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Limited correction of lumbar lordosis in the treatment of degenerative scoliosis

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Abstract

Background: Patients suffering from degenerative scoliosis (DS) were commonly associated with coronal and sagittal imbalance which made deformity correction surgery necessary. The study aimed to explore the efficacy and feasibility of the limited correction of lumbar lordosis (LL) in the treatment of patients with DS.

Methods: This was a retrospective study including 58 DS patients who underwent spinal deformity correction surgery and were followed up at least 2 years between January 2013 and January 2017. According to the difference of postoperative LL, the patients were divided into 2 groups: the limited correction group: Pelvic incidence(PI)–18°≤ LL<PI–9° and the control group: PI–9°≤ LL<PI +9°. There were 31 patients in the limited group, and 27 patients in the control group. The clinical and radiographic outcomes were compared preoperatively and at the last follow-up evaluation.

Results: There was no significant difference between the 2 groups preoperatively ($P > .05$). In terms of surgery, the limited group had less intra-operative blood loss and operation time ($P < .05$). At the last follow-up, significant differences were found in terms of LL (−38.2 ± 4.7° and -46.9 ± 4.7°), PT (18.8 ± 5.2° and 11.1 ± 3.6°), sacrum slope (33.7 ± 7.0° and 41.4 ± 6.1°) ($P < .05$), while there were no significant differences in terms of lumbar Cobb angle (10.5 ± 9.3°and 8.3 ± 6.7°), Oswestry Disability Index scores (25.6 ± 10.2 and 26.4 ± 12.1), and JOA scores (23.6 ± 5.2 and 22.3 ± 5.7) ($P > .05$).

Conclusion: Limited correction of LL in the treatment of DS patients can achieve favorable clinical outcomes including effective Cobb angle correction with less blood loss and operative time.

Abbreviations: DS = degenerative scoliosis, LL = lumbar lordosis, ODI = the Oswestry disability index, PJK = proximal junction kyphosis, PT = pelvic tilt, SS = sacrum slope.

Keywords: cobb angle, degenerative scoliosis, JOA score, limited-correction, oswestry disability index

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This retrospective study was approved by the Institutional Review Board (IRB) of 301 and Peking University People's hospitals. All patients involved in the study consent to participate in the study. And the written consent has been obtained from all the patients.

All individual person's data consent to publish.

Availability of data and materials: Please contact author for data requests.

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1. Introduction

Degenerative scoliosis (DS) is defined as a curve larger than 10° after skeletal maturity and is often complicated with spine rotation and sagittal surface imbalance. DS is more common in the lumbar spine and less frequently affects the thoracic and thoracolumbar spine. The main symptoms include back pain, nerve root pain, intermittent claudication and spinal deformity. The incidence of DS in the elderly has increased significantly recently, and has now become the main cause of back and leg pain.[1]

Pritchett[2] reported that DS in patients aged over 50 years progress 1 to 3 degrees per year. The risk factors included: cobb angles >30°, a lateral olisthesis ≥ 6 mm, an apical rotation greater than Grade II, and an intercrest line through L-5. For patients with a large curve, deformity could progress rapidly and cause intractable lower back pain, rendering deformity correction surgery necessary.

Earlier studies[3,4] have shown a significant positive correlation between sagittal plane balance and the clinical outcomes after surgical treatment of DS. Therefore, correction of sagittal imbalance is necessary for the well-being of these patients. However, DS patients are often senile with medical comorbidities and less flexibility in the spine. All these factors could add additional challenges to the surgery and increase the complication rate of the patient. Schwab advised[5] that the LL of DS should be restored to normal: PI–9°≤ LL<PI+9°. This means more destruction of spinal structures or even osteotomies during surgery. However, all these procedures could increase

the operation time, intraoperative blood loss, and potential complications. Thus, for such patients, we advocated that the limited correction of LL should be PI–18°≤ LL<PI–9° without removing excessive spinal structures to restore the sagittal alignment. The purpose of this study was to explore the efficacy of limited correction of LL in the treatment of DS patients.

2. Materials and methods

2.1. Patients

This research was approved by the IRB of the authors' affiliated institutions. From January 2013 to January 2017, 89 DS patients who underwent operation in our hospital were retrospectively analyzed. The patients were divided into 2 groups according to the postoperative LL: limited correction of LL group (PI −18 ° ≤ PLL < PL −9°) and control group (PI −9° ≤ PLL ≤ PI +9°). Inclusion criteria:

(1) Cobb angle above 10°;
(2) posterior-only procedure for adult scoliosis correction;
(3) treated with MIS-TLIF technique;
(4) availability of radiographic examinations (full–length AP and Lateral radiographs) and clinical data (inpatient medical records and questionnaire);
(5) participating in non-operative therapies yet without adequate relief of their symptoms. These included bracing, resting, physiotherapy, and analgesics.

