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"REDUNDANT CAUDA EQUINA NERVE ROOTS: THEIR IMPLICATIONS IN LUMBAR SPINAL STENOSIS"

Radio-Diagnosis

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ABSTRACT

Aims: This study examines the association between lumbar spinal stenosis and redundant nerve roots of the cauda equina (RNRCE), focusing on their prevalence and clinical implications. **Methods:** MRI data from 37 patients with lumbar stenosis and 21 without were retrospectively analyzed. Patients were grouped based on dural sac cross-sectional area (CSA). Chi-square tests and odds ratio calculations assessed the association between stenosis and RNRCE. **Results:** RNRCE was present in 60% of stenosis patients and 10% of controls. Stenosis patients were 15.6 times more likely to exhibit RNRCE ($p < 0.01$). **Conclusion:** Lumbar stenosis, indicated by a dural sac CSA of less than 50mm² on MRI, significantly increases the risk of RNRCE. These findings underscore the importance of recognizing RNRCE in lumbar spine evaluations to enhance diagnostic accuracy and patient management. Further research is needed to explore the full clinical implications of redundant nerve roots of the cauda equina.

KEYWORDS

Redundant nerve roots of the cauda equina (RNRCE), Lumbar spine degeneration, cauda equina, spinal stenosis

INTRODUCTION

Redundant nerve roots of the cauda equina (RNRCE) are observed on magnetic resonance imaging (MRI) of the lumbosacral spinal cord. They appear as elongated and tortuous nerve roots with a coiled appearance near areas of spinal canal stenosis [1,2]. This condition was first identified by Verbiest [3] in 1954, and the term was later introduced by Cressman and Pawl [1] in 1968. RNRCEs are commonly associated with degenerative spinal canal stenosis, and it is believed that chronic compression at the lumbar spinal stenosis (LSS) level leads to the elongation and tortuosity of the nerve roots. Rather than being a separate disease, RNRCEs may be part of the natural progression of lumbar canal stenosis [2,4].

Recognizing RNRCE in diagnostic imaging is essential to avoid misdiagnosis of other conditions, such as arteriovenous malformations. Studies have reported varying prevalence rates of RNRCE, ranging from 33.8% to 42% in patients with spinal canal stenosis. Symptoms of RNRCEs include back pain, claudication (cramping leg pain during exercise or walking), and paresthesia (burning or prickling sensations). However, it is challenging to determine whether these symptoms are directly caused by RNRCE or by the central canal stenosis itself [4,5].

Despite the clinical importance of RNRCEs, they are often overlooked in lumbar spine MRIs by radiologists and clinicians, likely due to a lack of information on their clinical significance. The clinical implications of RNRCEs remain a topic of debate. For instance, Suzuki et al. [4] found that older age, longer duration of symptoms, and greater severity of neurological symptoms were significant factors in patients with redundant nerve roots, while Min et al. [6] identified age as the only significant factor. This discrepancy underscores the ongoing controversy regarding the impact of RNRCEs on postsurgical outcomes.

This study aims to assess the association of RNRCEs with the severity and duration of symptoms in patients with lumbar spinal canal stenosis. Understanding this relationship is crucial for better management and treatment of patients with lumbar spinal stenosis. Clarifying whether RNRCEs significantly contribute to symptom severity or duration can enhance diagnostic accuracy and inform more effective therapeutic strategies.

In summary, RNRCEs are a significant but often overlooked aspect of lumbar spinal stenosis. Proper recognition and understanding of this condition can improve patient outcomes by facilitating accurate diagnoses and appropriate treatments. Further research is needed to elucidate the clinical significance of RNRCEs and their impact on long-term patient management.

MATERIALS AND METHODS

This retrospective study was conducted in the Department of Radiodiagnosis at J.J.M. Medical College, Davangere, Karnataka. The study included consecutive patients undergoing routine MRI scans of the lumbosacral spine, performed on a PHILIPS 1.5T Achieva MRI machine. The study duration spanned from May 2023 to June 2024.

Population and Grouping

Patients were divided into two groups based on their MRI findings:

- **Stenosis Group:** Patients with a dural sac cross-sectional area (CSA) of less than 100 mm² at any measured level.
- **Control Group:** Patients without spinal canal stenosis, with a CSA of 100 mm² or more at all levels.

Inclusion Criteria:

- **Stenosis Group:** Dural sac CSA < 100 mm².
- **Control Group:** No spinal canal stenosis, CSA ≥ 100 mm².

Exclusion Criteria:

- Prior spine surgery
- Congenital spinal canal stenosis
- Fractures
- Neoplasms
- Ankylosis
- Inflammatory or infectious diseases
- Myelopathy
- Recent spinal interventions (e.g., epidural injection, myelography)

Patient Cohort

The study analyzed retrospective T2-MRI images of the lumbar spine from 37 patients with lumbar stenosis and 21 patients without stenosis. The analysis focused on the correlation between redundant nerve roots of the cauda equina and the respective levels of stenosis.

Statistical Analysis

Statistical analysis was conducted using the Chi-square test to evaluate the associations between variables, with a significance threshold set at a p-value of less than 0.01.

This methodology ensured a rigorous evaluation of the relationship between redundant nerve roots of the cauda equina and lumbar spinal canal stenosis, providing valuable insights into their clinical implications.

RESULTS

In this study, the relationship between spinal canal stenosis and redundant nerve roots of the cauda equina (RNRCE) was rigorously

examined. Among patients with spinal canal stenosis, 60% exhibited RNRCE, significantly higher than the 10% prevalence in the control group [Table 1]. Statistical analysis, including a chi-square test and odds ratio calculation, confirmed a robust association ($p < 0.01$), with patients in the stenosis group being 15.6 times more likely to have RNRCE compared to controls. The computed chi-square value (12.36) exceeded the critical value (6.635), reinforcing the statistical significance of these findings [Table 2]. These results highlight the clinical relevance of identifying RNRCE in lumbar spine MRI evaluations, emphasizing its potential as a diagnostic marker and guiding treatment decisions for patients with spinal canal stenosis. This study underscores the importance of early detection and management of RNRCE to improve patient outcomes and optimize therapeutic approaches in clinical practice.

