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Spinal sagittal balance and spinopelvic parameters in patients with degenerative lumbar spinal stenosis; a comparative study

Majid Reza Farrokhi[a,b], Ali Haghnegahdar[b], Hamid Rezaee[a,b,*], Mohammad Reza Sharifi Rad[a,b]

[a] Shiraz Neuroscience Research Center, Shiraz University of Medical Sciences, Shiraz, Iran
[b] Neurosurgery Department, Shiraz University of Medical Sciences, Shiraz, Iran

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ABSTRACT

Objective: This study aims to evaluate the spinal sagittal balance and the spinopelvic parameters in patients with degenerative lumbar spinal stenosis and healthy controls in Iranian population.
Methods: We performed a case-control study in which 48 patients with lumbar spine stenosis and 54 age- and sex-matched healthy subjects with back pain were eligible for participation. We used INFINITT picture archiving and communication systems (PACS) of the Chamran Hospital for selecting the patients for the study group. The sagittal balance, pelvic incidence, lumbar lordosis, and sacral slope were measured in all the patients and controls using thoracolumbosacral radiographies in the standing position.
Results: There was no significant difference between the 2 groups regarding the baseline characteristics. The prevalence of sagittal imbalance was significantly higher in the patients with lumbar spine stenosis in comparison with the controls (31.2% *vs.* 14.8%; $P<0.001$). The sacral slope was significantly lower in patients with lumbar canal stenosis than the healthy controls ($31.39^\circ \pm 11.2$ *vs.* $43.7^\circ \pm 8.4$; $P<0.001$). The lumbar lordosis was significantly lower in patients with lumbar canal stenosis than the controls ($31.27^\circ \pm 12.4$ *vs.* $45.8^\circ \pm 10.7$; $P < 0.001$). The pelvic incidence was not significantly different between the 2 groups ($50.16^\circ \pm 11.9$ *vs.* $52^\circ \pm 9.6$; $P=0.342$).
Conclusion: The degenerative lumbar canal stenosis is associated with increased sagittal imbalance and decreased lumbar lordosis and sacral slope in a sample of the Iranian adult population.

1. Introduction

Lumbar spinal stenosis is the most common lumbar degenerative disease [1]. Spinal stenosis is a narrowing of the vertebral canal that may lead to compression of the spinal nerves or nerve roots, especially in the area of the lumbar vertebrae [2,3]. Lumbar spinal canal stenosis is among the most common morbidities of the aging population which is associated with high social and economic burden [4]. The prevalence of relative and absolute acquired lumbar canal stenosis has been reported as 22.5% and 7.3% of the normal population, respectively [5]. The prevalence of the disease increases with age and its peak is the age between 60 and 69 years [5]. The degenerative lumbar canal stenosis is the result of a reduction in the diameter of the spinal canal leading to mechanical pressure over neural elements. The reduction in the diameter of the lumbar canal is the result of hypertrophy of the ligaments and soft tissue and hyperostosis of the bony compartments [4]. The pathomechanism of degeneration of lumbar canal starts with a decrease in the height of the intervertebral disks leading to bulging and tearing of the annulus fibrosus. These events result in foraminal stenosis and overloading the facet joints. The resultant would be the facet hypertrophy, arthrosis, ligamentum flavum thickening and osteophytic overgrowth [6,7]. Finally the dural sac is involved and the pressure on neural elements results in neurologic symptoms and signs [8]. Neurogenic claudication describes a combination of back pain, leg pain, numbness, and motor weakness. Patients with degenerative lumbar spinal stenosis have been attributed to relative hypoxia of the cauda equina and nerve roots secondary to circulatory disturbance and to increased mechanical pressure [9]. It has been well established that the patients with degenerative lumbar canal stenosis have a forward bending posture because epidural pressure is increased by upright posture and decreased by forward flexion [10]. Although symptomatic stenosis involves some degree of neurogenic claudication, not all patients with lumbar

* Corresponding author at: Fellowship of Spine Surgery, Shiraz Neuroscience Research Center, Neurosurgery Department, Shiraz University of Medical Sciences, Chamran Hospital, Chamran Boulevard, Shiraz, Iran.
E-mail address: snrc.sums@gmail.com (H. Rezaee).

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spinal stenosis are symptomatic or exhibit neurogenic claudication. The principal goal of lumbar spinal canal stenosis surgery is thorough decompression of the neural elements corresponding to the patient's symptoms. The standard technique remains decompressive laminectomy, which includes total removal of the posterior ligamentous complex and limited undercutting of the facet joints [11–13]. It provides sufficient decompression of all anatomical zones through a wide operation window [11–14].

The sagittal alignment of the spine, i.e. spinal sagittal balance, is an important indicator of the outcomes after lumbar spine stenosis surgery [15–19]. It has also been shown that the deviation of the C7 plumb line from the posterior corner of the sacrum in patients with lumbar canal stenosis is associated with decreased health-related quality of life [20]. The sagittal balance is characterized by several pelvic and spine parameters and encompasses a wide range of variability in the normal population [15,21]. Currently, it is well documented that there is a linear correlation between pelvic incidence, the sacral slope and sagittal curves, especially lumbar lordosis [22]. The pelvic incidence is determined by pelvic tilt and sacral slope which are highly correlated with lumbar lordosis [23]. The shape and balance of the spine is ethnicity dependent [24,25]. The sagittal balance has been evaluated in the normal population [21–23] and patients with degenerative lumbar canal stenosis [26,27], but to our knowledge this is the first study in the literature which has retrospectively evaluated the spinal sagittal balance and the spinopelvic parameters in adult patients with degenerative lumbar spinal canal stenosis and healthy controls in the Iranian population.

