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RESEARCH ARTICLE
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RADIOLOGICAL ANALYSIS OF SKELETAL MANIFESTATIONS IN THE LONG BONES AND SPINE IN RELATION TO THYROID HORMONAL DISORDERS.

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Abstract

Background:
Thyroid hormones play a crucial role in maintaining bone mineral homeostasis and skeletal integrity. Both hyperthyroidism and hypothyroidism can alter bone remodeling, potentially leading to osteopenia, osteoporosis, and increased fracture risk. This study aimed to analyze the radiological skeletal manifestations in the long bones and spine of patients with thyroid hormonal disorders and to correlate these findings with thyroid function status.

Materials and Methods:
A cross-sectional observational study was conducted in the Department of Radiology, in collaboration with the Department of Anatomy at Sarojini Naidu Medical College Agra, and Mahamaya Rajkiya Allopathic Medical College, Ambedkar Nagar from October 2024 to March 2025. A total of 129 subjects were included—60 hypothyroid (Group I), 44 hyperthyroid (Group II), and 25 euthyroid controls (Group III). Standard radiological imaging of long bones and spine was performed, and findings were compared among groups. Statistical analysis was done to determine the significance of differences.

Results: Radiological abnormalities were significantly more frequent in thyroid disorder groups compared to controls. Generalized osteopenia was observed in 58% of hypothyroid and 66% of hyperthyroid patients ($p < 0.001$). Cortical thinning and coarse trabecular patterns were also prevalent ($p < 0.001$ and $p = 0.002$, respectively). In the spine, decreased vertebral bone density was seen in 53.3% of hypothyroid and 68.2% of hyperthyroid patients ($p < 0.001$). Biconcave vertebrae and compression deformities were also more common among thyroid disorder groups. Females were predominantly affected across all groups.

Conclusion: Thyroid hormonal disorders are associated with significant skeletal changes detectable through radiological imaging, primarily osteopenia, cortical thinning, and reduced vertebral bone density. Early imaging assessment in patients with thyroid dysfunction is recommended to detect bone loss and prevent fracture-related complications.

Keywords: Thyroid disorders, Bone mineral density, Osteopenia, Radiological analysis, Spine, Long bones, Hypothyroidism, Hyperthyroidism.

Introduction: Bone health is a lifelong concern that has recently gained significant attention in modern society, as awareness of its importance for overall well-being and quality of life continues to grow.[1] Thyroid hormones significantly influence bone mineral density and the maintenance of bone mineral homeostasis. In the modern era, factors such as sedentary behavior, insufficient physical activity, unhealthy dietary patterns, nutritional deficiencies, and various medical conditions-including hormonal imbalances and metabolic disorders-can adversely impact bone health through different mechanisms. Bone mass accumulates until early adulthood, reaching a peak level known as peak bone mass, after which a gradual decline in bone density occurs.[2]

There are various methods to assess bone health like x-ray, radio grammetry, radiographic absorptiometry or biochemical techniques.[3] However, most of these methods and techniques just give the glimpse of bone health rather than an exact picture of it. On the other hand, bone mass measurement is the gold standard to assess the density of bone and reveals its exact condition.[4]

Bone mineral density (BMD) has emerged as one of the most reliable indicators for assessing overall bone health. Conditions such as osteopenia and osteoporosis can be accurately identified through BMD evaluation. In fact, measurement of bone mass remains the most effective predictor of an individual's risk for fractures.[5] Bone mass is commonly assessed using dual-energy X-ray absorptiometry (DXA), which is considered the gold standard technique for evaluating bone mineral density (BMD). This method is preferred due to its high reproducibility, extensive normative data, non-invasive nature, minimal time requirement, and very low radiation exposure.[6]

Worldwide thyroid diseases are, debatably among the commonest disorder, there is significant load of thyroid diseases in India too. It has been estimated from various studies on thyroid disease that about 42 million people suffer from thyroid diseases in India. Basal metabolic rate is primarily interrupted by thyroid disorders either hypothyroidism or hyperthyroidism; however, effects of disturbed basal metabolism rate are reflected in various organs via diverse symptoms.[7]

