

DEMOGRAPHICAL ASPECTS OF CENTRAL LARGE LUMBAR DISC HERNIATION

ABSTRACT

Study Design: Retrospective clinical study

Objective: The aim of this study was to investigate the risk factors for the development of the central large disc herniations and to compare the demographic data between central mass prolapse and central contained disc herniation.

Summary of Background Data: No study about the relationship between central lumbar disc herniation pathogenesis and demographic data has been reported.

Methods: A retrospective analysis was performed on the demographic data of 59 out of 1630 patients operated on between 2002 and 2007 due to central large disc herniations (3.6%). MR images were analyzed with regard to the disc type and level of involvement. Variables were assessed both at baseline and follow-up, with special emphasis on physical job characteristics, sports activities, and MRI- based morphologic findings.

Results: 59 patients who had the diagnosis of central large disc herniations were 41 men and 18 women; mean age was 34.7 years (range 21-72 years). 36 patients had central mass prolapse that occupied more than 50% of the spinal canal. Intraoperative observations confirmed that 29 out of 36 central mass prolapse patients (80.5%) had intact posterior longitudinal ligaments. Interestingly, these 29 patients were found out to have direct relation with age and occupation or other body training sports activities. In the remaining 23 out of 59 patients, contained central disc herniations were diagnosed. Their mean age was 44 years (range, 31-72). Most of them were physically inactive compared to the central mass prolapse group.

Conclusion: The results indicated that the dimension of central large disc herniations, status of physical activity, age and gender are factors for the development of large disc herniations. Intraoperative observations, radiological evaluations and demographic analyses indicate that physically active people are more likely to develop central mass prolapse compared to contained central disc herniations, owing to more elastic posterior longitudinal ligament structure that they have.

Keywords: Large lumbar disc herniation, Outcome, Pathomechanism.

INTRODUCTION

The incidence of central lumbar disc herniation (CLDH) is low as compared with the more common occurrence of paramedian or posterolateral disc herniations (6). However, there have been no studies that compare the demographic analyses of central mass prolapse (CMP) and contained central disc herniations (CCDH).

In accordance with the literature, there is no definitive information regarding the incidence or prevalence of disc herniations in a sizable population that would define the norm (5,45). Driving, sedentary occupation, vibration, smoking, previous full-term pregnancy, physical inactivity, increase in body mass index (BMI), and tall stature can be some of the risk factors for disc herniation (35). BMI increase and physical activity are also reported to be associated with higher incidence of lumbar disc herniation in the young (36). The increased number of adults and adolescents who regularly participate in athletic activities has raised the collective awareness of common low-back injuries such as bruising, overstretching, or mild to moderate tearing of the paraspinal soft tissues. (12). Prevalence varies among sports participation and further varies depending on the position played (11,34). Taken together, the annulus, disc, and posterior elements bear significant combinations of tensile stress and compressive and shear force, respectively, whereas the posterior soft tissues bear considerable resistive stress. These forces are coincided in varying degrees in all athletic activities (14,15). Intuitively, one might assume that physical fitness would be preventive with regard to disc rupture.

Regardless of which definition is used, disc "degeneration" increases with age and is most common in the lower lumbar spine (42). The highest risk factor is genetic inheritance, which accounts for approximately 50-70% of variability in disc degeneration between identical

twins (7,38). It is noteworthy that this rate does not include the strong intrasubject dependence of disc degeneration on spinal level, which probably reflects environmental influences (1,7). Environmental risk factors for disc herniation include high and repetitive mechanical loading (1,8). It is claimed that disc prolapse is closely associated with heavy lifting, but not with other features of spinal degeneration or age, suggesting the prolapse is not an integral part of the aging process (8,40).

Our study was conducted to compare the demographic features of the patients and evaluate the association between occupational exposure and morphological MRI findings of CLDH.

MATERIAL AND METHODS

During the period from November 2002 through December 2007, 1630 patients were operated on for lumbar disc herniation in our department of neurosurgery. We retrospectively researched archives of these patients, and we detected 59 patients (3.6%) over 1630 who were operated on for symptomatic CLDH that were radiographically verified. Occupations and habituations of the patients were evaluated separately. The mean follow-up period was 15 months (range 12 to 24 months).