2. Materials and methods

2.1. Study design and population

We performed a retrospective case-control study in which 48 patients out of total of 75 patients, aged 43 to 80 years, with degenerative lumbar spinal canal stenosis who had undergone decompressive laminectomy [11,12] by the same surgical team in Chamran Hospital, affiliated to Shiraz University of Medical Sciences between January 2016 to April 2016 and 54 age- and sex-matched healthy individuals, aged 40 to 60 years, who referred with nondiscogenic back pain to the Shahid Motahari Outpatient Clinic, affiliated to Shiraz University of Medical Sciences, were eligible to participate and were enrolled from May 2016 to July 2016. All the patients and controls were Iranians and other ethnicities were excluded from the study. The medical research ethics committee as well as institutional review board of Shiraz University of Medical Sciences approved the study protocol before data collection began (approval number: 94-01-55-9678). We used INFINITT picture archiving and communication systems (PACS) version 3.0.11.4 (INFINITT Healthcare Co., Ltd., Korea) of the Chamran Hospital[1] for patient selection. The patients' data were extracted from their medical charts and the online INFINITT PACS system. Because of the retrospective nature of the study, it was not required to obtain written informed consent from the included patients. We recorded the demographic information, clinical examination and surgical intervention in all the patients (Table 1). Body mass index (BMI) in the patients and controls were classified as normal weight (18.5–24.99), overweight (25–29.99), and obese (≥30). Lumbar canal stenosis was diagnosed according to symptoms and signs of the disease including LBP, leg pain, numbness, and motor weakness which alleviated with the flexed position and exacerbated in extended position [10,13,27]. The diagnosis was confirmed in all the patients with preoperative lumbosacral magnetic resonance imaging (MRI) which revealed a cross-sectional area of the dural sac less than 100 mm^2 in these patients [28]. Fig. 1 shows the axial and sagittal T2-weighted MRI in a patient with lumbar canal stenosis. The radiographies were also extracted from the online INFINITT PACS. Written informed consent was obtained from all the individuals in the control group. The data in the control group were obtained by history taking, clinical examination and radiographies which were taken in the outpatient clinic. Clinical examination, radiography and lumbosacral MRI showed that the control group had no sign of degenerative lumbar spine disease and discogenic back pain or radiological abnormality in the lumbar spine.

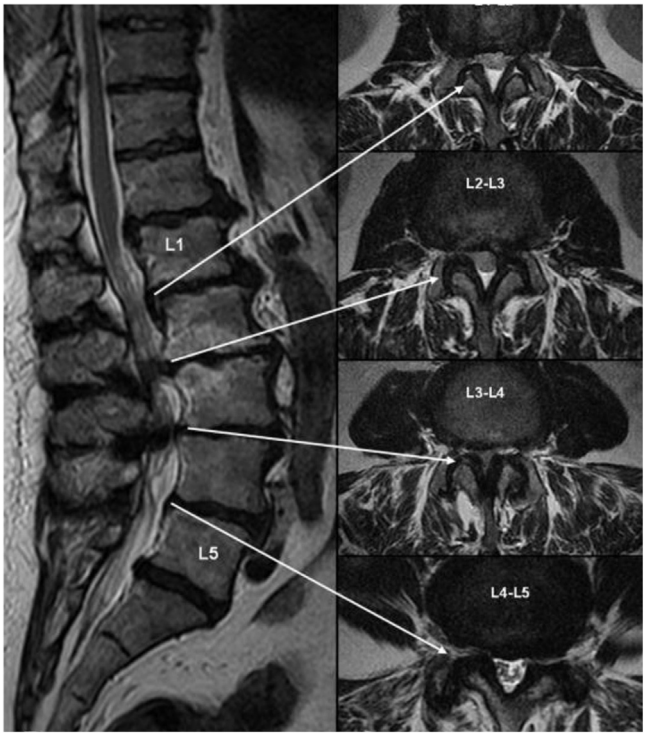

Fig. 1. Axial and sagittal T2-weighted MRI in a patient with degenerative lumbar canal stenosis.

2.1.1. Inclusion criteria

The patients who had undergone decompressive laminectomy in Chamran Hospital were included in the case group and the age- and sex-matched healthy individuals who referred with back pain to the Shahid Motahari Outpatient Clinic were included in the control group.

2.1.2. Exclusion criteria

The exclusion criteria were (1) lumbar spine trauma, (2) spinal tumors, (3) scoliosis, (4) spondylolysis with or without spondylolisthesis, (5) severe osteoarthritis in the lower limbs, (6) history of spine surgery or infection, (7) pelvic pathologies such as fractures and dysplasia, (8) those with incomplete imaging, (9) congenital anomalies, and (10) those with limb length discrepancies. Twenty-seven patients were excluded based on the criteria.

2.2. Clinical measurements

All the patients and controls had standing lateral radiographs of the thoracolumbosacral spine which were taken with the arms in the fists-on-clavicles position, elbows fully flexed with fists resting on the clavicles, and knees and hips fully extended [29]. All the radiographies were studied and the sagittal balance and spinopelvic

[1] Available at http://172.21.72.100/default.aspx.