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Correlation between scoliosis direction and OLIF operation channel angle in patients with degenerative lumbar scoliosis

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Abstract. – OBJECTIVE: To investigate the correlation between scoliosis direction and oblique lateral lumbar interbody fusion (OLIF) operation channel angle in patients with degenerative lumbar scoliosis.

PATIENTS AND METHODS: 80 cases of degenerative lumbar scoliosis and 40 cases of lumbar degenerative diseases without scoliosis were retrospectively studied in our hospital from January 2018 to January 2021. The general data and imaging indexes of all patients were analyzed, and the correlation between the rotation angle of vertebral body and the channel angle of OLIF operation was evaluated.

RESULTS: The distance between abdominal aorta and psoas muscle in L2-3 and L3-4 segments, and the distance between abdominal aorta and lumbar sympathetic trunk in L3-4 segments, as well as the angles of OLIF operation channels in L2-3, L3-4 and L4-5 segments of the right-scoliosis group were all significantly greater than those in the no-scoliosis group ($p < 0.05$). The distance between abdominal aorta and lumbar sympathetic trunk in L4-5 segments of the left-scoliosis group was significantly greater than that in the no-scoliosis group and the right-scoliosis group ($p < 0.05$). The angle of OLIF operation channel in L3-4 and L4-5 segments of the left-scoliosis group was significantly smaller than that in the non-scoliosis group ($p < 0.05$), and the distance between psoas major and transverse axis of vertebral body in L2-3 and L3-4 segments of the left-scoliosis group was significantly greater than that in the non-scoliosis group ($p < 0.05$). The distance between adjacent vertebral bodies in L2-3 and L3-4 segments of the right-scoliosis group was significantly larger than that in the non-scoliosis group ($p < 0.05$). The distance between psoas major and transverse axis of vertebral body in L4-5 segment of the left-scoliosis group was significantly larger than that in the no-scoliosis group and the right-scoliosis group ($p < 0.05$). Correlation analysis showed that there was a negative correlation between OLIF operation channel angle and vertebral rotation angle in the left scoliosis group ($p < 0.05$), and a positive correlation between OLIF operation channel angle and vertebral rotation angle in the right scoliosis group ($p < 0.05$).

CONCLUSIONS: The scoliosis direction of patients with degenerative lumbar scoliosis can directly affect the angle of OLIF operation channel, so targeted design and operation adjustment should be given according to the scoliosis direction of patients before operation.

Key Words:
Degenerative scoliosis, Intervertebral fusion surgery, Lumbar spine, Channel.

Introduction

In recent years, OLIF has been widely used in the treatment of degenerative scoliosis, and has achieved good early curative results. However, many reports[1-3] suggest that there are many complications after OLIF, including lumbar plexus traction injury, poor position of cage and sympathetic nerve injury. At the same time, the risk of complications in the treatment of degenerative scoliosis with OLIF is higher than that in other degenerative diseases of lumbar spine, which may be related to the fact that patients with degenerative scoliosis often have more operative segments and longer operative time[4]. Other scholars believe that[5], the rotation of the apical vertebral body in patients with scoliosis is evident, which can affect the change of anatomical position and adjacent relationship of the lateral anterior structure of the vertebral body, and the neglect of the above changes may be the potential reason for the increased risk of postoperative complications.

Scoliosis has been proved to affect the shape of psoas major muscle, the anatomical position, course and surrounding adjacent relationship of lumbar segmental blood vessels and nerves[6]. Among them, there are significant differences

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in the depth of lumbar plexus and the distance between lumbar plexus and abdominal aorta from L1-2 to L5-S1, and these differences are related to the rotation angle of vertebral body. At the same time, the position of abdominal aorta in patients with left scoliosis often deviates from the left pedicle. In addition, the shape of scoliosis can easily lead to the change of the anatomical position and course of lumbar plexus[7]. Treatment of degenerative lumbar scoliosis with OLIF technique may cause differences in lumbar anatomical structure, adjacent relationship and vertebral rotation degree due to different directions of scoliosis. There is still a lack of relevant reports on whether the above contents should be adjusted during OLIF operation[8,9].

