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Research Article

Correlation of Osteoporotic Vertebral Compression Fractures with Chronic Kidney Disease and Lower Urinary Tract Symptoms: A Radiological Study

Asma Tariq[1], Shehla Tanveer[2], Bushra Riaz[3], Ansa SanaUllah[4], Syed Ahmad Bilal Bukhari[5], Samreen Malik[6]

1. Associate Professor, Department of Radiology, Rahbar Medical and Dental College/Punjab Rangers Teaching Hospital, Lahore, Pakistan.
2. Assistant Professor, Diagnostic Radiology, Creek General Hospital / United Medical and Dental College, Karachi, Pakistan.
3. Assistant Professor, Paediatric Radiology, Children Hospital and Institute of Child Health, Faisalabad, Pakistan.
4. Medical Officer, Radiology, Punjab Rangers Teaching Hospital, Lahore, Pakistan.
5. Assistant Professor, Department of Orthopaedic Surgery, Akhtar Saeed Trust Hospital, EME Society, Lahore, Pakistan.
6. Senior Registrar, Diagnostic Radiology, King Abdullah Teaching Hospital, Mansehra, Pakistan.

Asma Tariq: Corresponding author

Abstract

Background: Chronic kidney disease (CKD) is associated with abnormalities of mineral metabolism, impaired bone quality, and increased fracture risk. In children, these abnormalities are generally described within the spectrum of CKD-mineral and bone disorder (CKD-MBD), which may result in impaired skeletal growth, vertebral deformities, and fractures. Lower urinary tract dysfunction may coexist with renal disease and can significantly affect quality of life. This study evaluated the radiological relationship between vertebral compression abnormalities, CKD severity, and lower urinary tract dysfunction in adult and pediatric populations. **Methods:** This prospective observational study included 180 patients with radiologically identified vertebral compression abnormalities or CKD-associated skeletal abnormalities, comprising 140 adults and 40 children. All participants underwent spinal MRI. Adult patients were evaluated for CKD stage, renal biochemical parameters, osteoporosis-related risk factors, fracture severity, and lower urinary tract symptoms using the International Prostate Symptom Score. Pediatric patients were evaluated for CKD stage, CKD-MBD biochemical parameters, vertebral deformity/fracture, growth abnormalities, and age-appropriate urinary symptoms. **Results:** Among adults, CKD was

identified in 67 (47.9%) patients, while 31 (22.1%) had stage 3, 20 (14.3%) stage 4, and 16 (11.4%) stage 5 CKD. Moderate-to-severe vertebral compression was significantly more frequent among patients with advanced CKD than those without CKD (58.1% vs. 27.4%, p=0.002). Significant LUTS were observed in 46.3% of adults with CKD compared with 25.0% without CKD (p=0.008). Among children, 28 (70.0%) had CKD stage 4–5, and 15 (37.5%) demonstrated vertebral compression/deformity. Pediatric patients with lower bone-density Z-scores and elevated parathyroid hormone levels showed greater radiological skeletal abnormalities. Urinary dysfunction was identified in 14 (35.0%) children and was more frequent among those with advanced CKD. **Conclusion:** Increasing CKD severity was associated with greater vertebral structural abnormalities and urinary dysfunction in both adult and pediatric populations. In children, these findings should be interpreted within the framework of CKD-MBD rather than conventional osteoporosis. Integrated radiological, renal, skeletal, and urological assessment may facilitate earlier identification of high-risk patients.

Keywords: Chronic kidney disease; vertebral compression fracture; CKD-mineral bone disorder; magnetic resonance imaging; lower urinary tract dysfunction; osteoporosis; pediatric nephrology; radiology; urinary symptoms.

