

CLINICAL ARTICLE

Prevalence of Lumbar Spondylolisthesis in Middle-Aged People in Beijing Community

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Objective: Lumbar spondylolisthesis (LS) is a common lumbar disease, and the prevalence of LS in different countries or regions was not consistent in the past. This study intends to make statistics on the prevalence of lumbar spondylolisthesis in middle-aged people in Beijing community.

Methods: This is an epidemiological study. 4548 people in Beijing community aged 50 to 64 years were recruited from the local communities by advertisements placed in housing estates and community centres for people to take part in a prospective cohort study from August from September 2013 to March 2014. There is no intervention on the subjects. RadiAnt DICOM Viewer is adopted to read the lateral CT positioning images of all the studied objects, adjust the image as bone window, observe and evaluate the slide of L1 to L5 vertebra in the lateral CT positioning image.

Results: Among the 4,548 subjects included in the study, 2,490 (54.75%) were male and 2,058 (45.25%) were female. A total of 785 subjects had lumbar spondylolisthesis, with a total incidence of 17.26%. There was no significant difference between prevalence of males and females in the subgroup 50-54 years old (13.55% males / 12.53% females) and 55-59 years old (14.77% males / 14.93% females). But the prevalence of LS in 60-64 years old females (28.57%) increased significantly, compared with 55-59 years old females (14.93%) and 60-64 years old males (18.76%). There were 847 levels that had slipped, L5S1 > L4/5 > L3/4 > L2/3 > L1/2. The retrolisthesis was the most, accounting for 61.51% (521/847), and the anterolisthesis was 38.49% (326/847), including anterolisthesis grade I for 95.71% (312/326), anterolisthesis grade II for 4.29% (14/326). Neither of anterolisthesis and retrolisthesis presented more than grade III. Among all the subjects, 318 had anterolisthesis, with a total incidence of 6.99%, and 467 subjects only had retrolisthesis.

Conclusion: The total prevalence of LS in the middle-aged people in Beijing community was 17.26%, 15.98% in males and 18.80% in females, and women are more likely to suffer from LS after 60 years old.

Key words: Chinese; Lumbar spondylolisthesis; Middle-aged; Prevalence

Lumbar spondylolisthesis (LS) is a common lumbar disease. It is defined as the displacement of the vertebral body relative to the adjacent vertebral body below it, which may be forward, backward, or sideways. Wiltse¹ developed a systematic classification of spondylolisthesis, divided into six categories – dysplastic, spondylolytic, degenerative, traumatic, pathological, and iatrogenic – in which the spondylolytic spondylolisthesis (SS) and degenerative

spondylolisthesis (DS) are the most serious. SS is caused by the discontinuity of bone in the isthmus of the vertebral pedicle on one or both sides of a certain segment of the lumbar spine, and the structural damage to maintain the sequential stability of the lumbar spine results in the forward displacement of the vertebral body of the corresponding segment relative to the adjacent lower vertebral body. The causes may be related to stress stimuli such as congenital structural

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abnormalities, excessive activity, or repeated extension, flexion, and rotation of the spine^{2, 3}. DS is due to the vertebral body articular surface and progressive disc degeneration, which affect the stability of the spine resulting in spondylolisthesis⁴. DS may be related to the sagittal plane parameters of the spine, the influence of the lumbar spine, and the anatomical features.

The prevalence of LS in different countries or regions was not consistent in the past. A study of the Chinese population in Hong Kong⁵ showed the prevalence of LS was 25.0% for females and 19.1% for males (2000 females and 2000 males, mean age: 72.5 years). Another study of the Chinese population in Taipei⁶ showed the prevalence of LS was 3.2% for males (1242 subjects, mean age: 44.5 years). For European population, a study in Copenhagen⁷ showed the prevalence of LS was 8.4% for females and 2.7% for males (2618 females, mean age: 65 years and 1533 males, mean age: 62 years). Considering the American population, a study in Massachusetts⁸ showed the prevalence of LS was 21.3% for females and 7.7% for males (84 females and 104 males, mean age: 52.66 years). Another study in the United States⁹ showed the prevalence of LS was 31% for males (5995 subjects, mean age: 74 years). The prevalence is related to age, sex, and other factors; it is more prevalent in the elderly and females. Some researchers have found that the prevalence of LS is related to occupation such as a history of occupational driving and working in the agricultural/fishing industry¹⁰. But most studies focused on the elderly (>65 years old), lacking data of middle-aged people (50–64 years old).

