design and specimen-restricted sampling size may target generalizability of results (ii) Clinical Analysis: Lack of pain severity diagnosis approaches or standard of living measures (iii) No longitudinal investigation to determine fracture progress and (iv) a single-center study may not be able to showcase diverse populations and predominantly female individuals restricts relevance to male subjects. Technical considerations include the evaluation of a single imaging modality limited standardization of signal intensity assessment and a lack of inter-observer reliability facts. The following are suggestions (i) Future Research Directions: Conduct multi-center research with larger more diverse populations Involve prospective longitudinal assessment research Involve systematical pain and functional determination tools Assess the cost-effectiveness of variable diagnostic approaches Determine gender-specific changes in the outcome (ii) Clinical Practice: Apply standardized assessment methods Develop risk stratification approaches involving valuable parameters Examine routine analysis in high-risk individuals Establish a clear referral cascade for suspected cases; (iii) Methodological Enhancement: involve variable imaging modalities for comparative analysis; Create standardized analysis methodologies; (iv) Technical Upgradation-Standardize signal intensity assessment approaches; and Create automated determination tools

CONCLUSION

This study reveals a significant vertebral fracture found in older people primarily in women who identify as housewives and are between the ages of 60 and 65. All of the participants had lower back pain and nearly one-third reported radiating pain despite the uncommon comorbidities. The equal distribution of fractures (50%) and their stronger correlation with radiating pain signal intensity DEXA scores and VBQ scores suggest that these variables may be useful in identifying the likelihood of fractures. The CSF signal intensity prevalence at L3 (88. 57 percent) reveals important radiological information. These results highlight the necessity of a comprehensive approach for fracture detection that incorporates imaging bone density health and clinical indicators. More thorough research is needed to validate these results and raise diagnostic standards.

Author’s Contribution

Udaya Shankar S R: Conceptualization, and Writing: Original Draft Preparation; Sree Shangamithra: Data Analysis and Interpretation; Vishal Sirohi, Arun Kumar KV, Sheik Mohideen, and Manoj Kumar R: Writing the paper and Validation; Pradeep Elangovan: Data Curation, and Writing: Review and Editing

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Ethics Approval and Consent To Participate

The ethical authorization (IHEC-I/3150/24) was secured from the Institutional Human Ethics Committee (CARE-IHEC-I), Chettinad Academy of Research and Education, India and written permission was obtained following a comprehensive explanation of the research methodology

Human and Animal Rights

Research Involving Humans

All clinical investigations were conducted according to the guidelines of Chettinad Hospital and Research Institute Institutional Ethical Committee, India.

Consent for Publication

Written permission was obtained following a comprehensive explanation of the research methodology.

Availability of Data And Materials

The data will be available on special request from the corresponding author

FUNDING
No funding agency supports this paper.

Conflict Of Interest
The authors declare no competing financial interest.

ACKNOWLEDGEMENTS
The authors express their gratitude to the Chettinad Hospital and Research Institute and their patients for their support during the detection and treatment process. Additionally, the authors used Grammarly for grammatical corrections and QuillBot Paraphraser for language corrections.

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