Introduction

Chronic kidney disease (CKD) is a progressive disorder associated with systemic complications involving the cardiovascular, hematological, neurological, musculoskeletal, and genitourinary systems. Among its important extra-renal complications, abnormalities of bone metabolism have received increasing attention because patients with moderate-to-severe CKD have a greater risk of skeletal fragility and fractures. Alterations in calcium, phosphate, parathyroid hormone (PTH), vitamin D metabolism, and bone turnover contribute to the complex spectrum referred to as CKD-mineral and bone disorder (CKD-MBD). The Kidney Disease: Improving Global Outcomes (KDIGO) guideline recognizes CKD-MBD as a disorder involving mineral metabolism, bone turnover and strength, growth abnormalities, and vascular or soft-tissue calcification. In patients with advanced CKD and evidence of CKD-MBD or fracture risk, assessment of bone health is recommended when the findings are expected to influence management.[1]

Vertebral compression fractures are an important manifestation of skeletal fragility. Although traditionally associated with postmenopausal osteoporosis and advanced age, vertebral fractures

may also occur in patients with chronic systemic diseases, including CKD. CKD-related abnormalities can affect both bone quantity and bone quality, meaning that fracture susceptibility may not be fully explained by bone mineral density alone. A systematic review and meta-analysis found that several studies demonstrated increased vertebral fracture risk among individuals with CKD, although the strength of the association varied after adjustment for confounding factors.[2]

Magnetic resonance imaging (MRI) is particularly useful in the assessment of vertebral compression abnormalities because it can demonstrate vertebral height loss, marrow edema, endplate abnormalities, fracture-related changes, spinal alignment, and associated neural or soft-tissue abnormalities. MRI can therefore provide information beyond conventional radiography and may help distinguish acute or subacute vertebral injury from chronic deformity. In patients with CKD, radiological assessment is particularly relevant because vertebral structural changes may occur in the context of altered bone turnover and renal osteodystrophy.

The pediatric population requires a different clinical and radiological framework. Children with CKD are vulnerable to CKD-MBD because normal skeletal growth and mineralization are disrupted by abnormalities in calcium-phosphate metabolism, vitamin D activity, PTH regulation, and renal function. Pediatric CKD-MBD may manifest through growth retardation, altered bone mineralization, skeletal deformity, and fractures. A large pediatric cohort study demonstrated progressive abnormalities in mineral metabolism and bone-density measures with advancing CKD stage, while other literature emphasizes the increased occurrence of skeletal deformities and fractures in children with CKD.[3,4]

Importantly, pediatric vertebral abnormalities should not simply be labeled as conventional age-related osteoporosis. In children, vertebral compression or deformity in the presence of CKD should generally be interpreted in relation to CKD-MBD, renal osteodystrophy, growth abnormalities, and altered skeletal development. KDIGO specifically recommends monitoring calcium, phosphate, PTH, and alkaline phosphatase from an earlier CKD stage in children than in adults and recognizes the importance of growth and skeletal assessment throughout childhood.[2-4]

Lower urinary tract dysfunction represents another clinically important complication in patients with chronic renal disease. Adult lower urinary tract symptoms (LUTS) may include urinary frequency, urgency, nocturia, weak stream, hesitancy, incomplete emptying, and urinary incontinence. These symptoms may occur alongside CKD because of age, comorbidities,

medications, bladder dysfunction, neurological disease, or underlying urological pathology. In pediatric patients, urinary dysfunction is assessed differently and may manifest as daytime frequency, urgency, urinary incontinence, nocturnal enuresis, recurrent urinary tract infections, dysfunctional voiding, or urinary retention.[5-7]

The relationship between vertebral pathology and urinary symptoms is potentially clinically relevant because spinal structural abnormalities may coexist with neurological or functional abnormalities affecting lower urinary tract control. However, urinary symptoms in patients with CKD are multifactorial and should not automatically be considered a direct consequence of vertebral compression. Therefore, an integrated assessment of renal function, vertebral morphology, skeletal status, and urinary function is necessary.[8-10]

The present study was designed to evaluate the correlation between vertebral compression abnormalities, CKD severity, and lower urinary tract dysfunction in adults and children. The adult analysis focused on osteoporotic/fragility-related vertebral compression fractures, whereas the pediatric analysis specifically evaluated CKD-MBD-associated vertebral deformities or fractures. The study additionally examined whether increasing renal disease severity was associated with greater radiological skeletal abnormalities and urinary dysfunction.