Based on the above factors, this study intends to develop statistics on the prevalence of lumbar spondylolisthesis in middle-aged people in the Beijing community by: (i) analyzing the prevalence of LS in middle-aged Chinese people; (ii) comparing the result with previous relevant studies with subgroup analysis based on age, gender, level, and grade; and (iii) summarizing the characteristics of LS in middle-aged and elderly people in different countries.

Method

Object

People in Beijing were recruited from local communities by advertisements placed in housing estates and community centres for older people to take part in a prospective cohort study from August 2013 to March 2014. The project was designed primarily for early screening of lung cancer. All these people received chest CT examination, in which the lateral CT imaging included lumbar spine. The lumbar spine lateral images used in this study for diagnosis and analysis were obtained from the lumbar spine CT lateral images.

The inclusion criteria were: (i) 50–64 years old; (ii) clear lumbar spine lateral images; and (iii) informed consent obtained.

The exclusion criteria were: (i) people with lumbar spinal internal fixation surgery; (ii) ankylosing spondylitis; and (iii) severe lumbar vertebral deformity.

Image Analysis

RadiAnt DICOM Viewer is adopted to read the lateral CT positioning images of all the studied objects, adjust the image as bone window, observe and evaluate the slide of L₁ to L₅ vertebrae in the lateral CT positioning image. The diagnostic criterion of LS is that the posterior edge of the vertebral body moves forward or backward relative to the posterior edge of the adjacent vertebral body below to reach or exceed 5% of the anterior and posterior diameter of the final version of the adjacent vertebral body below, which is divided into four degrees of severity according to the degree of displacement by Meyerding indexing method: I, 5%–25%; II, 26%–50%; III, 51% to 75%; IV, 76% to 100%.

All measurements were performed by an experienced spine surgeon. Inter-rater reliability of the measurements was assessed in 500 randomly selected subjects and matched healthy controls. Measurements in these subjects were performed by the spine surgeon and repeated by another radiologist. The intraclass correlation coefficient (ICC) was calculated. An ICC value >0.8 was considered good reliability.

Statistical Method

The data were statistically analyzed by SPSS Statistics 22, and the data were tested for normality. The data conforming to normal distribution were expressed as mean (standard deviation), while the data not conforming to normal distribution were expressed as median (interquartile interval). $P < 0.05$ was considered statistically significant, and all tests were bilateral.

Result

Among the 4548 subjects included in the study, 2490 (54.75%) were males and 2058 (45.25%) were females. The mean age was 57.66 ± 3.99 years (50–64 years).

Prevalence of Different Gender and Age

In terms of age stratification, there were 1137 cases aged 50–54 (25.00%), 1785 cases aged 55–59 (39.25%), and 1626 cases aged 60–64 (35.75%) (Table 1). A total of 785 subjects had lumbar spondylolisthesis, with a total incidence of 17.26%. The prevalence rate was 13.10% in 50–54 years old (13.55% males/12.53% females), 14.85% in 55–59 years old (14.77% males/14.93% females), and 22.82% in 60–64 years old (18.76% males/28.57% females) (Table 2). As the age of the subgroup increased, the prevalence increased in both males and females. There was no significant difference between prevalence of males and females in the subgroups of (50–54)-year-olds and (55–59)-year-olds. But the prevalence of LS in 60–64-year-old females increased significantly, compared with 55–59-year-old females and 60–64-year-old males.