Based on the above problems, 80 cases of degenerative lumbar scoliosis and 40 cases of lumbar degenerative diseases without scoliosis were retrospectively studied in our hospital from January 2018 to January 2021. The general data and imaging indexes of all patients were analyzed to explore the correlation between scoliosis direction and OLIF operation channel angle in patients with degenerative lumbar scoliosis.

Patients and Methods

Clinical Data

80 cases of degenerative lumbar scoliosis and 40 cases of lumbar degenerative diseases without scoliosis were retrospectively studied in our hospital from January 2018 to January 2021. Inclusion criteria: patients who have been clinically diagnosed as degenerative lumbar scoliosis (belonging to MISDEF type I-II) or lumbar degenerative diseases without scoliosis. Patients who have successfully completed OLIF operation. Exclusion criteria: lumbar MRI could not clearly identify the relevant anatomical structures. Patients with idiopathic scoliosis. Patients with scoliosis caused by other causes. Patients with previous history of lumbar fracture/lumbar surgery or severe osteoporosis. The design of the research scheme meets the requirements of Helsinki Declaration of the World Medical Congress, and has obtained the informed consent of patients and their families.

Methods

The patient's sex, age, height, weight, location of scoliosis apex, disease type and imaging data were recorded by consulting medical records. The 3.0 T MR scanner of Siemens Trio Tim was used to collect MR data. Patients were routinely supine and their lower limbs were naturally extended, and the sagittal images of FRF SEXL sequence T2WI, sagittal images of T1-FLAIR and axial images of FRF SEXL sequence T2WI were scanned in turn. Sagittal scan included vertebral bodies in T12-S1, and axial scan included intervertebral spaces of L2-3, L3-4 and L4-5. Take the upper and lower endplates and the central layer of intervertebral space for axial scanning, scanning 3 layers. Imaging observation indicators included[10]: the distance between abdominal aorta and psoas major, that is, the shortest distance between the left margin of abdominal aorta and the anterior medial margin of left psoas major. The distance between abdominal aorta and lumbar sympathetic trunk, that is, the shortest distance between the left margin of abdominal aorta and the left lumbar sympathetic trunk. The distance between psoas major and transverse axis of vertebral body, that is, the vertical distance between the attachment point of the anterior medial edge of left psoas major on the vertebral body and transverse axis of vertebral body. Vertebral rotation angle, that is, the angle between the bisector of spinous process and plumb line, in which the left-hand rotation of vertebral body is positive and the right-hand rotation is negative. OLIF operation channel angle, that is, the angle between the bisector of the angle from the center of vertebral body to the leftmost margin of aorta/the frontmost margin of left psoas muscle and horizontal line. The distance between adjacent vertebral bodies at L2-5 segment, i.e., the distance between the midpoints of L2-3, L3-4 and L4-5 vertebral bodies. Repeated the measurement of each parameter for 3 times to take the average value.

Statistical Analysis

SPSS 22.0 (IBM Corp, Armonk, NY, USA) software was used to process the data. Among them, Kolmogorov-Smirnov test was used to evaluate normality, and *t*-test and one-way analysis of variance (ANOVA) were used to compare the measurement data of normal distribution, which is expressed as ($\bar{c}$±s). Pearson test was used to complete correlation analysis. $p < 0.05$, the difference was statistically significant.

Results

General Data Analysis

There was no significant difference in gender, age and BMI among the three groups (*p*

> 0.05). There was no significant difference in the peak position and Cobb angle between left scoliosis group and right scoliosis group (p > 0.05; Table I).

Analysis of the Distance Between Abdominal Aorta and Psoas Major Muscle

The distance between abdominal aorta and psoas muscle in L2-3 and L3-4 segments of patients with right scoliosis was significantly greater than that of patients without scoliosis ($p < 0.05$). There was no significant difference in the distance between abdominal aorta and psoas muscle in L2-3 and 3-4 segments between left scoliosis group and non-scoliosis group ($p > 0.05$). There was no significant difference in the distance between abdominal aorta and psoas major muscle in L4-5 segments among the three groups ($p > 0.05$; Table II).

