Sedimentation Sign Appraisal in Lumbar Spinal Stenosis

Mazin S. Mohammed Jawad

ABSTRACT:

BACKGROUND:

Lumbar nerve roots normally sediment, due to gravity, to the dorsal part of the dural sac, which is known as negative sedimentation sign. If there is a magnetic resonance finding of nerve roots in the ventral part of the dural sac the sedimentation sign is positive.

OBJECTIVE:

To evaluate the presence of the MRI finding of positive sedimentation sign in patients clinically suspected to have lumbar spinal stenosis and if this sign can be a valid tool to differentiate symptomatic spinal canal stenosis from other causes of non-specific back pain.

METHODS:

A planned cohort design prospective study had conducted over a year through July 2019 at the department of neurosurgery at Medical City / Baghdad / Iraq. The study incorporates 200 patients. Those with symptomatic lumbar spine canal stenosis (n=100) show claudication with or without low back pain, leg pain, a dural sac cross-sectional area < 80 mm^2, and a walking interval < 200 meters. The nonspecific low back pain group (n=100) had no leg pain, no claudication, a cross-sectional area of the dural sac >120 mm^2, and a walking interval >1000 meters. The frequency of a positive sedimentation sign compared between both groups to evaluate if this sign can be a valid tool to differentiate spinal canal stenosis from other causes of back pain, intra-rater and inter-rater assessment dependability in a stochastic subsample executed.

RESULTS:

A positive sedimentation sign recognized in 96 patients in the symptomatic lumbar spine canal stenosis group (96%; 95% Confidence Interval CI, 90%–98%), no positive sedimentation sign recognized in the nonspecific low back pain group (0%; 95% Confidence Interval CI, 0%–5%). Credibility was Kappa (κ) =1.0 (intra-rater) and Kappa (κ) =0.90 (inter-rater), in sequence.

CONCLUSION:

A positive sedimentation sign is dependably seen in lumbar spine canal stenosis cases, recommending its value in clinical application.

KEYWORDS: lumbar stenosis, sedimentation sign.

INTRODUCTION:

Lumbar spinal stenosis (LSS) is a common cause of spinal surgeries. [1–4] An all-inclusive spectrum of clinical, electrophysiologic, and radiologic signs point toward the diagnosis. The reason for surgery is not to address in several cases, and instructions for clinicians is self-contradictory and lacking.[5–14] Supplementary demonstrative clues demanded to promote the apprehension of LSS to conduct settlements concerning spinal surgery.

The diagnostic challenges prevail in the constant lack of clinical manifestations at rest due to pain plus limited function transpires only with physical activity.

Established clinical scores correspond defectively with the degree of stenosis and the cross-sectional area (CSA) regarding the dural sac in the magnetic resonance image (MRI).[15] Static examinations such as an applied hyperextension do not satisfactorily reflect the circumstance through dynamic exercise. The smallest CSA of the dural sac in the MRI affirms as a valid discriminator for LSS.[16,17] Nevertheless, under and overdiagnosis of LSS is common when adopting CSA as a discriminator. Underdiagnoses perceive in cases with (a) foraminal stenosis, (b) dynamic stenosis throughout physical exercise, also (c) rapidly developing stenosis. In those incidents, subjects may encounter clinical manifestations of LSS lacking a correlating pathological CSA.

Department of Neurosurgery, Al-Imamein Al-Kadhemein Medical City, Baghdad, Iraq.

Overdiagnosis issues in patients with an older age who exhibit clinical symptoms not credited to LSS but exhibit a pathologic CSA. Standing or gadolinium-enhanced MRI, axial weight, or straight leg raise during MRI or computed tomography seem to enhance the demonstrative interpretation of the scans.[18–26] The distinguishing advantage of different radiologic investigations have not yet been credited.[16,27,28]