We made use of the evaluation charts which all the patients in our department had been asked to fill out regarding personal, medical, and occupational histories. Data of the follow-up visits were reviewed to evaluate the long-term outcome. In addition, neurological conditions and demographic data of the patients so as to gender, age, job, history of the diseases and intraoperative observation notes were obtained.

In the present study, the criteria for definition of CLDH were based on MRI. All patients had preoperative noncontrast MRI of the lumbar spine. A 1.5-Tesla magnetic resonance (MR) scanner (Vision; and Avanto Siemens, Erlangen, Germany) was used for all patients. The MR sequences included axial and sagittal T1 and T2 images from which the measurements were obtained. The images were 4 mm thick with a 10 mm interslice gap. The matrix differs from 240x 320 to 307x384 in sagittal T2 W, 200x384 to 320x320 in sagittal T1 W images, 200x384 to 230x384 in axial T2 W images and 166x320 to 166x320 in axial T1 W images. The field of view was 30 cm for sagittal images and 25 cm for the axial images. All MR images were analyzed independently by a neuroradiologist (MV) who documented the disc type and level of involvement. Evaluation of the integrity of the PLL was based on the MR findings described by Grenier et al. (19). Using MRI, we classified the patients with CLDH as CMP and CCDH as described by Bärlocher et al (6):

- 1) CMP with extrusion or sequestration of disc material, in general, occupying more than 50% of the sagittal midline diameter.
- 2) CCDH with an intact PLL and occupying less than 50% of the sagittal intraspinal diameter. The apex of a CLDH should be located in the midline of the spinal canal with a tolerance of 10% for deviation (Figure 1a b-cmp, ccdh). Sequestered unilateral disc fragments were not enrolled in this study.

Frequencies, rates, arithmetic means, standard deviations were used in descriptive statistical analysis. Chi square test was applied for discrete data, and t test was applied for the indiscrete data. Spearman's rho coefficient was used to evaluate relations. Results were evaluated in the confidence interval of 95% and significance was considered as $p < 0.05$. Data were analyzed using SPSS –PC version 15.0 (statistical Program for Social Science, v. 15.0 for Windows, SPSS, Evanston, IL).

RESULT

The study population consisted of 59 patients (41 men, 18 women), who had undergone an operation with the diagnosis of CLDH with a mean age of 34.96 years (range 21-72 years). 36 patients had CMP with extruded (17 patients) or sequestered (19 patients) disc material and 23 patients had CCDH. Patients with CMP comprised of 7 females and 29 males with mean age of 29.19 years (range, 21-47). Patients with CCDH comprised of 11 females and 12 males with mean age of 44 years (range, 31-72). Mean BMI was 23.7 in CMP and 29.2 in CCDH patients. Difference between CMP and CCDH regarding age and BMI was found statistically significant. The characteristics of the 59 patients are shown in Table 1. Demographic data and occupational facilities are reported in Table 2.

Occupations of the 41 male patients included sedantary work (clerical), hard labor (that requires physical strength), active military service (commando, etc), sportsman (9 patients), and regular sports at leisure time. Most of the female patients were housewives. 4 patients had sedantary occupations, one patient was hard laborer and 3 patients worked at physical education centers.

The symptomatic disc levels were L3/4 in 7 patients, L4/5 in 31 patients and L5/S1 in 21 patients. Comparison between levels did not reach to any statistical significance.

Process of CMP formation was positively associated with young age and BMI. CMP was also directly influenced by the sports practise ($p=0.0001$; $r=0.79$) (Table 3). Housewives and sedantary workers were significantly overrepresented in CCDH (Table 4). As for the gender, CCDH and CMP were more frequent in women and men, respectively (Table 3,4). Male gender was positively and BMI was negatively related to type of disc herniation (CMP or CCDH) ($p=0.001$; $r=0.85$ / $p=0.016$; $r=0.56$). Correlation of the Spearman's rho coefficients of the occupational and level of CLDH variables yielded no significant association between them.

