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EVALUATE SCOLIOSIS SEVERITY AND ITS IMPACT ON SPINAL CURVATURE, VERTEBRAL HEIGHT REDUCTION USING ADVANCE COMPUTED TOMOGRAPHY IMAGING TECHNIQUES

Original Research

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Acknowledgement: The authors acknowledge the radiology team of Ghurki Trust and Teaching Hospital for their support during data collection.

Conflict of Interest: None
Grant Support & Financial Support: None

ABSTRACT

Background: Scoliosis is a complex spinal disorder characterized by abnormal lateral curvature, often resulting in vertebral deformity and compromised posture. Conventional radiographs provide limited assessment, particularly in evaluating vertebral height and axial rotation. Computed Tomography (CT) offers high-resolution, three-dimensional imaging, enabling detailed evaluation of spinal alignment, curvature, and structural integrity. This study explores the role of CT imaging in determining scoliosis severity and its degenerative implications on vertebral architecture.

Objective: To assess the severity of scoliosis and its effects on spinal curvature and vertebral height reduction using advanced computed tomography techniques.

Methods: This cross-sectional study was conducted over four months in the Radiology Department of Ghurki Trust and Teaching Hospital. Fifty patients aged 7 to 70 years, fulfilling strict inclusion and exclusion criteria, underwent CT scans using a 16-slice Toshiba Aquilion machine. Demographic data, Cobb angles, vertebral height measurements, and degenerative spinal findings were recorded. CT images were interpreted by expert radiologists, and data were analyzed using SPSS version 26. Statistical correlations were drawn between scoliosis severity and structural spinal changes.

Results: Among the 50 patients, 29 (58%) were female and 21 (42%) male. Left-sided convexity was more common (66%) compared to right (34%). Cobb angle distribution included 17 (34%) patients at 10°, 13 (26%) at 15°, 10 (20%) at 20°, and 5 (10%) each at 30° and 40°. Vertebral height reduction was observed in all patients: 2 mm in 12 (24%), 3 mm in 23 (46%), 4 mm in 13 (26%), and 5 mm in 2 (4%) cases. Degenerative spinal changes were present in 8 (16%) patients; osteopenia in 6 (12%) and osteoporosis in 1 (2%). Disc degeneration was universal, graded as mild in 35 (70%), moderate in 13 (26%), and severe in 2 (4%).

Conclusion: CT imaging proved highly effective in detecting scoliosis severity, vertebral height loss, and associated degenerative changes. The correlation between increased Cobb angles and vertebral deformation supports CT as a valuable tool for early diagnosis, monitoring, and treatment planning in scoliosis management.

Keywords: Cobb Angle, Computed Tomography, Scoliosis, Scoliosis Severity, Spinal Curvature, Spinal Degeneration, Vertebral Compression.

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INTRODUCTION

Scoliosis is a complex spinal condition defined by a lateral curvature of the vertebral column exceeding 10 degrees in the coronal plane, often accompanied by spinal rotation and resultant thoracic or lumbar deformity (1). This abnormal spinal alignment not only alters posture and trunk symmetry but can also lead to significant clinical implications, especially when progressive. Scoliosis can originate from diverse causes and is broadly categorized as idiopathic, neuromuscular, congenital, or syndrome-associated (2). Among adults, scoliosis is diagnosed when a Cobb angle of 10 degrees or greater is observed in a skeletally mature individual, and may develop as a progression of adolescent idiopathic scoliosis (AIS), secondary to degenerative spinal disorders (scoliosis de novo), or as a complication of spinal surgery and systemic conditions (3). The pathogenesis of scoliosis is multifactorial. While idiopathic forms remain the most prevalent and poorly understood, other cases stem from identifiable causes such as congenital vertebral malformations, neuromuscular disorders like cerebral palsy or muscular dystrophy, and syndromic conditions such as Marfan syndrome and neurofibromatosis (4). Occasionally, spinal deviation may occur in the absence of significant vertebral rotation or bony abnormality, often due to compensatory mechanisms in response to pain, spinal cord tumors, or infections (5). AIS, the most common form of scoliosis, typically manifests during adolescence and exhibits a notable gender disparity, disproportionately affecting females with increasing severity as the Cobb angle rises (6,7).