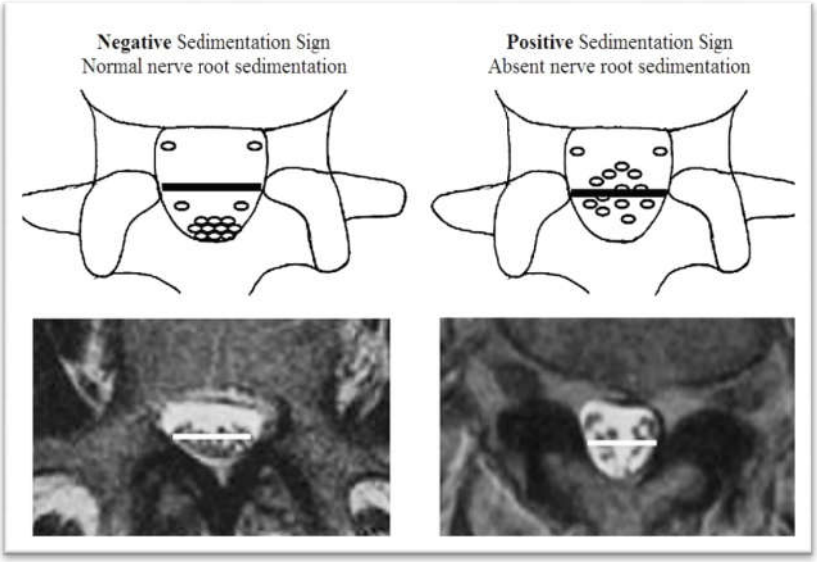

Figure 1: Comparison of MRI scans with a negative sedimentation sign (left) and a positive sedimentation sign (right).

Earlier researches have afforded proof that a treadmill examination is a relevant instrument for the determination of LSS.[8,11,29–32] Electrophysiologic studies could approve the diagnosis considerably, but their utility in daily clinical routine is not feasible in various circumstances.[33]

One basis for the symptoms of the LSS is ischemia of the nerve roots caused by squeezing by osseous, ligamentous, or discal structures.[34–41] This could describe the long-time distinguished S-shaped coiling and curling of nerve roots over related segmental stenosis, leading to the perception of duplication.[42–53]

Latterly, these redundant nerve roots stated to be of supportive demonstrative advantage in sagittal MRI scans in nearly 34% of subjects with LSS. [54]

In sagittal MRI scans, an extra aspect beheld. In subjects with no suspicion of LSS, MRI in the recumbent setting determines that lumbar nerve roots sediment, as a consequence of gravity, to the dorsal component of the dural sac (Figure 1). In cases with symptoms of LSS, there is a positive sedimentation sign, which is the failure of nerve roots to sediment (Figures 1 and 2). Previously, nerve root sedimentation was reported only regarding arachnoiditis, probably caused by degenerative spinal disease.[55,56]

PATIENTS AND METHODS:

A planned cohort design prospective study had conducted over a year through July 2019 at the department of neurosurgery at Medical City/ Baghdad / Iraq.

Inclusion and exclusion criteria:

Patients admitted for inpatient or outpatient treatment with symptoms of nonspecific LBP, leg pain, or claudication valued for eligibility. Research elimination rules were a peripheral arterial disease, patients who could not endure an MRI examination because of an embedded pacemaker, or known claustrophobia eliminated as well. Patients with neuropathy or other musculoskeletal impairments jeopardizing the capacity to walk, such as severe osteoarthritis of the hip or knee and rheumatoid arthritis or previous spine surgery excepted. Moreover, cases with LSS at level L5/S1 omitted because nerve roots S1 and S2 leave the dural sac in an anterior point,

hindering sedimentation to the dorsal component of the dural sac. Hence, the analysis of the sedimentation sign at the L5/S1 level would be misleading.

The imaging protocol involved Sagittal and axial T2WI spin-echo sequences (2617/120/90/2(TR/TE/angle/NSA sequences)) with 4 mm thickness in the axial study. Picture archiving system (PACS) had adopted with integrated digital area measurement (GE health care centricity PACS), and two experienced independent radiologists knowledgeable of the clinical data of the patients assessed the MRI of the patients separately.

Both clinical and morphologic criteria had employed to allot patients to 2 assemblages. Group 1 possessed symptomatic and morphologic stenosis: claudication, with or without LBP and leg pain, with or without neurologic deficit, a CSA ≤ 80 mm^2, and a walking distance of < 200 m (LSS group).

Patients in group 2 had no symptomatic and morphologic stenosis: non-specific LBP, no leg pain, no claudication, no neurologic deficit, a CSA of the dural sac > 120 mm^2, and a walking distance on the treadmill test > 1000 m (LBP group). Cases have dural sac CSA between 81 and 120 mm^2, and a walking distance on the treadmill test between 200 and 1000 m excluded in this study. Patients enlisted until a sample size of 100 patients in each group had succeeded. All patients registered in our study acquired an MRI of the dural sac and performed a standardized ambulatory treadmill test. MRI scans (T2-weighted transverse layers of 4-mm thickness, 1.5 Tesla) were conducted twice for each patient on different days by two experienced independent operators. Throughout the examination, the patient assumed a standardized dorsal position, with hips and knees bent over a wedge.