Methodology

Study Design and Setting

A prospective observational radiological study was designed to evaluate the association between CKD, vertebral structural abnormalities, and lower urinary tract dysfunction at Rahbar Medical and Dental College / Punjab Rangers Teaching Hospital. The study population consisted of adult and pediatric patients referred for spinal imaging because of vertebral pain, suspected vertebral compression, CKD-related skeletal concerns, or associated urinary symptoms.

For purposes of this model article, the study population consisted of 180 patients, including 140 adults and 40 pediatric patients.

Study Population

The participants were divided into two predefined groups:

Adult group

Adults aged ≥40 years with MRI evidence of vertebral compression fracture or vertebral structural abnormality were included.

Pediatric group

Children and adolescents aged 5–17 years with established CKD and clinical suspicion of skeletal involvement, vertebral deformity, back pain, growth abnormality, or radiological vertebral abnormality were included.

The pediatric group was analyzed separately because vertebral skeletal abnormalities associated with CKD in children represent CKD-MBD/renal osteodystrophy rather than conventional age-related osteoporosis.

Inclusion Criteria

Adults

- Age ≥40 years.
- MRI evidence of vertebral compression fracture or vertebral compression deformity.
- Availability of renal function testing.
- Availability of clinical urinary symptom assessment.
- Willingness to participate.

Children

- Age 5–17 years.
- Established CKD stage 2–5 or dialysis-dependent CKD.
- Clinical or radiological suspicion of skeletal involvement.
- Availability of biochemical CKD-MBD parameters.
- Availability of spinal MRI where clinically indicated.
- Parental/guardian consent and appropriate child assent.

Exclusion Criteria

Patients were excluded if they had:

- Acute major traumatic vertebral fracture.
- Known primary malignant vertebral disease.
- Vertebral infection.
- Primary metabolic bone disease unrelated to CKD.
- Previous major spinal surgery involving the evaluated vertebral region.
- Incomplete renal or radiological records.
- Inability to complete urinary symptom assessment.

Clinical Assessment

Demographic data, body mass index, duration of CKD, medication history, dialysis status, history of previous fractures, diabetes, hypertension, steroid exposure, smoking history in adults, and relevant comorbidities were documented.

In children, age, sex, height, weight, growth percentile, CKD duration, dialysis status, primary renal diagnosis, history of fractures, and CKD-MBD treatment were recorded.

Renal Assessment

Serum creatinine and estimated glomerular filtration rate (eGFR) were recorded. CKD was categorized according to standard CKD staging.

Adults were categorized into:

- G1–G2
- G3a
- G3b
- G4
- G5

Pediatric participants were categorized according to their established CKD stage.

Additional biochemical parameters included:

- Serum calcium
- Serum phosphate
- Alkaline phosphatase
- Parathyroid hormone
- 25-hydroxyvitamin D where available

KDIGO recommends monitoring calcium, phosphate, PTH, and alkaline phosphatase in patients with CKD-MBD, with biochemical monitoring beginning earlier in children.[1]

Radiological Assessment

All patients underwent MRI of the clinically relevant spinal region using standard T1-weighted, T2-weighted and fluid-sensitive sequences.

The following radiological parameters were recorded:

1. Vertebral level involved.
2. Anterior vertebral height.
3. Middle vertebral height.
4. Posterior vertebral height.
5. Percentage vertebral height reduction.
6. Endplate irregularity.
7. Bone marrow edema.
8. Posterior wall involvement.
9. Spinal canal compromise.
10. Associated degenerative changes.
11. Additional vertebral deformities.

Adult vertebral compression fractures were classified according to the degree of vertebral height reduction as:

- **Mild:** 20–25%
- **Moderate:** >25–40%
- **Severe:** >40%

In children, vertebral deformities were interpreted with consideration of age, skeletal maturity, vertebral morphology, growth-related variation, and CKD-MBD. Pediatric findings were therefore not classified as conventional osteoporosis solely on the basis of vertebral height loss.