Table 1: Number of Redundant nerve roots in cases and controls with mean cross sectional area of spinal canal

Group	Presence or absence of redundancy	No.	Mean Age	Mean CSA of spinal canal
Control	Yes	2	44	82 mm^2
	No	19	38	97 mm^2
Cases	Yes	23	63	37 mm^2
	No	14	56	49 mm^2

Table 2: Percentage and number of redundancy with cross sectional area of spinal canal

Max. stenosis (in mm^2)	Presence or absence of redundancy		Total
	Yes	No	
<55	21 (60%)	14 (40%)	35
>55	4 (17.3%)	19 (82.6%)	23
Total	25	33	

DISCUSSION

Our study provides compelling evidence that patients with spinal canal stenosis have a higher likelihood of exhibiting redundant nerve roots of the cauda equina (RNRCE) compared to those without stenosis. RNRCEs are characterized by tortuous, serpentine, large, and elongated nerve roots within the subarachnoid space of the lumbar spine [Figure 1] [5,7]. Previous studies have suggested a potential causal link between RNRs and lumbar spinal stenosis [5,8], indicating that the mechanical impact of stenosis involves the constriction or tethering of nerve roots, thereby restricting their normal movement during spinal flexion and extension. This restriction can lead to elongation, redundancy, and tortuosity of the nerve roots [Figure 2] [4].

Our findings align with previous research, showing a higher incidence of redundancy among patients with more severe spinal canal stenosis [9]. Since all participants in our study exhibited moderate to severe central canal stenosis, it was not feasible to compare the frequency of RNRCE with those without stenosis or with mild stenosis. However, our results demonstrated a prevalence of RNRCE exceeding 60% in cases of moderate to severe stenosis. The true prevalence of RNRs in patients with lumbar canal stenosis remains uncertain, with reported rates varying between 8.2% and 42% in different studies [4,5]. This variation is likely due to differences in the definition and measurement of central canal stenosis severity.

In our study, patients with smaller dural sac cross-sectional areas (CSAs) at the point of maximum stenosis had a higher risk of developing RNRCE. This observation supports the hypothesis that a more constricted spinal canal causes nerve roots to suffer and thicken, resulting in a redundant appearance on MRI.

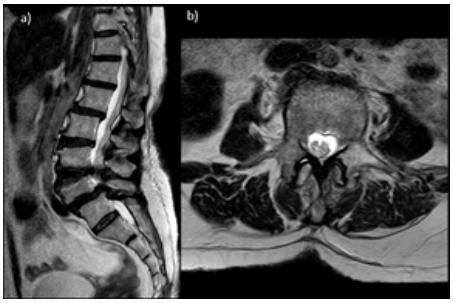

Figure 1: 70-year-old female, with neurogenic claudication. (A) Sagittal T2-weighted MR image shows the degenerative changes and disc herniations with spinal canal stenosis at L3-L4 & L4-L5. The cauda equine nerve roots exhibit a wavy and looping orientation. Spondylolisthesis is also present at L3-L4 & L4-L5. (B) Axial T2-weighted MR images in the above stenotic levels provides evidence for looping & serpiginous slightly thickened nerve roots.

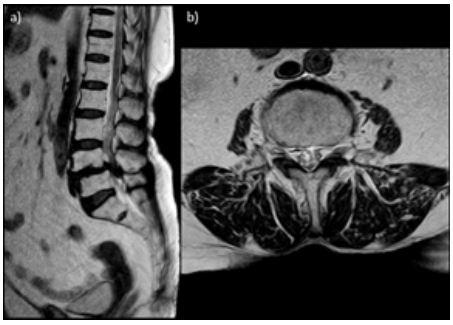

Figure 2: 65-year-old female, with neurogenic claudication. (A) Sagittal T2-weighted MR image shows the degenerative changes and disc herniations with spinal canal stenosis at L4-L5. The cauda equine nerve roots exhibit a wavy and looping orientation. Spondylolisthesis is also present at L4-L5. (B) Axial T2-weighted MR images in the above stenotic levels provides evidence for looping & serpiginous slightly thickened nerve roots.

Suzuki et al. examined 130 patients with severe canal stenosis, characterized by complete or incomplete contrast blockage on myelogram, and divided them into groups based on the presence or absence of redundancy. They found a significant correlation between the degree of stenosis and the presence of RNRCE, although the study design was biased by only including patients with severely constricted spinal canals [4].

Similarly, Ono et al. investigated 44 cases of stenosis secondary to spondylolisthesis at L4-L5, where myelograms showed complete canal blockage. They measured the dural sac CSA at the point of maximum stenosis and found no statistically significant difference between the analyzed groups. However, this study also demonstrated selection bias by only including patients with severe stenosis and complete canal blockage on the myelogram [5].

Our study underscores the importance of assessing RNRCE in patients undergoing lumbar spine MRI evaluations to enhance diagnostic accuracy and inform treatment strategies effectively. Future research should aim to include a broader range of stenosis severity to better understand the true prevalence and implications of RNRCE in lumbar spinal stenosis.

CONCLUSION:

In conclusion, this study confirms that lumbar stenosis, measured by a dural sac CSA of less than 50mm² on MRI, significantly increases the risk of RNRCE. The findings underscore a strong link between lumbar stenosis and RNRCE, enhancing clinical diagnosis and management of lumbar spinal pathologies.

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