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Research Article

Magnetic Resonance Imaging Correlation of Pelvic Floor Disorders with Degenerative Lumbar Spine Disease and Lower Urinary Tract Symptoms

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Abstract

Degenerative lumbar spine disease (DLSD) and pelvic floor dysfunction (PFD) frequently coexist, sharing anatomical innervations from the sacral plexus (S_2–S_4) that mediate both pelvic floor muscle tone and lower urinary tract symptoms (LUTS). While this neuro-anatomical cross-talk is established in adults, its manifestation across the pediatric spectrum—specifically in older children and adolescents with developmental spinal anomalies or early-onset lumbar disc degeneration—remains under-characterized. The objective of this cross-sectional study was to evaluate the magnetic resonance imaging (MRI) structural correlations between lumbar spine degeneration, morphometric pelvic floor muscle impairment, and clinical LUTS severity across both pediatric and adult cohorts. A total of 360 patients presenting with lower back pain and urinary storage or voiding dysfunction were evaluated, comprising an Adult Cohort (n = 240, aged 18 to 65 years) and a Pediatric/Adolescent Cohort (n = 120, aged 8 to 17 years). Multi-planar 3.0T MRI was utilized to assess lumbar disc degeneration (Pfirrmann grading), neural canal/foraminal stenosis, sacral nerve root compression, and pelvic floor morphometry (puborectalis muscle thickness, levator hiatus area, and bladder neck descent during strain). Clinical LUTS were quantified using the International Prostate Symptom Score (IPSS) in adults and the Dysfunctional Voiding Symptom Score (DVSS) in pediatric patients. In the adult cohort, advanced lumbar disc degeneration (Pfirrmann grades IV–V) and S_2–S_4 nerve root compression were strongly correlated with increased levator hiatus area ($r = 0.62, p < 0.001$) and elevated IPSS scores ($r = 0.68, p < 0.001$). In the pediatric cohort, early-onset lumbar disc herniation, spinal dysraphism, or tethered cord syndrome correlated significantly with puborectalis muscle atrophy (mean thickness: 3.8 mm vs. 5.6 mm in controls, $p < 0.001$) and severe dysfunctional voiding ($r = 0.58, p < 0.001$). Multivariable regression confirmed that lower lumbar/sacral nerve root compression on MRI was an independent predictor of severe LUTS in both adults (aOR: 4.15, 95% CI: 2.18–7.90) and pediatric patients (aOR: 3.85, 95% CI: 1.72–8.62). Structural MRI changes in the lumbar spine directly correlate with pelvic floor muscle morphometric defects and LUTS severity in both adult and pediatric populations, underscoring the clinical necessity of joint neuro-urological and radiological evaluation.

Keywords: Lumbar spine degeneration, pelvic floor dysfunction, lower urinary tract symptoms, magnetic resonance imaging, puborectalis muscle, pediatric spina bifida, sacral nerve roots.

Introduction

The anatomical and functional interplay between the lumbar spine, pelvic floor musculature, and lower urinary tract is anchored in shared somatic and autonomic nerve supply originating from the L_4–S_4 spinal segments. Somatic motor fibers via the pudendal nerve (S_2–S_4) directly innervate the levator ani complex (puborectalis, pubococcygeus, and iliococcygeus) and the external urethral sphincter, while parasympathetic fibers mediate detrusor contraction during micturition. [1–3]

In adults, degenerative lumbar spine disease (DLSD)—including intervertebral disc herniation, facet joint arthrosis, and central canal or neural foraminal stenosis—frequently leads to radiculopathy and micro-ischemia of sacral nerve roots. Chronic neural impingement disrupts tonic neuromuscular activation of the pelvic floor, predisposing patients to pelvic organ prolapse, levator hiatus enlargement, and lower urinary tract symptoms (LUTS) such as urgency, frequency, strain voiding, and urinary incontinence. [4–6]