The Cobb angle remains the gold standard for scoliosis assessment, providing an objective quantification of curve magnitude on radiographic imaging. Accurate measurement of vertebral rotation is essential for curve classification, prognosis, and therapeutic decision-making, as it often correlates with the clinical presentation of asymmetry and back prominence (8). Prevalence studies estimate that 0.4% to 0.5% of adolescents are affected by AIS, and the likelihood of severe curvature increases with age and female gender predominance (9). In adults, scoliosis prevalence is approximately 2–3%, encompassing both idiopathic forms carried over from adolescence and degenerative changes acquired later in life (10). Known risk factors include female sex, early onset age, family history, elevated body mass index, and diminished bone mineral density (11). A key distinction within scoliosis subtypes lies between structural and nonstructural curves. Structural scoliosis involves intrinsic vertebral changes and tends to progress, potentially compromising cardiopulmonary function and quality of life if untreated. In contrast, nonstructural scoliosis often resolves once the underlying pathology, such as leg length discrepancy or muscle spasm due to disc prolapse or tumors, is managed (12). Longitudinal outcomes of untreated scoliosis vary with curve severity. Curvatures less than 30 degrees at skeletal maturity typically remain stable, while those between 30 and 45 degrees may lead to chronic back pain. Curves exceeding 45 degrees often demonstrate yearly progression and may contribute to notable deformity, functional impairment, and psychosocial distress. Thoracic curves surpassing 90 degrees are associated with a twofold increase in early mortality, often due to cardiopulmonary complications such as cor pulmonale (13,14).

Advanced imaging modalities, including sagittal CT scans, are indispensable for evaluating vertebral deformities in scoliosis. These scans provide precise assessments of vertebral height loss, rotation, and structural compromise, all of which guide diagnosis and inform surgical or conservative treatment strategies. Imaging markers, such as significant height loss in lumbar vertebrae, indicate advanced structural involvement and help predict outcomes and monitor progression over time. Despite the expanding body of literature on scoliosis, many uncertainties remain regarding its natural history, risk stratification, and optimal timing for intervention across different age groups and etiologies. Therefore, this study aims to investigate the clinical and radiological patterns of scoliosis in a defined population, focusing on vertebral deformities and their implications for diagnosis and management. The objective is to enhance early detection, refine classification, and support evidence-based treatment approaches tailored to curve severity and patient-specific factors.

METHODS

A cross-sectional study was conducted over a period of four months at Ghurki Trust and Teaching Hospital to evaluate radiological features in patients diagnosed with scoliosis. A total of 50 patients were included in the study, selected through a non-probability convenient sampling technique. Both male and female participants, aged between 7 and 80 years, were eligible for inclusion if they provided informed consent, had no prior history of spinal surgery, trauma, or infection, and did not have any neurological conditions affecting the spine. Patients with congenital anomalies not associated with vertebral height reduction—such as spina bifida—were

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excluded. Additional exclusion criteria included severe trauma or pathology resulting in global spinal instability or deformity, incomplete or poor-quality CT scans, and any previous spinal injuries. Imaging was carried out using a Toshiba Aquilion 16-slice computed tomography (CT) scanner. CT scans were evaluated to determine the Cobb angle and identify vertebral height loss, which are indicative of structural deformities associated with scoliosis. All images were reviewed by qualified radiologists, and standardized radiographic criteria were applied to ensure measurement consistency and diagnostic accuracy.

Data were analyzed using SPSS (Statistical Package for the Social Sciences), version 26. Descriptive statistics were used to summarize demographic data, Cobb angle values, and the extent of vertebral height reduction. The association between Cobb angle and other variables such as disc degeneration and osteoporosis were evaluated using Pearson or Spearman correlation tests, depending on data distribution. The Chi-square test was employed to assess associations between categorical variables. A p-value of less than 0.05 was considered statistically significant. Graphical tools, including bar charts and other visual aids, were generated in SPSS to enhance data presentation and interpretation. Ethical approval for the study was obtained from the Institutional Review Board (IRB) of Ghurki Trust and Teaching Hospital. Written informed consent was obtained from all participants prior to inclusion, and the study was conducted in accordance with the principles outlined in the Declaration of Helsinki.