Triiodothyronine (T3) and thyroxine (T4) are the two main hormones secreted by thyroid gland. Among these hormones T3 is synthesis in smaller quantity in comparison of T4. However, peripherally T4 hormones deiodinase to form T3 hormones.[8]

Material and Methods:

The cross-sectional observational study was conducted to evaluate the radiological skeletal manifestations in the long bones and spine of patients with thyroid hormonal disorders and to correlate these findings with thyroid function status in the department of Radiology, collaboration with the Department of Anatomy at Sarojini Naidu Medical College Agra, and Mahamaya Rajkiya Allopathic Medical College, Ambedkar Nagar, during a period of time October 2024 to March 2025.

Radiological Examination

All participants underwent standard radiological imaging of:

- Long bones (upper and lower limb long bones)
- Spine (cervical, thoracic, and lumbar regions)

Conventional X-ray imaging was used for all examinations. Radiographs were obtained in appropriate anteroposterior (AP) and lateral views depending on the anatomical region.

Radiological Assessment Parameters

Radiological features evaluated for long bones included:

- Generalized osteopenia
- Cortical thinning
- Coarse trabecular pattern
- Subperiosteal bone resorption
- Pathological fractures

Radiological findings assessed for the spine included:

- Decreased vertebral bone density
- Biconcave vertebrae ("codfish" vertebrae)
- Compression deformities
- Scoliosis or kyphosis
- Normal radiographic appearance

Study design: it is cross sectional, observational study.
Sample size: total 129 samples
Inclusion criteria:

1. Patients aged 18 to >65 years of age.
2. Patients with biochemically confirmed thyroid hormonal disorders (hypothyroidism or hyperthyroidism).
3. Patients who have undergone radiological imaging of the long bones and spine.
4. Patients who provided written informed consent to participate in the study.

Exclusion criteria:

1. Patients with secondary bone diseases such as renal osteodystrophy, hyperparathyroidism, osteomalacia, or metabolic bone disorders.
2. Patients with malignancies involving the skeletal system or metastatic bone disease.
3. Patients receiving drugs that affect bone metabolism like corticosteroids, bisphosphonates, anticonvulsants.
4. Pregnant or lactating women or willing to get pregnant.
5. Patients with incomplete clinical data or poor-quality radiographs that prevent accurate interpretation.
6. Alcoholics and smokers.

Result:

Table 1: table represents distribution of study population according to thyroid status.

Condition	Groups	Number of Cases (n)	Percentage (%)
Hypothyroidism	Group I	60	47
Hyperthyroidism	Group II	44	34
Euthyroid (Control)	Group III	25	19
	Total	129	100%

Table: Age and Gender Distribution of Study Population (Mean ± SD)

Condition	Group	Number of Cases (n)	Mean Age (years ± SD)	Male (n, %)	Female (n, %)	Male/ female ratio
Hypothyroidism	Group I	60	45.2±10.8	21 (35%)	39(65%)	1:1.8
Hyperthyroidism	Group II	44	43.6±9.7	13 (30%)	31(70%)	1:1.2
Euthyroid (Control)	Group III	25	44.8±11.3	10 (40%)	15(60%)	1:1.6

Table 2: Age Distribution of Study Population.