Assessment of Lower Urinary Tract Symptoms

Adults

The International Prostate Symptom Score (IPSS) was used to quantify lower urinary tract symptoms.

Symptoms were categorized as:

- Mild: 0–7
- Moderate: 8–19
- Severe: 20–35

The analysis included both storage and voiding symptoms.

Children

Age-appropriate urinary history was obtained, including:

- Daytime frequency
- Urgency
- Daytime urinary incontinence
- Nocturnal enuresis
- Dysuria
- Recurrent urinary tract infection
- Difficulty initiating urination
- Weak urinary stream

- Incomplete bladder emptying
- Urinary retention

Where clinically indicated, renal/bladder ultrasonography and urodynamic assessment were considered.

Pediatric CKD-MBD Assessment

Pediatric skeletal abnormalities were evaluated in relation to:

- CKD stage
- Serum calcium
- Serum phosphate
- PTH
- Alkaline phosphatase
- Vitamin D
- Growth impairment
- Bone-density assessment where available
- MRI findings

This approach is consistent with evidence showing that children with CKD develop progressive abnormalities in mineral metabolism and bone measures with increasing CKD severity.[3,4]

Statistical Analysis

Data were analyzed using SPSS version 26.0.

Continuous variables were presented as mean ± standard deviation or median with interquartile range where appropriate. Categorical variables were presented as frequencies and percentages.

The chi-square test or Fisher's exact test was used to compare categorical variables. Independent-samples t-test or Mann–Whitney U test was used for continuous variables depending on distribution.

Pearson or Spearman correlation analysis was used to assess relationships between renal parameters and radiological severity.

Multivariable logistic regression was used to identify independent predictors of moderate-to-severe vertebral compression or significant urinary dysfunction.

A p-value <0.05 was considered statistically significant.

Ethical Considerations

The study protocol was designed in accordance with the Declaration of Helsinki. Ethical approval was obtained from the institutional review committee. Written informed consent was obtained from adult participants and parents/guardians of pediatric participants. Age-appropriate assent was obtained from children where applicable.

Results

Baseline Characteristics

A total of 180 participants were included, comprising 140 adults and 40 pediatric patients.

Among adults, the mean age was 67.2 ± 11.6 years, with 82 (58.6%) females and 58 (41.4%) males.

Among pediatric participants, the mean age was 12.1 ± 3.4 years, with 22 (55.0%) males and 18 (45.0%) females.

Table 1: Baseline characteristics of study participants

Variable	Adults (n=140)	Children (n=40)
Mean age (years)	67.2 ± 11.6	12.1 ± 3.4
Male	58 (41.4%)	22 (55.0%)
Female	82 (58.6%)	18 (45.0%)
CKD present	67 (47.9%)	40 (100%)
CKD stage 2	8 (5.7%)	4 (10.0%)
CKD stage 3	31 (22.1%)	8 (20.0%)
CKD stage 4	20 (14.3%)	13 (32.5%)
CKD stage 5	16 (11.4%)	15 (37.5%)
Dialysis	14 (10.0%)	11 (27.5%)
Moderate/severe vertebral abnormality	51 (36.4%)	15 (37.5%)
Urinary dysfunction/LUTS	51 (36.4%)	14 (35.0%)

Adult CKD and Vertebral Compression Findings

Among the 140 adult participants, 67 (47.9%) had CKD. Vertebral compression was mild in 44 (31.4%), moderate in 35 (25.0%), and severe in 16 (11.4%).

Moderate-to-severe vertebral compression was more frequent among participants with CKD compared with those without CKD.

Among adults with advanced CKD (G4–G5), 22 of 36 (61.1%) demonstrated moderate-to-severe vertebral compression compared with 29 of 104 (27.9%) among those without advanced CKD (p=0.001).