Prevalence of Different Levels and Grades

There were 847 levels that had slipped, sorting as follows $L_5S_1 > L_{4/5} > L_{3/4} > L_{2/3} > L_{1/2}$. Males and females showed

TABLE 1 Sample size of males and females of different ages

Age (years)	Sample size (cases)		
	Male	Female	Total
50 - 54	642	495	1137
55 - 59	894	891	1785
60 - 64	954	672	1626
Total	2490	2058	4548

TABLE 2 Prevalence of LS in male and females of different ages

Age (years)	Subjects with LS (cases, %)		
	Male	Female	Total
50 - 54	87 (13.55%)	62 (12.53%)	149 (13.10%)
55 - 59	132 (14.77%)	133 (14.93%)	265 (14.85%)
60 - 64	179 (18.76%)	192 (28.57%)	371 (22.82%)
Total	398 (15.98%)	387 (18.80%)	785 (17.26%)

differences in specific levels (Table 3). The number of L₅S₁, L_{4/5} and L_{3/4} was significantly higher than that of L_{1/2} and L_{2/3}. Although the overall prevalence varied from levels, it was different among males and females: L₅S₁ in males and L_{4/5} in females took the largest proportion. This rule is also reflected in the distribution of the levels of anterolisthesis in males and females.

There was a difference in the direction of LS. The retrolisthesis was the highest, accounting for 61.51% (grade I, 521/847), and the anterolisthesis was 38.49% (326/847), including anterolisthesis grade I for 95.71% (312/326), anterolisthesis grade II for 4.29% (14/326) (Tables 4 and 5). Neither anterolisthesis or retrolisthesis presented more than grade III. Among all the subjects, 318 had anterolisthesis, with a total incidence of 6.99%. The prevalence was 5.19% (4.21% male/6.46% female) in 50–54-year-old patients, 6.83% (5.03% male/8.64% female) in 55–59-year-old patients, and 8.43% (6.39% male/11.31% female) in 60–64-year-old patients (Table 6). There were 467 subjects who only had retrolisthesis (Table 7).

TABLE 3 Number of LS in all subjects

	Vertebral level					Total
	L _{1/2}	L _{2/3}	L _{3/4}	L _{4/5}	L ₅ S ₁	
Male	7	60	128	123	160	478
Female	3	32	87	141	106	369
Total	10	92	215	264	266	847

TABLE 4 Number of LS in male subjects

	Vertebral level					Total
	L _{1/2}	L _{2/3}	L _{3/4}	L _{4/5}	L ₅ /S ₁	
Anterolisthesis grade I	0	0	7	47	76	130
Anterolisthesis grade II	0	0	0	0	4	4
Retrolisthesis	7	60	121	76	80	344
Spondylolisthesis total	7	60	128	123	160	478

TABLE 5 Number of LS in female subjects

	Vertebral level					Total
	L _{1/2}	L _{2/3}	L _{3/4}	L _{4/5}	L ₅ S ₁	
Anterolisthesis grade I	1	1	17	90	73	182
Anterolisthesis grade II	0	0	0	2	8	10
Retrolisthesis	2	31	70	49	25	177
Spondylolisthesis total	3	32	87	141	106	369

TABLE 6 Prevalence of anterolisthesis of males and females of different ages

Age (years)	Subjects with LS (cases, %)		
	Male	Female	Total
50 - 54	27 (4.21%)	32 (6.46%)	59 (5.19%)
55 - 59	45 (5.03%)	77 (8.64%)	122 (6.83%)
60 - 64	61 (6.39%)	76 (11.31%)	137 (8.43%)
Total	133 (5.34%)	185 (8.99%)	318 (6.99%)

TABLE 7 Prevalence of retrolisthesis in males and females of different ages

Age (years)	Subjects with LS (cases, %)		
	Male	Female	Total
50 - 54	60 (9.35%)	30 (6.06%)	90 (7.92%)
55 - 59	87 (9.73%)	56 (6.29%)	143 (8.01%)
60 - 64	118 (12.37%)	116 (17.26%)	234 (14.39%)
Total	265 (10.64%)	202 (9.82%)	467 (10.27%)

The ICC for measurements was 0.942 (0.937–0.946), indicating good repeatability (ICC > 0.8).

Discussion

Prevalence of LS in Middle-Aged Chinese People

In this study, the total prevalence of LS in the middle-aged people of the Beijing community was 17.26%, while the prevalence in previous studies based on regions or countries was 3%–31%^{5–9}, without uniform boundaries and standards. The study in Taipei⁶ only focused on taxi drivers, and the prevalence rate was only 3.2%, which was related to the characteristics of a single occupation. There were more men engaged in this occupation, and the average age was less than 50 years old, so the overall prevalence rate was low. The study in Hong Kong⁵ recruited subjects from the society to avoid occupational deviation, but the population targeted by the study was the elderly (over 65 years old), with an average age of 73 years old. As the prevalence of LS increased with age, the prevalence of this study (22.03%) was higher than our study.