Age Group (years)	Group I Hypothyroidism (n=60)	Group II Hyperthyroidism (n=44)	Group III Control (n=25)	Total (n=129)
18 – 27	7	5	3	15 (11%)
28 – 37	13	10	5	28 (22%)
38 – 47	17	13	6	36 (28%)
48 – 57	15	10	6	31 (24%)
58 – 67	6	4	3	13 (10%)
> 67	2	2	2	6 (5%)
Total	60	44	25	129 (100%)

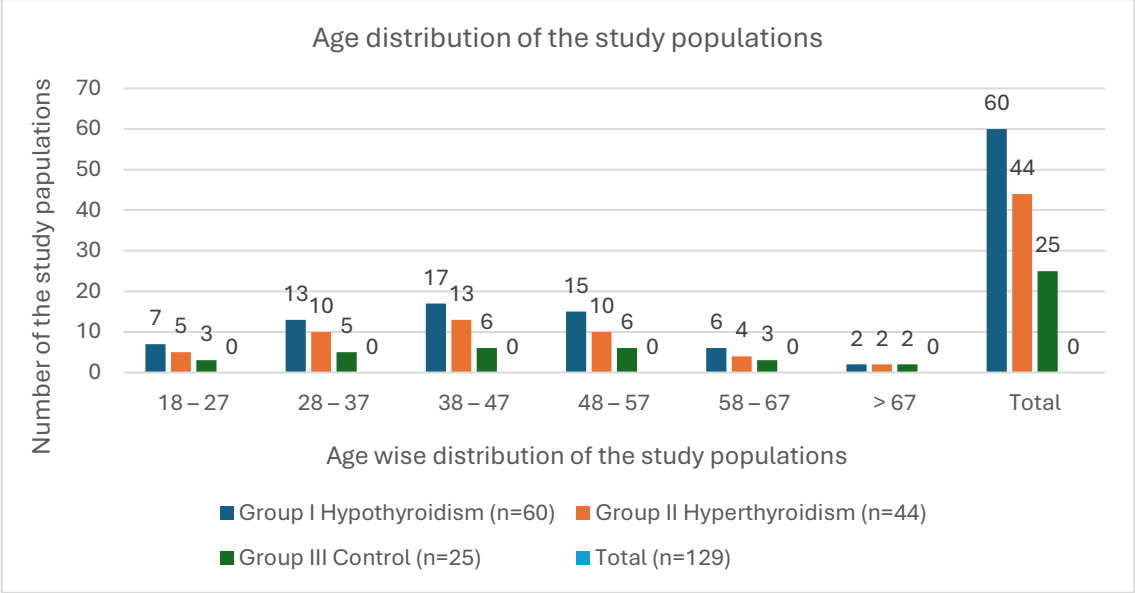

Figure 1: Graphical represents age wise of the study populations.

Table: Gender Distribution of Study Population.

Gender	Group I Hypothyroidism (n=60)	Group II Hyperthyroidism (n=44)	Group III Control (n=25)	Total (n=129)
Male	21	13	10	44 (34%)
Female	39	31	15	85 (66%)
Total	60	44	25	129 (100%)