RESULTS

A total of 50 participants were included in the study, with ages ranging from 7 to 80 years. The mean age was 43.48 years, and the median age was 50 years, indicating a broad age distribution. The standard deviation was 21.2, reflecting a wide variability in the sample population. Regarding gender distribution, 29 participants (58%) were female and 21 (42%) were male. Analysis of spinal convexity revealed that 33 patients (66%) exhibited a left-sided curve, while 17 patients (34%) showed convexity towards the right. Cobb angle assessment categorized participants into five groups: 17 individuals (34%) had angles between 0–10 degrees, 13 (26%) had 11–20 degrees, 10 (20%) had 21–30 degrees, and 5 participants each (10%) fell into the 31–40 and 40–45 degree categories. This distribution demonstrates that the majority of patients had mild to moderate scoliotic curves. The vertebral levels affected by scoliosis were also recorded. The highest frequency was noted in the lumbo-sacral region with 17 patients (34%), followed by the upper thoracic region (T1–T6) with 14 patients (28%), and the lower thoracic region (T7–T12) with 12 cases (24%). Additionally, thoraco-lumbar involvement was seen in 4 patients (8%), while 3 cases (6%) showed deformities in the L1–L5 region.

Computed tomography findings showed that 16 patients (32%) had normal imaging, while structural abnormalities were observed in the remaining 34 individuals (68%). Osteophytes were present in 10 patients (20%), degenerative changes in 8 (16%), osteopenia in 6 (12%), kyphosis in 5 (10%), and spinal dysraphism in 4 patients (8%). Only 1 case (2%) was found to have osteoporosis, emphasizing the predominance of osteodegenerative and structural abnormalities in the studied group. Disc degeneration grading revealed that 35 patients (70%) had mild degeneration, 13 patients (26%) exhibited moderate degeneration, and only 2 patients (4%) demonstrated severe degeneration. These findings suggest that mild disc degeneration was the most prevalent radiological change observed in this cohort. Further analysis was conducted to explore the correlation between Cobb angle severity and associated structural findings, including disc degeneration, vertebral level involvement, and CT abnormalities. A noticeable trend was observed in patients with higher Cobb angles (≥31°), who exhibited increased rates of moderate to severe disc degeneration compared to those with milder curvatures. Specifically, the frequency of disc degeneration was more pronounced in patients with Cobb angles between 31–45°, suggesting a progressive degenerative burden with worsening spinal curvature. Similarly, vertebral level involvement revealed that higher Cobb angles were predominantly associated with deformities localized to the lumbo-sacral and lower thoracic regions. This pattern aligns with the mechanical stress distribution typically observed in these areas during curve progression. In terms of CT findings, abnormalities such as osteophyte formation, kyphotic changes, and general degenerative changes were more frequently present in patients with advanced scoliosis. These results indicate a clear anatomical and radiological association between the severity of spinal curvature and degenerative spinal pathology, emphasizing the importance of early detection and stratified intervention in scoliosis management.

Table 1: Descriptive Statistics of Patient Age Distribution

Mean	**43.48**
Median	50.00
Std. Deviation	21.202
Range	73

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Mean	**43.48**
Minimum	7
Maximum	80

Table 2: Frequency of Gender of Patients

	No. of patients	Percent
Female	29	58.0
Male	21	42.0
Total	50	100.0

Table 3: Frequency of convexity of patients

	No. of patients	Percent
Towards Right	17	34.0
Towards Left	33	66.0
Total	50	100.0

Table 4: Frequency of Cobb Angle of Patients

Cobb Angle (degrees)	No. of patients	Percent
0-10	17	34.0
11-20	13	26.0
21-30	10	20.0
31-40	5	10.0
40-45	5	10.0
Total	50	100.0

Table 5: Frequency of Affected Vertebral Level of Patients

Affected vertebral Level		
Vertebral Level	No. of patients	Percent
T1 -T6	14	28.0
T7 - T12	12	24.0
Thoraco-Lumber	4	8.0
L1 - L5	3	6.0
Lumbo-Sacral	17	34.0
Total	50	100.0

Table 6: Frequency of CT Findings of Patients:

CT findings of patients	No. of patients	Percent
Normal	16	32.0
Osteophytes	10	20.0
Spinal Dysraphism	4	8.0
Kyphosis	5	10.0
Degenerative changes	8	16.0
Osteopenia	6	12.0
Osteoprosis	1	2.0
Total	50	100.0