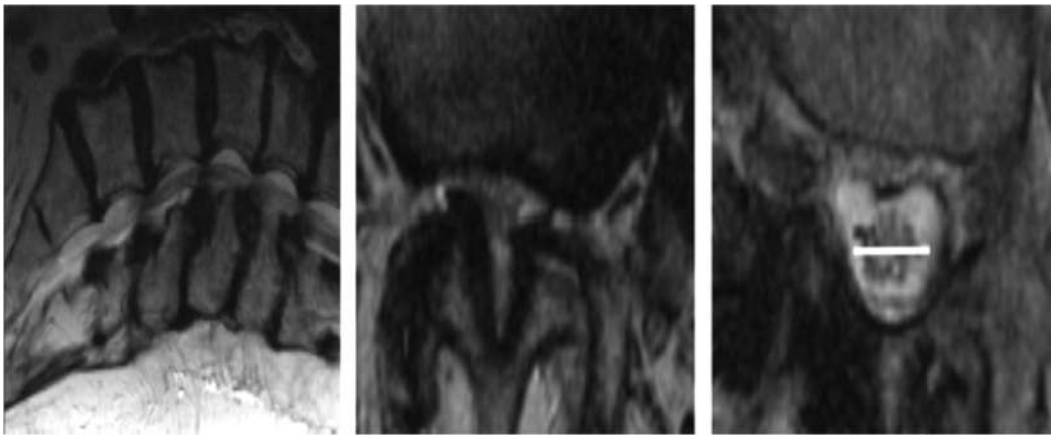

Figure 2: MRI scans of a patient with a positive sedimentation sign. Left, Absolute stenosis at level L3/4 (T2, female, 66 years, treadmill test 35 m). Centre, Cross-sectional area of narrowest segment at level L3/4 50 mm^2. Right, Positive sedimentation sign above level L3/4.

Using a picture archiving system with integrated digital area measurement (Radiology Software), the most diminutive CSA of the dural sac was graded on the 2 separate MRI scans by an experienced objective radiologist who was oblivious of the sedimentation sign as well as other supplementary clinical information. Later, the mean value of these 2 computations was measured.

The CSA was estimated between L1 and L5. To define this area, units per section were digitally subtracted. During the analysis, the gantry of the MRI was aligned vertically to the virtual axis of the spinal canal.

A positive sedimentation sign (+ve SED) was defined as the lack of nerve root sedimentation in at least 1 transverse MRI scan, at a level above or below, overlooking the location of the scan within the level and its proximity to the maximal stenosis (Figures 1 and 2). As a rule, nerve roots commonly sediment, due to gravity, to the dorsal part of the dural sac, which was defined as a negative sedimentation sign (-ve SED). The only exclusion

from this is the 2 nerve roots leaving the dural sac 1 segmental level below the stenosis.

If there are nerve roots in the ventral part of the dural sac excluding for the ones exiting the dural sac, the sedimentation sign is positive. By this scheme, no intermediate or indeterminate results of the sedimentation sign are to be expected. The sedimentation sign was estimated at a level above or below the maximal stenosis because, at the level of the stenosis, nerve roots lie tightly packed in the dural sac and, consequently, cannot be identified and assessed appropriately.

Patients classified into the divisions of either positive or negative sedimentation sign, scored from the two scans. Intra-rater reliability appraised by reevaluating patients after six months between the first and second MRI reading sessions. Two additional independent raters, orthopedic, and neurosurgeon evaluated the MRI scans to assess inter-rater trustworthiness.

Moreover, the pain was measured using the visual analog scale (VAS) independent of its localization in the back or legs. Functional deprivation was estimated using the Oswestry disability index (ODI).

A patterned treadmill test had conducted within six weeks before or following the patient's MRI exam.29 If a patient did not encounter any symptoms during the treadmill test, it was ended after 30 minutes, which equalizes a walking distance of >1000 m. The pain, its location, and neurologic deficits, if any, were reported after the test.

Fisher Irwin test had used to appraise discrepancies in symmetries and the Mann–Whitney U test for the interpretation of variances in continuous variables. Spearman's Rho for correlations, and to estimate the reliability of the sedimentation sign Cohen kappa utilized. Statistical analyses performed using SPSS 20.

RESULTS:

The characteristics of LSS and LBP groups are in Table 1. The median pain level of seven is on the VAS in both groups, the ODI of 60% in the LSS group and 67% in the LBP group were connotative of the enormity of the patients' symptoms. Patients in the LSS group were older than those in the LBP group, although the gender distribution was comparable. Regarding the LSS group, the smallest CSA is L1/2 in 5%, at L2/3 in 17%, at L3/4 in 34%, and L4/5 in 44%.

In the LSS group, a +ve SED sign was seen in 96 of 100 patients (96%; 95% CI, 90%–98%). In the LBP group, no patient had a +ve SED sign (0%; 95% CI, 0%–5%; Table 2).

The percentage of the occurrence of a positive sedimentation sign was similar in segmental levels L1–L5. Of the four patients with false -ve SED sign results, three had a large disc herniation at level L3/4 (1 patient) or L4/5 (2 patients), pushing all nerve roots to the dorsal part of the dural sac, and had a microdiscectomy. The last patient had spinal stenosis with a CSA of 80 mm2 but extensive foraminal stenosis made by degenerative scoliosis. This case got a long-segment fusion Th12-L4. Following surgery, all four subjects with false -ve SED sign results were pain-free and without functional constraint.