Conversely, in pediatric and adolescent populations, lower urinary tract symptoms and pelvic floor dysfunction are traditionally attributed to primary behavioral voiding postponement, non-neurogenic neurogenic bladder, or congenital neural tube defects. However, emerging pediatric neuro-radiological studies demonstrate that subtle mechanical or congenital spinal pathology—including early-onset lumbar disc herniation, spina bifida occulta, filum terminale lipomas, and tethered cord syndrome—can induce subclinical sacral radiculopathy. This neurological interruption impairs normal pelvic floor relaxation during micturition, precipitating high-pressure dysfunctional voiding, vesicoureteral reflux, and recurrent pediatric urinary tract infections. [7–10]

High-resolution magnetic resonance imaging (MRI) provides exceptional soft-tissue contrast, enabling concurrent multi-planar visualization of lumbar intervertebral discs, nerve root compression, and pelvic floor muscle morphometry (such as puborectalis muscle volume and levator hiatus dimensions).

Despite these shared neuro-anatomical pathways, comparative MRI studies simultaneously examining pelvic floor muscle changes and lumbar spine pathology across both pediatric and adult cohorts remain scarce.

This cross-sectional comparative study aimed to determine the multi-planar MRI structural correlations between degenerative or structural lumbar spine disease, pelvic floor muscle morphometry, and the clinical severity of lower urinary tract symptoms in pediatric and adult patient populations.

Methodology

A prospective cross-sectional comparative study was conducted over an 18-month period, evaluating 360 patients presenting

with concurrent lower back pain/spinal symptoms and lower urinary tract symptoms (LUTS) at Department of Radiology, Rahbar Medical and Dental College / Punjab Rangers Teaching Hospital, Lahore, Pakistan.
The study cohort was divided into two distinct age groups: an Adult Cohort (n = 240, aged 18 to 65 years) and a Pediatric/Adolescent Cohort (n = 120, aged 8 to 17 years). Approval was obtained from the institutional ethics review committee, and written informed consent was acquired from adult participants and parents/legal guardians of pediatric patients (along with pediatric assent).

Inclusion criteria for adults comprised back pain with storage or voiding LUTS lasting > 3 months. Pediatric inclusion required chronic lower urinary tract symptoms (daytime incontinence, urgency, straining, or recurrent urinary tract infections) with or without back pain or gait abnormalities. Exclusion criteria across both cohorts included prior pelvic or spinal surgery, active pelvic malignancy, acute urinary tract infection at evaluation, or metallic implants precluding MRI acquisition.

Symptom severity was quantified using validated scoring tools: the International Prostate Symptom Score (IPSS; scale 0–35) . for adults, and the Dysfunctional Voiding Symptom Score (DVSS; scale 0–30) for pediatric patients.

Imaging was performed on a 3.0T MRI scanner (Siemens Magnetom Skyra) using standardized multi-planar T1-, T2-weighted, and 3D T2-SPACE sequences covering the lumbar spine (L_1–S_5) and pelvic floor. Lumbar spine parameters included Pfirrmann disc degeneration grade (I–V), severity of central canal stenosis, neural foraminal narrowing, and S_2–S_4 nerve root compression/displacement. Pelvic floor morphometric parameters measured on axial and coronal views included puborectalis muscle thickness (mm), levator hiatus area (cm^2), and sagittal bladder neck descent during strain (mm).

Statistical analyses were performed using SPSS version 26. Pearson/Spearman correlation coefficients evaluated relationships between continuous MRI parameters and symptom scores. Independent t-tests and Chi-square tests compared subgroup differences. Multivariable logistic regression identified independent MRI structural predictors of severe LUTS (IPSS age 20 or DVSS age 15) in adult and pediatric groups

Results

Table 1: Demographic, Clinical, and Baseline Structural Parameters Stratified by Age Cohort

Parameter	**Adult Cohort (n=240)**	**Pediatric Cohort (n=120)**	**p-value**
Age (Years ± SD)	48.5 ± 11.2	12.4 ± 2.8	N/A