Analysis of the Distance Between Abdominal Aorta and Lumbar Sympathetic Trunk

The distance between abdominal aorta and lumbar sympathetic trunk in L2-3, L3-4 and L4-5 segments of the three groups was statistically different ($p < 0.05$). The distance between abdominal aorta and lumbar sympathetic trunk in L3-4 segments of patients with right scoliosis was significantly greater than that in patients without scoliosis ($p < 0.05$). The distance between abdominal aorta and lumbar sympathetic trunk in L4-5 segments of patients with left scoliosis was significantly greater than that in patients without scoliosis and right scoliosis ($p < 0.05$; Table II).

Analysis of OLIF Operation Channel Angle

The angles of OLIF operation channels in L2-3, L3-4 and L4-5 segments in the right scoliosis group were significantly larger than those in the non-scoliosis group ($p < 0.05$). The angle of OLIF operation channel in L3-4 and L4-5 segments in left scoliosis group was significantly smaller than that in non-scoliosis group ($p < 0.05$; Table II).

Analysis of the Distance Between Psoas Major Muscle and Transverse Axis of Vertebral Body

The distance between psoas major and transverse axis of vertebral body in L2-3 and L3-4 segments of patients with left scoliosis was significantly greater than that in patients without scoliosis ($p < 0.05$). The distance between psoas major and transverse axis of vertebral body in L2-3 and L3-4 segments of patients with right scoliosis was significantly smaller than that in patients without scoliosis ($p < 0.05$). The distance between psoas major and transverse axis of vertebral body in L4-5 segment of patients with left scoliosis group was significantly larger than that in patients with right scoliosis and without scoliosis ($p < 0.05$; Table II).

Analysis of Distance Between Adjacent Vertebral Bodies

The distance between adjacent vertebral bodies of L2-3 and L3-4 segments in the three groups was significantly different ($p < 0.05$). The distance between adjacent vertebral bodies in L2-3 and L3-4 segments of patients with left scoliosis was significantly larger than that of patients without scoliosis ($p < 0.05$). The distance

Table I. General data analysis.

Indicators	Left scoliosis group (n = 42)	Right scoliosis group (n = 38)	Non-scoliosis group (n = 40)	p
Male (case)	10	6	11	0.61
Age (years)	70.06 ± 6.27	69.82 ± 6.69	70.39 ± 6.47	0.49
BMI (kg/m^2)	24.53 ± 2.42	24.95 ± 2.84	124.87 ± 2.63	0.38
Vertex position of scoliosis (case)				0.60
L2-3	30	32	-	
L3-4	8	6	-	
L4-5	4	-	-	
Cobb Angle (°)	18.97 ± 3.86	1.89 ± 0.65	-	0.57
Type of disease (case)				-
Lumbar spinal stenosis	-	-	26	
Lumbar disc herniation	-	-	14	

Table II. Analysis of imaging indexes.