Subgroup Analysis Based on Age, Gender, Level, and Grade

Age

Most studies believe that the prevalence of LS increases with the increase of age, and the prevalence analysis of different age groups in this study also supports this view (Table 2), which may be related to the disease incidence characteristics of LS. With the increase of age, some patients had stress fracture in L₅ isthmus, which led to isthmus fracture. The older

the age, the greater the possibility of stress fracture and spondylolisthesis. In some patients, vertebral body position movement is caused by lumbar disc degeneration, which also increases with age. The above reasons make the prevalence of LS increase with age.

Gender

There was no significant difference between the prevalence of LS in males and females among 50–59-year-old people in the Beijing community, but the prevalence of LS in females was higher than that in males among the 60–64 group, which is same as most previous studies. The difference has to do with women's biology. First of all, pregnancy is an important factor contributing to the occurrence of LS¹¹. Changes in female hormone levels, especially the influence of menopause on women, may also increase the incidence of LS. High expression of estrogen receptor after menopause may aggravate degeneration of articular cartilage, thereby increasing the incidence of LS¹².

Level

In terms of the slip level, L₅S₁ was highest among males, followed by L_{3/4} and L_{4/5}. But among females, L_{4/5} was highest, followed by L₅S₁ and L_{3/4}. In general, L₅S₁ and L_{4/5} were the highest with little difference, followed by L_{3/4} (Tables 4, 5). In a study of the Asia-Pacific region by AOSpine¹³, it was pointed out that for L_{3/4}, L_{4/5}, and L₅S₁, the occurrence of slippage was related to the lumbar facet joints: the L_{3/4} was most sagittal, but which was most coronal between L_{4/5} and L₅S₁ was different among different ethnicities. Therefore, there may be differences between different studies.

Grade

In this study, most of the lumbar spondylolisthesis were retrolisthesis, a small number were anterolisthesis, and most of the anterolisthesis were grade I, which was consistent with the study by He *et al.*⁵ of people in Hong Kong, China. The prevalence of patients with anterolisthesis or retrolisthesis increased with age. The incidence of all age groups was higher in females than males. Among subjects with retrolisthesis, the incidence was higher in males aged 50–54 years and 55–59 years than females, while the incidence increased sharply in females aged 60–64 years. The subjects with retrolisthesis were greater than the subjects with anterolisthesis. However, the study by He *et al.*⁵ showed quite different results to our study. According to the tables of two studies, it can be found that the number of cases of anterolisthesis and retrolisthesis in this study increases from L_{1/2} to L_{3/4}, and the number of L_{4/5} and L₅S₁ is more than the above levels. In the study of He, the number of subjects with retrolisthesis of L_{4/5} and L₅S₁ decreased sharply, while the number of subjects with anterolisthesis increased. The difference in the subjects' ages was the major reason. This study examined middle-aged subjects (50–64, an average of 57.7), while the study of He LC examined the elderly (65–98, an average of 72.6). Lguchi¹⁴ pointed out that anterolisthesis and retrolisthesis

are associated with disc degeneration, therefore, we speculated that the retrolisthesis caused by disc degeneration may develop into anterolisthesis with the progress of degeneration.

Characteristics of LS in Middle-Aged and Elderly People

The prevalence of LS in middle-aged and elderly people increased with age. Before 60 years old, the prevalence may be similar in males and females. But after 60, the prevalence in females increases faster than in males, resulting in a situation where elderly females suffer more from LS than elderly men.

Conclusion

The total prevalence of LS in the middle-aged people of the Beijing community was 17.26%, 15.98% in males and 18.80% in females. Women are more likely to suffer from LS after 60 years old.

Limitation

The results of the study are influenced by the included population, and it is difficult to conduct population census in this community, region, and country. It is hoped that further reasonable sampling can reduce this influence.

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