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Table 7: Frequency of Disc Degeneration Grading

	No. of patients	Percent
Mild degeneration	35	70.0
Moderate degeneration	13	26.0
Severe Degeneration	2	4.0
Total	50	100.0

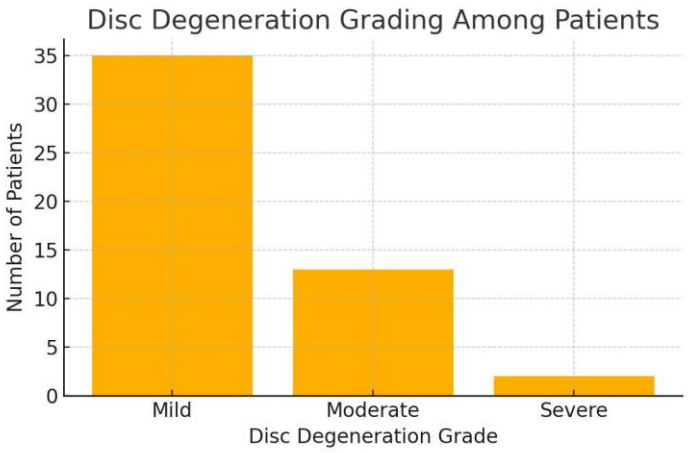

Figure 1 Disc Degeneration Grading Among Patients

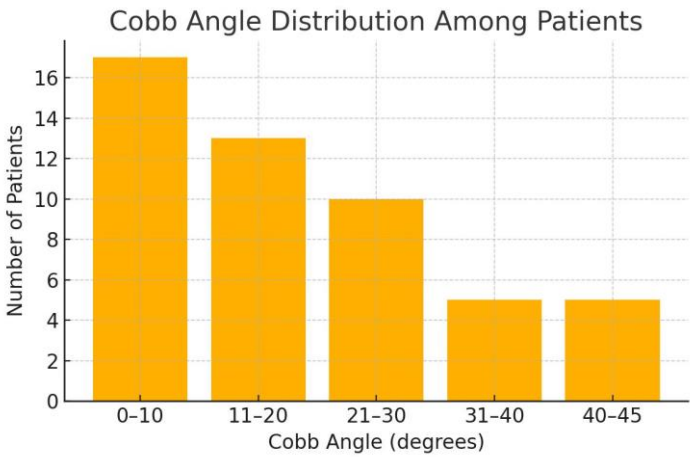

Figure 2 Cobb Angle Distribution Among Patients

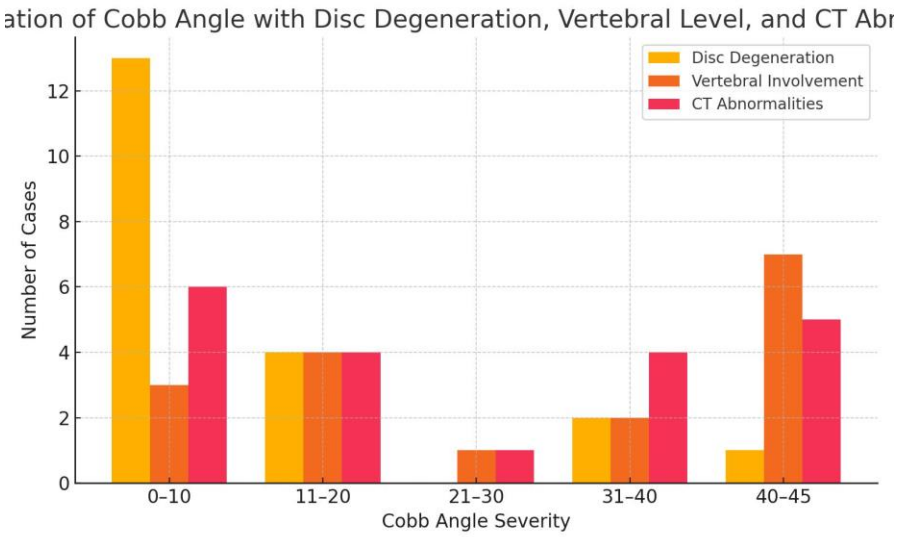

Figure 3 Relation of Cobb Angle with Disc Degeneration, Vertebral Level, and CT Abnormalities