Table 1: Gender, Age, VAS, ODI, CSA, and Walking Distance of LSS and LBP Study Groups.

Characteristics	LSS (n 100)	LBP (n 100)
Sex (F/M)	53/47	49/51
Age years*	60 (57–64)	46 (39–53)
VAS*	7 (6-8)	7 (6-8)
ODI* (%)	60%	67%
CSA* (mm^2)	60 (55–70)	170 (165–195)
Treadmill* (m)	<100	>1000

*Values are expressed as median (interquartile range).
LSS, symptomatic lumbar canal stenosis; LBP, nonspecific low back pain; VAS, visual analog scale; ODI, Oswestry disability index; CSA, Cross-sectional area.

Table 2: Cross Tabulation of Results of Sedimentation Sign in LSS and LBP Study Groups.

	LSS	LBP	Total
+ve SED	96	0	96
-ve SED	4	100	104
Total	100	100	200

+ve SED, positive sedimentation sign; -ve SED, negative sedimentation sign; LSS, lumbar canal stenosis; LBP, nonspecific low back pain.

Of the random sample used for reliability assessment, six were from the LSS assemblage, and fourteen from the LBP group. No discrepancies to detect amidst first and second readings by the principal analyst (intra-rater kappa, 1.0). Among the two raters, there was an understanding in the rating of 19 of the 20 patients (inter-rater kappa, 0.90). One patient with multilevel stenosis most severe at L3/4 because of lumbar scoliosis showed nerve roots tightly packed at one side of the dural sac and appraised as positive.

No countable difference in pain on the VAS between the two groups ($P = 0.08$) occurred. However, patients in the LBP group experienced a higher severity of functional limitation as measured by the ODI (67% in the LBP group vs. 60% in the LSS group; $P < 0.01$). The correlation between ODI and the smallest CSA of the dural sac was Rho = 0.16.

DISCUSSION:

Our study revealed that in cases with symptomatic and morphological central LSS above L5, +ve SED in 94%, but in patients with LBP lacking signs of stenosis, it was invariably negative. This study addresses a question, specifically, whether patients with symptomatic and morphologic LSS have different test outcomes than patients without this target disorder.[57,58] To elucidate this inquiry, a homogeneous group of LSS patients defined by implementing the smallest CSA of the dural sac and treadmill test results as morphologic and functional pre-request. The corresponding group consisted of LBP subjects without signs of stenosis.

The comparably great pain and function scores in both assemblages of our representation reflect a blend of patients with intractable symptoms. One underlying speculation for the VAS being comparable in both groups and not more eminent in patients with LBP as envisioned might be the circumspect election process in this research. Nevertheless, the ODI was higher in the LBP group, inferring an adaptation response in the LSS group because of creeping progress.

All patients had admitted to our Department of Neurosurgery for inpatient or outpatient treatment, following an earlier ineffective conservative treatment of LBP. Per the current literature, our study did not reveal any correspondence between ODI and the smallest CSA of the dural sac, maintaining the assumption that the ODI may not be the optimal evaluation instrument for LSS patients.[15]

The questioned correctness of the CSA in distinguishing LSS makes it essential to research for other demonstrative signs that may improve the confidence in diagnosing this situation. The power of the sedimentation sign is that it is readily detectable on MRI scans and that it attested exceptional reliability in this research. The distinctness of this sign may be part of the cause of why it is not in focus so far. There are, nonetheless, some shortcomings to consider. Our study focuses on central stenosis, but the SED sign doesn't detect foraminal stenosis.[59–61] There is jeopardy of measurement error because a blinded assessment of the SED sign to the CSA of the dural sac wasn't achievable totally. Yet, the justifiable nature of the sedimentation sign aids minimizes eyewitness error. We exclude LSS at the L5/S1 level from this study. Nonetheless, because central stenosis at these segmental levels is rare, we recognize this exclusion as not a barrier to our findings.

This study does not infer that a +ve SED sign at its own can diagnose clinically significant LSS. The purpose of this study will be to examine whether the sedimentation sign is a relevant tool to distinguish patients who will benefit from spine surgery.

CONCLUSION:

On MRI in the supine position of patients without symptomatic and morphologic LSS, lumbar nerve roots sediment as a result of gravity to the dorsal part of the dural sac and not seen in patients with LSS. Accordingly, in patients without prior spine surgery, the SED sign, measured beside the smallest CSA of the dural sac and the treadmill test, will probably enhance the diagnosis of symptomatic LSS, and a +ve SED can affirm LSS, and with high sensitivity, a -ve SED can revoke LSS.

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