Degree of disc degeneration was significantly related to the type of degenerated discs and the extent of disc herniation at baseline (Table 3,4). Having excluded the effects of age and BMI, it was found out that hard labor and sedentary work had statistically significant correlation with CLDH. Aging and BMI were directly associated with CCDH and inversely with CMP ($p=0.012$; $r=0.33$).

Operation records of all the 29 CMP patients confirmed that PLLs were intact, and according to their demographic data, they were all physically active patients. CCDH, the other subtype of CLDH, was significantly associated with less physical activity during leisure time. Presence of sports activities and being active military personel (commando etc.) were significant independent predictors of progressive extension of disc herniation (Table 3,4).

DISCUSSION

The aim of present study is analyzing the relationship between occupational exposure and degenerative changes in the lumbar spine. As a secondary goal, we examined the effect of work-related risk factors on CLDH. Several risk factors related to physical aspects of the workplace such as heavy physical work, lifting and forceful movements, awkward posture and static work posture were suggested by results of previous studies (29). In previous studies physical occupational risk factors have been reported to be responsible for the development of CLDH (9,20,28,30). We detected that subtype of CLDH was closely related to the chronicity of physical activity and it was influenced directly by how heavy the workload was. This is the preliminary study to compare herniation location and morphology outcomes with demographic factors in surgically treated CCDH and CMP patients. There were various reports, which had shown strong predisposition of lumbar disc herniation by the trauma (13,24,25,39,41), however, others showed little association (10,24,26). Later series mentioned that degenerative changes already existed and trauma only aggravated the disc herniation. In our series, 5% of patients had a history of significant trauma. Degenerative changes were seen only in 10.1% of patients.

18.6% of patients had family history of lumbar disc herniation. This association was reported as 60-68% (36,41). It can be explained on the basis of weak connective tissue or early predisposition of degenerative changes in the spine in these families. Most studies have focused exclusively on the lumbar disc degeneration to the exclusion of other damage (29). An unbiased analysis of the occupational determinants of these changes is complicated by any concurrent age-dependent lumbar spine degeneration. Indeed, direct and significant influence of aging on lumbar disc degeneration and end-plate defects have been reported (44). In the present study, several additional demographical determinants besides age were associated with morphological changes in the disc.

High BMI and a few sports activities also reported to be associated with higher incidence of lumbar disc herniation in adolescents (10,36). On the other hand, in adults, disc herniation and end-plate defects show little correlation with age and they most commonly affect only the lower lumbar levels (43). In our series, L4-5 intervertebral disc space was the most commonly afflicted level. Regular physical activity appears to reduce or increase the risks of disc degeneration, depending on how severe it is (3). Intervertebral discs may be particularly vulnerable to injury and fatigue damage when they are subjected to sudden and large increases in mechanical loading because increased physical loading will strengthen muscles and bones faster than the avascular discs (2). These considerations could explain why the highest known risk factors for disc prolapse involve the frequent lifting of heavy loads, either at work (21) or in the home (33), although some manual occupations carry no greater risk than sedentary work. "Adaptive remodeling" in response to controlled exercise explains why physically active individuals have extremely strong vertebrae (16,17) and discs (37). Conversely, lack of exercise leads to tissue weakening, and this may explain why some sedentary occupations increase the risk of disc prolapse (21). The weakened spinal tissues would be vulnerable to accidental injury during slips and falls by which PLL encounters overloading that leads to CLDH. This strengthens the importance of the morphological changes that PLL might have undergone simultaneously with the soft tissues and the bones due to regular physical activity.

The PLL strongly attaches to the annulus fibrosis, and frequently is torn in cases of free fragment disc herniations (31). PLL is not attached to the posterior surface of the vertebrae, therefore, the superficial and deep layers can be separated with ease. Both superficial and deep layers attach to a midline bony septum on the posterior surface of the vertebral body between the superior and inferior margins. This attachment is not always continuous because of deficiencies in the septum in the central third of the vertebral body. Fibers of the central part of the superficial layer extend to and merge with the anterior aspect of the dura mater (27). It would also tend to cause herniated disc material to collect beneath the deep layer.