DISCUSSION

The findings of this study revealed important demographic and radiological patterns in scoliosis, aligning in part with existing literature while also highlighting unique observations. The mean age of participants was 43.48 years, with a median age of 50 years, indicating a

predominantly adult cohort. This demographic profile is consistent with studies suggesting that scoliosis prevalence increases with age, particularly in individuals aged 40–50 and older adults beyond 90 years, where degenerative changes become more prominent. A wide age range of 7 to 80 years allowed for a broad representation, enhancing the generalizability of the results across age groups. Gender distribution in this study showed a predominance of females (58%), which supports previous epidemiological patterns in idiopathic scoliosis, where females are not only more frequently affected but also exhibit more severe curvature progression with increasing Cobb angles. Prior literature has consistently documented that the female-to-male ratio increases with curve severity—from 1.4 in curves measuring 10–20 degrees to 7.2 in curves above 40 degrees—indicating a gender-based susceptibility to curve progression, which was echoed by the current study (15-17).

Anatomical analysis of curve convexity revealed that 66% of participants had left-sided spinal curves, which contrasts with classical idiopathic scoliosis patterns predominantly showing right-sided thoracic convexity in patients with normal visceral anatomy. However, existing literature also acknowledges left convexity in cases with variations in internal organ orientation or thoracolumbar/lumbar involvement. The high frequency of left convex curves in this sample may be attributed to a higher proportion of adult cases with lower spinal involvement, where left-sided convexity is more common due to age-related biomechanical deterioration (18,19). Degenerative changes were the most prevalent radiological finding, followed by osteopenia and a small percentage of osteoporosis. These degenerative findings were significantly associated with vertebral height reduction, suggesting a strong link between mechanical degeneration and spinal curvature severity. This observation aligns with previous reports indicating that vertebral degeneration contributes directly to spinal imbalance and progressive deformity in adult scoliosis. Disc degeneration grading revealed a majority of cases with mild degeneration (70%), while moderate and severe degeneration accounted for 26% and 4% respectively (20,21). These findings reinforce the notion that degenerative scoliosis often initiates subtly, with progressive disc and bone changes over time leading to more visible deformities.

The study also provided insight into the vertebral levels most frequently affected by scoliosis. The lumbo-sacral region accounted for the highest proportion of cases, followed by the upper and lower thoracic regions. This anatomical distribution may reflect the weight-bearing and mobility demands on the lumbar spine, predisposing it to degenerative alterations and curvature development, especially in older individuals (22). While this study offers valuable insights, certain limitations are acknowledged. The sample size was relatively small (n=50), and the sampling technique was non-probability based, which may limit the external validity of the findings. Additionally, the study did not differentiate between idiopathic and degenerative scoliosis subtypes, which could have provided deeper clinical relevance. Quantitative assessment of vertebral height reduction was also lacking, despite being an essential objective of the study. Future research should aim to incorporate longitudinal data to observe progression patterns, utilize probabilistic sampling techniques, and perform multivariate analyses to explore the interaction between clinical, demographic, and radiological factors. A key strength of the study was its inclusion of a wide age range, enabling assessment across pediatric, adult, and elderly populations. The combination of clinical and CT-based parameters provided a robust evaluation of scoliosis characteristics, and the use of standardized imaging tools improved data reliability. Future investigations should further explore the biomechanical underpinnings of curve progression and the potential for early intervention in mild degenerative changes to prevent severe deformities. Integrating biochemical markers of bone health and spinal loading dynamics could also enhance understanding of scoliosis etiology in diverse populations.

CONCLUSION

This study concluded that computed tomography is an effective and reliable imaging modality for assessing spinal curvature and vertebral height reduction in patients with scoliosis. The findings highlighted a predominance of left-sided convexity and a frequent presence of disc degeneration, with a notable association between degenerative changes and the extent of vertebral compromise. CT imaging not only allowed precise visualization of angular deformities but also offered critical insights into the structural and degenerative aspects of the condition. These results emphasize the clinical value of CT in the comprehensive evaluation and management planning of scoliosis, particularly in cases where detailed assessment of bony architecture is essential.

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AUTHOR CONTRIBUTION

Author	Contribution
Fariha Imran*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Urooj Javed	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Iram Sharif	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Jawad Anwar	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Maria Javed	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Iqra Saeed	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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