Parameter	**Adult Cohort (n=240)**	**Pediatric Cohort (n=120)**	**p-value**
Gender (Male / Female %)	108 / 132 (45.0% / 55.0%)	54 / 66 (45.0% / 55.0%)	0.999
Primary Spine Diagnosis (%)			< 0.001
- Lumbar Disc Degeneration / Herniation	185 (77.1%)	18 (15.0%)	
- Central / Foraminal Spinal Stenosis	42 (17.5%)	4 (3.3%)	
- Spinal Dysraphism / Tethered Cord / Spondylolysis	13 (5.4%)	98 (81.7%)	
Primary LUTS Presentation (%)			< 0.001
- Storage Symptoms (Urgency, Frequency, Incontinence)	148 (61.7%)	82 (68.3%)	
- Voiding Symptoms (Hesitancy, Straining, Weak Stream)	92 (38.3%)	38 (31.7%)	
LUTS Severity Score (Mean ± SD)	IPSS: 18.5 ± 5.8	DVSS: 14.2 ± 4.6	N/A
Presence of S_2–S_4 Nerve Root Compression on MRI (%)	138 (57.5%)	52 (43.3%)	0.011

Note: Adult patients predominantly presented with degenerative disc disease and spinal stenosis, whereas pediatric patients were characterized by spinal dysraphism, tethered cord syndrome, and early-onset structural anomalies.

Table 2: Multi-Planar Pelvic Floor Muscle Morphometry on 3.0T MRI

Pelvic Floor MRI Parameter	Adult Cohort (n=240)	Pediatric Cohort (n=120)	Pediatric Age-Matched Controls (n=40)*	p-value
Puborectalis Muscle Thickness (mm)	6.8 ± 1.4	3.8 ± 0.9	5.6 ± 0.8	< 0.001
Levator Hiatus Area (cm^2)	18.2 ± 3.5	11.4 ± 2.1	9.2 ± 1.5	< 0.001
Bladder Neck Descent During Strain (mm)	12.4 ± 4.1	6.2 ± 2.3	2.8 ± 1.1	< 0.001
Levator Ani Muscle Defect / Asymmetry (%)	88 (36.7%)	31 (25.8%)	2 (5.0%)	< 0.001

Note: *Control values derived from healthy pediatric patients undergoing pelvic MRI for non-urologic, non-spinal indications. Pediatric patients with spinal pathology exhibited marked puborectalis muscle thinning and levator hiatus expansion compared to controls.

Table 3: Correlation Matrix Between Lumbar Spine MRI Findings, Pelvic Floor Morphometry, and LUTS Scores

Clinical & Radiological Variable	Adult IPSS Score (r, p-value)	Adult Levator Hiatus Area (r, p-value)	Pediatric DVSS Score (r, p-value)	Pediatric Puborectalis Thickness (r, p-value)
Pfirrmann Disc Degeneration Grade	$r = 0.58, p < 0.001$	$r = 0.52, p < 0.001$	$r = 0.35, p = 0.001$	$r = -0.32, p = 0.002$
S_2–S_4 Sacral Nerve Root Compression	$r = 0.68, p < 0.001$	$r = 0.62, p < 0.001$	$r = 0.58, p < 0.001$	$r = -0.54, p < 0.001$
Central Canal Stenosis Severity	$r = 0.61, p < 0.001$	$r = 0.48, p < 0.001$	$r = 0.42, p < 0.001$	$r = -0.38, p < 0.001$
Levator Hiatus Area (cm^2)	$r = 0.64, p < 0.001$	1.00	$r = 0.52, p < 0.001$	$r = -0.68, p < 0.001$

Note: Sacral nerve root compression on MRI correlated strongly with clinical LUTS severity and pelvic floor morphometric impairment across both adult and pediatric cohorts.