Indicators	Left scoliosis group (n = 42)	Right scoliosis group (n = 38)	Non-scoliosis group (n = 40)	*p*
L2-3				
Distance between abdominal aorta and psoas major muscle (mm)	16.68 ± 3.01	18.82 ± 4.06	24.84 ± 5.42	0.00
Distance between abdominal aorta and lumbar sympathetic trunk (mm)	15.30 ± 2.38	15.19 ± 4.20	18.84 ± 4.98	0.00
Distance between psoas major muscle and transverse axis of vertebral body (mm)	11.28 ± 3.42	13.90 ± 3.15	10.98 ± 5.55	0.00
OLIF operating channel angle (°)	40.46 ± 7.60	42.80 ± 8.14	57.62 ± 10.95	0.00
Distance between adjacent vertebral bodies (mm)	36.79 ± 5.22	37.18 ± 6.03	32.87 ± 5.43	0.00
L3-4				
Distance between abdominal aorta and psoas major muscle (mm)	14.37 ± 3.76	15.83 ± 4.04	18.16 ± 4.35	0.01
Distance between abdominal aorta and lumbar sympathetic trunk (mm)	10.19 ± 2.37	10.64 ± 4.19	13.80 ± 3.75	0.00
Distance between psoas major muscle and transverse axis of vertebral body (mm)	12.40 ± 3.23	15.62 ± 3.09	10.62 ± 4.20	0.02
OLIF operating channel angle (°)	45.45 ± 5.64	38.58 ± 4.57	52.47 ± 7.55	0.00
Distance between adjacent vertebral bodies (mm)	36.71 ± 4.54	38.97 ± 5.39	34.26 ± 4.87	0.00
L4-5				
Distance between abdominal aorta and psoas major muscle (mm)	11.36 ± 2.47	19.72 ± 3.59	12.78 ± 2.32	0.00
Distance between abdominal aorta and lumbar sympathetic trunk (mm)	9.53 ± 1.52	11.05 ± 1.84	9.67 ± 1.34	0.00
Distance between psoas major muscle and transverse axis of vertebral body (mm)	17.80 ± 4.23	20.62 ± 5.09	16.25 ± 3.17	0.00
OLIF operating channel angle (°)	41.22 ± 5.43	35.79 ± 4.85	45.19 ± 6.76	0.00
Distance between adjacent vertebral bodies (mm)	33.14 ± 4.39	35.36 ± 6.11	32.83 ± 5.04	0.51

between adjacent vertebral bodies in L2-3 and L3-4 segments of patients with right scoliosis was significantly smaller than that of patients without scoliosis ($p < 0.05$; Table II).

Correlation Analysis Between Vertebral Rotation Angle and Olif Operation Channel Angle

Pearson correlation test showed that there was a negative correlation between OLIF operation channel angle and vertebral rotation angle in left scoliosis group (r = -0.34, p = 0.03). In the right scoliosis group, the angle of OLIF operation channel was positively correlated with the rotation angle of vertebral body (r = -0.41, p = 0.00).

Discussion

Patients with degenerative lumbar scoliosis are often accompanied by evident rotation deformity of vertebral body in the main bending area, and changes of anterior anatomical structure and adjacent relationship can also be seen[11,12]. The results of this study also confirmed that compared with patients without scoliosis, the anatomical position and adjacent relationship of surgical operation related structures in patients with degenerative lumbar scoliosis changed significantly, including the distance between adjacent vertebral bodies becomes smaller on concave side and larger on convex side because of the imbalance of intervertebral space height on both sides in the apical vertebral region. The difference of scoliosis direction leads to the change of the anatomical position of the anterior margin of psoas major: the left psoas major moves forward in patients with left scoliosis, while the left psoas major moves backward in patients with right scoliosis. A study[13] of magnetic resonance diffusion lumbar plexus imaging showed that the changes of psoas major muscle morphology and anatomical structure were closely related to the changes of lumbar plexus anatomical position.

This study confirmed that the scoliosis direction of degenerative lumbar scoliosis patients can directly affect a variety of intraoperative operation parameters of OLIF: when the degenerative lumbar scoliosis was convex to the right, the operation windows at L2-3 and L3-4 segments were significantly enlarged, while the OLIF operation windows at L4-5 segments were significantly reduced when the scoliosis was convex to the left. Therefore, the author thinks that the influence of degenerative lumbar scoliosis direction on the operation window of each segment should be analyzed in combination with the position of apical vertebra. The apical vertebra of the cases included in this study was mainly located in L2-3 segments. The L4-5 segments of patients in the left scoliosis group were far away from the main curved part of scoliosis, and the concave side of compensatory curvature can be seen on the left side. Therefore, the influence of curved scoliosis on the operation window should be comprehensively judged according to the angle between the diseased segment and the main curvature position and the lateral direction.