Table 2: Vertebral compression severity according to CKD status in adults

Vertebral finding	CKD present n=67	No CKD n=73	p-value
Mild	18 (26.9%)	26 (35.6%)	
Moderate	27 (40.3%)	21 (28.8%)	
Severe	12 (17.9%)	4 (5.5%)	
Moderate/severe combined	39 (58.2%)	25 (34.2%)	0.003

CKD Stage and Radiological Severity

The frequency of moderate-to-severe vertebral compression increased progressively with CKD stage.

Among adults with CKD stage 3, moderate-to-severe vertebral compression was identified in approximately 48.4%, compared with 60.0% in stage 4 and 75.0% in stage 5.

Table 3: Vertebral compression according to adult CKD stage

CKD category	Patients	Moderate/severe compression
No CKD	73	25 (34.2%)
G1–G2	8	3 (37.5%)
G3	31	15 (48.4%)
G4	20	12 (60.0%)
G5	16	12 (75.0%)

A significant inverse correlation was observed between eGFR and vertebral compression severity (Spearman $r = -0.39$, $p<0.001$).

Adult Lower Urinary Tract Symptoms

Among the 140 adult participants, 51 (36.4%) demonstrated clinically significant LUTS.

Significant LUTS were more common among patients with CKD than those without CKD.

Among patients with CKD, 31 (46.3%) had moderate-to-severe urinary symptoms compared with 20 (27.4%) among participants without CKD (p=0.018).

Table 4: Lower urinary tract symptoms according to CKD status

LUTS severity	CKD n=67	No CKD n=73
None/mild	36 (53.7%)	53 (72.6%)
Moderate	23 (34.3%)	16 (21.9%)
Severe	8 (11.9%)	4 (5.5%)
Moderate/severe	31 (46.3%)	20 (27.4%)
p-value		**0.018**

Relationship Between Vertebral Compression and LUTS

Patients with moderate-to-severe vertebral compression demonstrated a greater frequency of significant LUTS.

Among adults with moderate-to-severe compression, 27 (52.9%) had moderate-to-severe LUTS compared with 24 (27.0%) among those with no or mild compression (p=0.003).

This association remained significant after adjustment for age, sex, diabetes, CKD stage, and previous fracture.

Pediatric Findings

All 40 pediatric participants had established CKD. Twenty-eight (70.0%) had advanced CKD stages 4–5.

The most common underlying renal diagnoses were congenital anomalies of the kidney and urinary tract, hereditary nephropathies, glomerular disease, and reflux-related renal disease.

Table 5: Characteristics of pediatric participants

Variable	n (%)
Total	40 (100%)
Age 5–9 years	9 (22.5%)
Age 10–13 years	15 (37.5%)
Age 14–17 years	16 (40.0%)
CKD stage 2	4 (10.0%)
CKD stage 3	8 (20.0%)
CKD stage 4	13 (32.5%)
CKD stage 5	15 (37.5%)
Dialysis-dependent	11 (27.5%)
Growth impairment	16 (40.0%)
Vertebral compression/deformity	15 (37.5%)
Urinary dysfunction	14 (35.0%)

Pediatric CKD-MBD Findings

Pediatric patients with vertebral abnormalities demonstrated greater biochemical evidence of CKD-MBD.

Elevated PTH was observed in 12 of 15 (80.0%) children with vertebral abnormalities compared with 13 of 25 (52.0%) without vertebral abnormalities.

Similarly, low bone-density Z-scores were more frequent among children with vertebral abnormalities.

Table 6: Pediatric CKD-MBD characteristics according to vertebral abnormality

Parameter	Vertebral abnormality n=15	No vertebral abnormality n=25
Elevated PTH	12 (80.0%)	13 (52.0%)
Hyperphosphatemia	9 (60.0%)	9 (36.0%)
Low/low-normal calcium	7 (46.7%)	7 (28.0%)
Vitamin D insufficiency	10 (66.7%)	13 (52.0%)
Low bone-density Z-score	10 (66.7%)	8 (32.0%)
Growth impairment	9 (60.0%)	7 (28.0%)

The overall pattern suggested increasing skeletal abnormalities with worsening renal function and biochemical evidence of CKD-MBD.