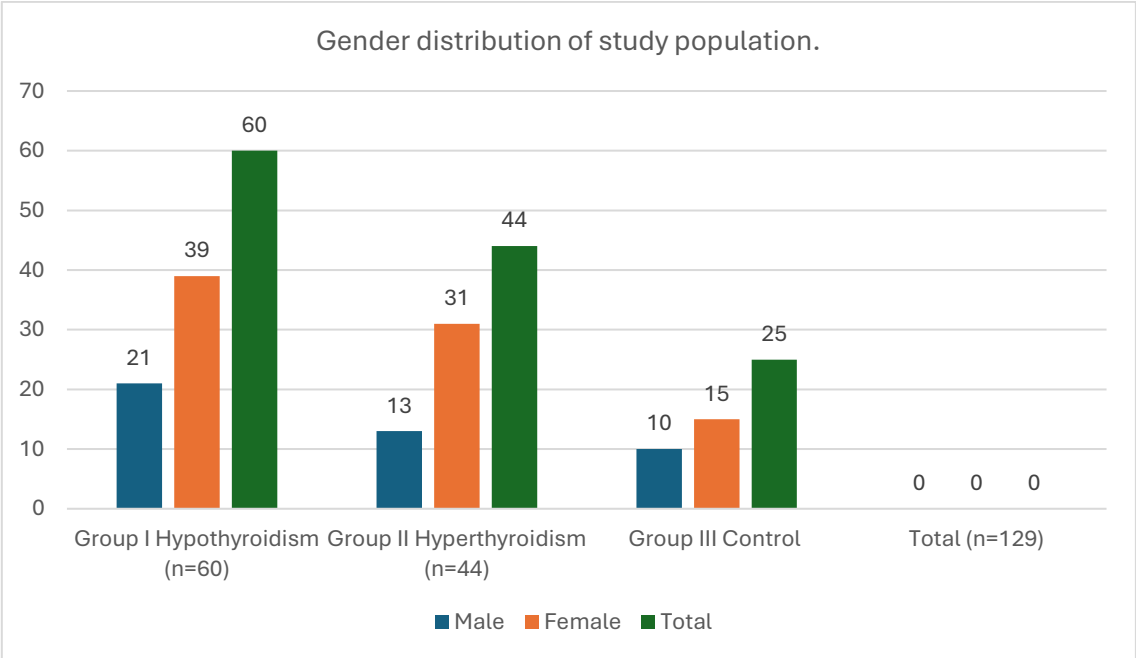

Figure: 2 Graphical represents gender distribution of the study population.

Table 4: Radiological examination of the long bones was performed for all 129 subjects. The findings were categorized according to the thyroid status of the participants.

Radiological Finding	Group I Hypothyroidism (n=60)	Group II Hyperthyroidism (n=44)	Group III Control (n=25)	p-value
Generalized osteopenia	35 (58%)	29 (66%)	3 (12%)	<0.001*
Cortical thinning	27 (45%)	24 (54%)	2 (8%)	<0.001*
Coarse trabecular pattern	30 (50%)	21 (48%)	4 (16%)	0.002*
Subperiosteal resorption	6 (10%)	12 (27%)	0	0.008*
Pathological fracture	4 (6%)	5 (11%)	0	0.045*

Table 5: Radiological evaluation of the spine (cervical, thoracic, and lumbar regions) the observed radiological features.

Radiological Finding (Spine)	Group I Hypothyroidism (n=60)	Group II Hyperthyroidism (n=44)	Group III Control (n=25)	p-value
Decreased vertebral bone density	32 (53.3%)	30 (68.2%)	2 (8.0%)	<0.001*
Biconcave vertebrae ("codfish" appearance)	9 (15.0%)	10 (22.7%)	0	0.032*
Compression deformity of vertebrae	5 (8.3%)	8 (18.2%)	0	0.041*
Scoliosis/ kyphosis	7 (11.7%)	6 (13.6%)	1 (4.0%)	0.251
Normal spine	22 (36.7%)	10 (22.7%)	22 (88.0%)	<0.001*

Discussion:

This study found that patients with thyroid hormonal disorders, particularly hyperthyroidism and hypothyroidism, showed significant radiological skeletal changes compared to euthyroid controls. Common findings included osteopenia, cortical thinning, and decreased vertebral bone density. These results suggest that both excess and deficiency of thyroid hormones disrupt bone remodeling, increasing the risk of bone fragility. Similar findings have been reported by Zhu et al. (2022) and Zhang et al. (2024), confirming that thyroid dysfunction adversely affects skeletal integrity, especially in females who are more prone to thyroid disorders.

Conclusion:

Thyroid dysfunction significantly affects bone structure, leading to detectable skeletal changes on radiological imaging. Early imaging evaluation of long bones and spine in thyroid patients is recommended to identify osteopenia and prevent complications such as fractures.

Limitations of the study:

1. Cross-sectional design limits causal inference.
2. Single-center study with small sample size reduces generalizability.
3. No longitudinal follow-up to assess progression or improvement.
4. Confounding factors like diet, physical activity, and vitamin D were not fully controlled.
5. Only radiological assessments were performed; biochemical bone markers were not evaluated.
6. Limited representation of older adults (>65 years).

Conflict of Interest: The authors declare no conflict of interest related to this study.

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