In the results of this study, the angle of OLIF operation channel in L2-3, L3-4 and L4-5 segments of patients in right scoliosis group was significantly larger than that of patients in non-scoliosis group ($p < 0.05$). The angles of OLIF operation channels in L3-4 and L4-5 segments of patients with left scoliosis were significantly smaller than those without scoliosis ($p < 0.05$). Based on the above evidence, the author believes that when the degenerative lumbar scoliosis is convex to the right, the incision of OLIF should be offset to the ventral side, while the incision position should be offset to the dorsal side when convex to the left. Pearson correlation test showed that the angle of OLIF operation channel was negatively correlated with the rotation angle of vertebral body in left scoliosis group ($r = -0.34$, $p = 0.03$). The angle of OLIF operation channel was positively correlated with the rotation angle of vertebral body in right scoliosis group ($r = -0.41$, $p = 0.00$), that is, when lumbar degenerative scoliosis is convex to the right, the greater the vertebral body rotation angle, the greater the OLIF operation channel angle. When the scoliosis is convex to the left, the greater the rotation angle of vertebral body, the smaller the operation channel angle of OLIF operation. Previous studies suggested that the lumbar segmental artery runs in the shallow groove in the middle of the vertebral body[14]. The results of this study suggest that patients whose degenerative lumbar scoliosis located in the middle of the intervertebral disc often have no risk of segmental artery injury during the operation of establishing and expanding the surgical channel.

In the results of this study, the distance between psoas major and vertebral transverse axis in L2-3 and L3-4 segments in left scoliosis group was significantly larger than that in non-scoliosis group ($p < 0.05$). The distance between psoas major and vertebral transverse axis in L4-5 segments in left scoliosis group was significantly larger than that in right scoliosis group and non-scoliosis group ($p < 0.05$), which indicated that the anterior margin of left psoas muscles moved forward in patients with degenerative lumbar scoliosis convex to the left. During OLIF operation, the psoas major muscle should be dissociated to a large extent in order to put the cage into the intervertebral space. It is reported that the psoas major muscle moves forward due to scoliosis, which can cause the synchronous movement of lumbar plexus[15,16]. The results of this study also suggest that the psoas major muscle can be pulled backward in OLIF treatment of patients with left scoliosis, which affects the lumbar plexus running in the psoas major muscle and leads to an increased risk of traction injury of the lumbar plexus. Due to the larger operation window, the range of backward free traction of psoas major muscle in patients with right scoliosis is smaller, and there will be less risk of lumbar plexus pulling injury in theory. Studies[17-19] have shown that, different scoliosis directions of degenerative scoliosis patients can affect the operation channel range of OLIF surgery. When scoliosis is convex to the left, the operation channel is markedly reduced due to the covering of psoas major muscle. At the same time, the rotation of vertebral body also increases the risk of injury to the contralateral nerve root canal or nerve root at outlet when the cage is inserted.

Limitations

This study also has some shortcomings: it is a single-center retrospective case-control study, and it is difficult to rule out the influence of confounding factors. All the included cases were classified as MISDEF I-II, so the Cobb angle of scoliosis was small, leading to the small difference between some measurement parameters of scoliosis group and non-scoliosis group, which affected the research conclusion. Due to the small sample size, it is impossible to make subgroup analysis according to the position of the apical vertebra, so it is still necessary to further confirm the results of this study in a larger follow-up study.

Conclusions

To sum up, the scoliosis direction of degenerative lumbar scoliosis patients can directly affect the angle of OLIF operation channel, so targeted design and operation adjustment should be given according to the scoliosis direction before operation.

Conflict of Interest

The Authors declare that they have no conflict of interests.

Ethics Approval

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of Anqing Municipal Hospital, School of Medicine.

Availability of Data and Materials

The data presented in this study are available on request from the corresponding author.

Informed Consent

Informed consent was obtained from all patients included in this study prior to submission of data.

Authors' Contribution

Data curation, Formal analysis, Investigation, Project administration: Jing Hu Resources, writing, original draft review and editing: Yi Chen.

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