Table 4: Multivariable Logistic Regression Analysis for Structural MRI Predictors of Severe LUTS

Predictor Variable	Adult Cohort aOR (95% CI)	Adult p-value	Pediatric Cohort aOR (95% CI)	Pediatric p-value
S_2–S_4 Nerve Root Compression	4.15 (2.18–7.90)	< 0.001	3.85 (1.72–8.62)	0.001

Predictor Variable	Adult Cohort aOR (95% CI)	Adult p-value	Pediatric Cohort aOR (95% CI)	Pediatric p-value
Advanced Lumbar Disc Degeneration (Pfirrmann IV–V)	3.28 (1.68–6.42)	0.001	2.45 (1.08–5.58)	0.032
Levator Hiatus Enlargement (> Upper Terpile)	2.95 (1.52–5.72)	0.001	3.12 (1.42–6.85)	0.004
Puborectalis Muscle Atrophy (< Lower Terpile)	2.62 (1.31–5.24)	0.006	3.48 (1.58–7.68)	0.002
Tethered Cord / Filum Terminale Thickening	N/A	N/A	4.62 (1.98–10.78)	< 0.001

Note: Sacral nerve root compression and pelvic floor muscle atrophy were independent structural predictors of severe lower urinary tract symptoms in both adult and pediatric populations.

Discussion

This cross-sectional study demonstrates direct structural correlations between lumbar spine pathology, pelvic floor muscle impairment, and lower urinary tract symptom severity across adult and pediatric populations. High-resolution 3.0T multi-planar MRI confirmed that mechanical or congenital disruption of $S_2–S_4$ spinal segments directly alters pelvic floor morphometry, predisposing both adults and children to refractory LUTS.

In the adult cohort, degenerative lumbar disc disease and spinal stenosis correlated with enlargement of the levator hiatus area and descent of the bladder neck during strain. Micro-vascular compromise and axonal degradation of the pudendal and pelvic splanchnic nerve roots ($S_2–S_4$) impair tonic motor unit firing in the levator ani complex. This neurogenic weakness leads to pelvic floor laxity, reduced urethral resistance, and detrusor instability, manifesting as high IPSS storage scores and stress/urgency urinary incontinence. [11–14]

In the pediatric cohort, although absolute rates of degenerative disc disease were lower (15.0%), structural anomalies such as spina bifida occulta, thick filum terminale, and tethered cord syndrome were highly prevalent (81.7%). Pediatric patients with sacral nerve root compromise demonstrated marked puborectalis muscle atrophy (mean thickness 3.8 mm vs. 5.6 mm in healthy controls) and levator hiatus widening. In children, sacral radiculopathy frequently causes non-coordinating pelvic floor spasticity or flaccidity, disrupting the normal voiding reflex and leading to high DVSS scores, dysfunctional voiding, and secondary bladder wall trabeculation. [15–17]

Cross-cohort comparative analysis revealed that S_2–S_4 sacral nerve root compression on MRI serves as an independent predictor of severe LUTS in both adults (aOR: 4.15) and pediatric patients (aOR: 3.85). Furthermore, in pediatric patients, tethered cord dynamics represented the single strongest predictor of severe dysfunctional voiding (aOR: 4.62), emphasizing that unexplained or treatment-resistant pediatric voiding dysfunction warrants screening spine MRI evaluations. [18–20]

Limitations of this study include its cross-sectional design, which limits long-term causal conclusions, and the lack of post-surgical neuro-urological follow-up data.

These findings highlight the necessity of an integrated neuro-urological diagnostic framework. Clinical evaluation of refractory LUTS in both adults and pediatric patients should incorporate lumbar spine and pelvic floor MRI protocols to identify underlying neurological and structural drivers.

Conclusion

High-resolution magnetic resonance imaging demonstrates significant structural correlations between lumbar spine pathology, pelvic floor muscle morphometric defects, and lower urinary tract symptoms in both adult and pediatric populations. Sacral nerve root compression (S_2–S_4), puborectalis muscle atrophy, and levator hiatus enlargement are major independent predictors of severe LUTS regardless of age. Radiologists, pediatric urologists, and spine surgeons should maintain a high index of suspicion for underlying spinal pathology when managing refractory pelvic floor and lower urinary tract dysfunction.

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