Pediatric Urinary Dysfunction

Urinary dysfunction was present in 14 (35.0%) pediatric participants.

The most frequent symptoms were daytime urgency/frequency, urinary incontinence, recurrent urinary tract infection, and difficulty with bladder emptying.

Urinary dysfunction occurred in 10 of 28 (35.7%) children with CKD stages 4–5 compared with 4 of 12 (33.3%) children with CKD stages 2–3.

Among children with vertebral abnormalities, urinary dysfunction was identified in 8 (53.3%), compared with 6 (24.0%) without vertebral abnormalities.

Table 7: Pediatric urinary dysfunction according to vertebral findings

Urinary finding	Vertebral abnormality n=15	No vertebral abnormality n=25
Urgency/frequency	5 (33.3%)	4 (16.0%)
Daytime incontinence	4 (26.7%)	3 (12.0%)
Recurrent UTI	3 (20.0%)	4 (16.0%)
Voiding difficulty	2 (13.3%)	1 (4.0%)
Any urinary dysfunction	8 (53.3%)	6 (24.0%)

Multivariable Analysis

After adjustment for age, sex, CKD stage, diabetes, and previous fracture, advanced CKD and moderate-to-severe vertebral compression remained significant predictors of clinically significant LUTS among adults.

Table 8: Predictors of moderate-to-severe LUTS in adults

Predictor	Adjusted OR	95% CI	p-value
Age ≥65 years	1.92	1.01–3.65	0.046
CKD stage 4–5	2.41	1.22–4.78	0.011
Moderate/severe vertebral compression	2.76	1.37–5.56	0.005
Diabetes mellitus	1.83	0.94–3.56	0.075
Previous vertebral fracture	1.69	0.82–3.48	0.154

Among pediatric participants, advanced CKD, elevated PTH, low bone-density Z-score, and vertebral deformity showed positive associations with urinary dysfunction, although the small pediatric sample limited the statistical power of multivariable modeling.

Discussion

The present study demonstrated an association between CKD severity, vertebral structural abnormalities, and lower urinary tract dysfunction in both adult and pediatric populations. The principal finding was that moderate-to-severe vertebral compression abnormalities were more frequent among patients with advanced CKD. In adults, CKD stage 4–5 was independently associated with greater radiological severity, while moderate-to-severe vertebral compression was also associated with a greater prevalence of LUTS.

The relationship between CKD and skeletal fragility is biologically plausible. Progressive renal dysfunction causes disturbances in phosphate handling, vitamin D metabolism, calcium balance, PTH regulation, and bone turnover. These abnormalities can produce changes in bone quality and strength. KDIGO recognizes that patients with CKD G3a–G5D have increased fracture rates and recommends consideration of bone mineral density assessment in selected patients when the result would influence treatment decisions.[11-12]

The findings of the present adult cohort are consistent with previous evidence suggesting that CKD is associated with increased fracture risk. A systematic review and meta-analysis found that several observational studies reported higher vertebral fracture risk among patients with CKD, although adjustment for confounders reduced or eliminated the association in some studies.[2] Therefore, CKD should be regarded as an important risk marker rather than assumed to be a direct independent cause of every vertebral fracture.[13-15]

MRI provided valuable information regarding the structural characteristics of vertebral abnormalities. In addition to vertebral height reduction, marrow signal abnormalities and endplate changes can help characterize acute or subacute fracture-related changes. This is clinically useful in CKD patients because vertebral pain may otherwise be attributed to degenerative spinal disease.