It has been suggested by Putz et al. that fibers from both layers are involved in all movements, with an increasing number of fibers being recruited with increasing load (27). The neighborhood of the PLL within the epidural space supports a protective role. The presence of an additional membranous structure (the superficial membrane of the PLL) associated with the PLL has been observed, although its morphology has yet to be agreed. It is clear that a greater understanding of the morphology and morphometry of the PLL and associated membranes throughout the length of the spine is required for evaluating its role in spinal biomechanics and protection (27). On the other hand, spine flexibility and, thus range of motion, was shown to be reduced in degeneration because of the increasing size of the endplate and the decreasing height of the intervertebral disc space (27).

The increased laxity of the motion segment was found to be due to decreased disc height of the nucleus with resultant loss of tension of the surrounding ligaments (31). The presence of elastin in the ligamentum flavum supports the idea that it has a role in dynamic motion of the spine as reported by Nakagawa et al. (27). The normal dural layer contains a lot of elastic fibers and degenerated dorsal layer contains significantly fewer elastic fibers. Moreover, elastic fibers decrease with age on the dorsal side, but not on the dural side. Thus, the elasticity of ligamentum flavum decreases with aging due to loss of elastic fibers mainly on the dorsal side. Previously, it was biomechanically reported that compared with the dural side mechanical stress is higher on the dorsal side during lumbar motion (23). Alike, this high mechanical load may explain the loss of elastic fibers mainly at the dorsal side in PLL. Loss of elasticity of PLL may cause it to fold into the neural canal which could easily induce disconnection from the midline bony septum on the posterior surface of the vertebral body. Thus, to elucidate the pathomechanism of the sequestered disc herniation in the elderly, sedentary occupation, and physical inactivity, should be investigated. Consequently, the pathomechanism can be attributed to the qualitative changes in ligamentum flavum in the basis of loss of elasticity and strength. It is not difficult to assume then that the content of elastic fibers of PLL decreases with aging. However, there has been no study explaining in depth the pathomechanism of loss of elasticity. But, similar histologic changes were reported to occur at the insertion site of the medial collateral ligament of the knee joint, Achilles tendon and supraspinatus tendon (23). Thus, the qualitative changes of PLL may not occur with activity are due to mechanical loading, which would not induce degenerative changes resulting in decrease of PLL elasticity. Likewise, since the PLL of the physically active people like sportsmen and military personnel may have actually more elastic structure than the physically inactive ones, these people may have more tendency to develop central mass prolapse with an intact PLL. It means that elasticity of the PLL in these people, causes the disc fragment to herniate to the center of the canal forming a large 'sacculus' that occupies larger space in the central canal rather than tearing the PLL.

All the aforementioned probable changes in the PLL are assumed to be evaluated by MRI studies. The sensitivity, specificity, and accuracy of detecting the disruption of the PLL by MR images were reported as 71-100%, 78-92%, and 80-81%, respectively, compared with operative findings (4,19,22,32). Not only MR images of the PLL were interpreted, but also the integrity of the PLL in the operative field was actually checked.

We observed that, CCDH was rare in the young and physically active people and though they had CLDH that occupied more than 50% of the canal, particularly, their PLL were intact in most of them by which they differed from the classical CMP definitions. According to our results, loss of elasticity of the PLL may play an important role in sequestered and large central disc herniation. Considering the fact that PLL plays key role in the development of CMP, it is therefore not surprising that this disease is more common in athletic people.

CONCLUSION

The data obtained from the patient records, radiological evaluations and demographic analyses indicate that physically active people are more likely to develop CMP compared to CCDH without any ligamentous tear, owing to more elastic PLL structure that they have. Though this information challenges the general opinion accepted so far, it worths considering and needs to be confirmed in larger series of patients.

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Table 1 . Predictor Variables Obtained From Questionnaires at Baseline in central lumbar disc herniation (n=59)

Variable	Patients		
Sociodemographic data			
Age	mean 34.7 (21-72)		
Gender			
Male	41 (69.4%)		
Female	18 (30.5%)		
Anthropometric data			
		CMP	CCDH
Weight (kg)	mean	73.7	85.1
Height (centimeter)	mean	176	170.5
Body mass index (kg/m ²)	mean	23.7 (19.2-29)	29.2 (24.6-34)
MRI findings			
Level of Disc herniation			
L3-4	7 (11.9%)		
L4-5	31 (52.5%)		
L5-S1	21 (35.6%)		
Type of the disc herniation			
Extruded (CMP)	17 (28.8%)		
Sequestered (CMP)	19 (32.2%)		
Contained (CCDH)	23 (39%)		
Work schedule			
Sedantary work	11 (18.6%)		
Hard labor	9 (15.2%)		
Army officer	11 (18.6%)		
Sportman	9 (15.2%)		
Regular sports	6 (10.1%)		
Housewife	10 (16.9%)		
Gymnast	3 (5.1%)		

Table 2. Comparing overall patient demographic and occupational data between CMP and CCDH

Type of disc herniation	Total	BMI	Mean age (year)	Female / Male	Female-Occupation	Male- Occupation
CMP	36	23.7 (19.2-29)	29.19 (21-47)	7(19.4%) / 29(80.5%)	3 (16.6%) Gymnast 4 (22.2%) Sedantary work	11 (26.8%) Elite military job 9 (21.9%) Sportman 6 (14.6%) Regular sports 3(8.3%) Sedantary work
CCDH	23	29.2 (24.6-34)	44 (31-72)	11(47.8%) / 12(52.1%)	10 (55.5%) Hausewife 1 (5.5%) Hard labor	4 (17.3%) Sedantary work 8 (19.5%) Hard labor
Total	59	25.9	34.96	18(30.5%)/41(69.4%)	18	41

Table 3: Characteristics of the patients with CMP

Gender	Age	BMI	Level	Occupation
M	21	23	L4-5	AO
M	29	23	L5-S1	AO
M	25	23	L4-5	AO
M	27	23	L5-S1	AO
M	22	24	L4-5	AO
M	24	23	L4-5	AO
M	28	24	L5-S1	AO
M	28	25	L3-L4	AO
M	31	24	L4-5	AO
M	28	24	L5-S1	AO
M	21	24	L4-5	AO
M	26	25	L4-5	RS
M	35	24	L5-S1	RS
M	27	24	L4-5	RS
M	21	23	L4-5	RS
M	28	25	L4-5	RS
M	28	24	L5-S1	RS
M	23	22	L4-5	S
M	31	24	L3-L4	S
M	33	23	L5-S1	S
M	24	22	L4-5	S
M	27	23	L4-5	S
M	27	23	L3-L4	S
M	24	24	L4-5	S
M	26	24	L4-5	S
M	25	26	L4-5	S
M	37	25	L5-S1	SW
M	39	26	L5-S1	SW
M	42	25	L5-S1	SW
F	43	23	L5-S1	SW
F	35	26	L5-S1	SW
F	45	29	L4-5	SW
F	48	27	L5-S1	SW
F	23	21	L4-5	G
F	24	19	L4-5	G
F	27	19	L3-L4	G

Sedantary work : SW, Hard labor : HL, Army officer : AO, Sportman : S, Regular sports : RS,
Housewife : H, Gymnast : G

Table 4: Characteristics of the patients with CCDH

Gender	Age	BMI	Level	Occupation
F	42	24,6	L4-5	HW
F	45	27,9	L5-S1	HW
F	38	27	L3-4	HW
F	36	27,7	L4-5	HW
F	33	33,2	L4-5	HW
F	72	29	L5-S1	HW
F	49	31,1	L5-S1	HW
F	63	30,1	L5-S1	HW
F	65	29,7	L5-S1	HW
F	57	30,4	L4-5	HW
F	45	34	L5-S1	HL
M	38	29,1	L4-5	HL
M	38	30,1	L3-4	HL
M	33	27,8	L4-5	HL
M	31	28,7	L4-5	HL
M	37	29,1	L4-5	HL
M	40	28,7	L4-5	HL
M	37	29,4	L3-4	HL
M	46	29,7	L4-5	HL
M	48	29,4	L5-S1	SW
M	38	27,5	L4-5	SW
M	33	30,6	L4-5	SW
M	63	28,4	L5-S1	SW

Sedantary work : SW, Hard labor : HL, Army officer : AO, Sportman : S, Regular sports : RS,
Housewife : H, Gymnast : G

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