An important feature of this study was the inclusion of a pediatric subgroup. Pediatric CKD represents a distinct clinical situation because the skeleton is actively growing. Abnormalities in phosphate, calcium, PTH, vitamin D metabolism, and bone turnover may interfere with normal

bone mineralization and growth. KDIGO recommends monitoring mineral metabolism beginning from CKD G2 in children and emphasizes assessment of growth and skeletal health.[16-18]

The pediatric findings in this study showed that vertebral abnormalities were more frequent in children with biochemical evidence of CKD-MBD. Elevated PTH and reduced bone-density measurements were particularly common among children with vertebral abnormalities. These findings are consistent with the KNOW-Ped CKD cohort, in which worsening CKD was accompanied by increasing abnormalities in mineral metabolism and lower bone-density measures.[19-20]

Importantly, the pediatric skeletal findings should not be interpreted as conventional osteoporosis. Children with CKD can develop renal osteodystrophy and CKD-MBD characterized by altered bone turnover, impaired mineralization, growth abnormalities, and increased fracture susceptibility. Published pediatric reviews describe skeletal deformities, impaired growth, and fractures as important consequences of CKD-MBD.[4,5]

Another important observation was the association between vertebral abnormalities and urinary dysfunction. In adults, significant LUTS were more frequent among patients with moderate-to-severe vertebral compression. Several mechanisms may potentially contribute to this relationship, including age-related comorbidity, neurological or spinal dysfunction, impaired mobility, medication effects, and independent urological disease. Consequently, the observed association should not be interpreted as evidence that vertebral compression directly causes LUTS.

The pediatric urinary findings require similar caution. Urinary dysfunction is common in children with underlying renal disease and may reflect congenital urinary tract abnormalities, recurrent infection, bladder dysfunction, neurological factors, or the primary cause of CKD itself. The higher prevalence of urinary symptoms among children with vertebral abnormalities may therefore represent overlapping renal, spinal, and bladder pathology rather than a simple causal pathway.

From a clinical perspective, these findings support an integrated approach to patients with CKD and vertebral abnormalities. In adults, patients with CKD and fragility fractures may benefit from renal biochemical evaluation, bone-health assessment, and appropriate spinal imaging. In children, evaluation should additionally include growth assessment, CKD-MBD biochemical testing, and age-appropriate skeletal assessment. KDIGO specifically emphasizes the importance of biochemical monitoring and consideration of bone-density assessment when clinically relevant.[1]

The study also highlights the potential role of radiology in identifying patients who require further nephrological or urological evaluation. A vertebral compression abnormality on MRI in a patient with CKD may represent more than an isolated orthopedic problem. Conversely, urinary symptoms in a patient with spinal abnormalities should prompt consideration of neurological and urological contributors when clinically appropriate.

Limitations

This study has several limitations. First, the numerical findings presented in this manuscript are illustrative and must be replaced by actual patient-level data before submission. Second, the study design does not establish a causal relationship between CKD, vertebral compression, and urinary dysfunction. Third, the pediatric subgroup was relatively small, limiting the statistical power of subgroup analyses. Fourth, not all participants may have undergone bone mineral density assessment or urodynamic testing, potentially introducing measurement variability. Fifth, urinary symptoms are multifactorial and may be influenced by age, diabetes, neurological disease, medications, mobility, and underlying urological abnormalities. Finally, pediatric vertebral morphology varies with skeletal maturation, making direct comparison between pediatric and adult fracture classifications inappropriate.

Conclusion

Chronic kidney disease was associated with an increased frequency and severity of vertebral structural abnormalities, particularly in patients with advanced renal impairment. In adults, moderate-to-severe vertebral compression was associated with a higher prevalence of lower urinary tract symptoms, while in children, vertebral abnormalities were frequently accompanied by biochemical evidence of CKD-mineral and bone disorder and urinary dysfunction.

The pediatric findings should be interpreted in the context of CKD-MBD/renal osteodystrophy rather than conventional osteoporosis. MRI provides valuable information regarding vertebral morphology and fracture-related changes, while renal biochemical assessment and urinary evaluation provide complementary clinical information. Early recognition of skeletal and urinary abnormalities in patients with CKD may facilitate appropriate referral to nephrology, radiology, orthopedics, urology, and pediatric services.

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