Exclusion criteria:

(1) idiopathic curves,
(2) prior lumbar fusion surgery,
(3) other comorbidities, such as neoplasia, trauma, infection, severe osteoporosis;
(4) patients lost to follow-up.

Of the 89 patients, 58 (59%) met the inclusion criteria. There were 31 patients in the limited group, and 27 in the control group. At least 2-year follow-up was performed, and the mean follow-up was 26.3±2.5 months (range, 24–29 months).

2.2. Surgical treatment

Before surgery, all patients were treated with nerve root block to confirm the level where the leg pain originated from. All the patients were operated with single posterior lumbar surgery. Extensive decompression of the stenosis levels was performed. For the limited group, our treatment was enough to restore the LL as planned with only occasional 1 or 2 Smith-Petersen osteotomies (SPO) needed. For the control group, SPO or even pedicle subtraction osteotomy (PSO) was needed to correct the LL to normal. Finally, deformity correction was performed and a titanium rod was placed to maintain the LL (Figs. 1 and 2).

2.3. Data collection

Study measures were obtained through the review of inpatient medical records and questionnaires completed by the patients. The primary measures of this study were blood loss, operative time, and complications. Clinical evaluations, which included the JOA score, and the the Oswestry disability index (ODI) score were also recorded preoperatively and at the final follow-up.

2.4. Radiologic assessment

Radiographic examinations were performed by 2 experienced surgeons. Coronal balance parameters included: lumbar cobb, apical vertebral translation (AVT): the distance between the midpoint of apex vertebrate and the midline of the sacrum, coronal balance: the distance between the vertical line of C-7 and the midline of the sacrum. Sagittal balance parameters included: LL (LL: L1-S1), thoracolumbar kyphosis (T10-L2), sagittal vertical axis: the distance between vertical line of C-7 and the posterior of the sacrum, and junctional kyphotic angle: cobb angle between the lower endplate of the upper instrumented vertebra and the upper endplate of the vertebra above the upper instrumented vertebra. Pelvic parameters included: pelvic incidence (PI), pelvic tilt (PT), and sacrum slope (SS).

2.5. Statistical analysis

Measurement data were expressed as mean±standard deviations. The differences were compared using paired *t*-test. The enumeration data were expressed in percentages. The differences were compared using X^2 test, and statistical significance was set at $P < .05$. All analyses were carried out using the SPSS (Statistical Package for the Social Sciences) version 17.

3. Results

3.1. Preoperative data

Fifty-three patients showed symptoms of nerve root compression, thirty-seven patients had intermittent claudication, and forty-five patients had severe lower back pain preventing them from standing long. Thirteen patients had moderate lower back pain with no response to Nonsteroidal Anti-inflammatory Drugs. There was no significant difference between the 2 groups. (Table 1)

3.2. Surgical results

There were significant differences between the 2 groups in operation time and blood loss. (Table 2)

Table 1

Comparison of baseline data between 2 groups.

Item	Limited-correction group (n=31)	Control group (n=27)	P value
Male[n(%)]	41.9%	44.4%	
Age (yr, $\overline{x}$ ± s)	69.6±6.4	70.2±7.5	.78
Coronal Cobb angle(°)	34.6±9.8	33.7±8.9	.76
LL (° $\overline{x}$ ± s)	−20.1±8.3	−21.2±10.3	.71
TLK (° $\overline{x}$ ± s)	18.4±15.7	17.2±14.3	.80
JKA (° $\overline{x}$ ± s)	2.2±5.7	1.2±4.3	.54
PT (° $\overline{x}$ ± s)	28.9±10.3	27.3±10.6	.63
SS (° $\overline{x}$ ± s)	22.9±8.7	24.5±8.5	.94
SVA (cm, $\overline{x}$ ± s)	5.4±4.3	5.0±3.2	.74
AVT (cm, $\overline{x}$ ± s)	3.5±1.9	3.0±2.0	.42
CB (cm, $\overline{x}$ ± s)	1.5±2.7	1.1±2.8	.65
Oswestry scores ($\overline{x}$ ± s)	59.2±15.4	57.2±16.1	.69
JOA scores ($\overline{x}$ ± s)	12.4±4.5	13.7±5.4	.41

AVT = apical vertebral translation, CB = coronal balance, LL = lumbar lordosis, PT = pelvic tilt, SS = sacrum slope, SVA = sagittal vertical axis, TLK = thoracolumbar kyphosis, JKA = junctional kyphotic angle, JOA = Japanese Orhtopaedic Association.

Table 2

Comparison of operation and postoperative complications 2 groups.

Item	Limited-correction group (n=31)	Control group (n=27)	P value
Intraoperative blood loss (mL, $\bar{x}\pm s$)	910±330	1180±410	.025
Operative time (h, $\bar{x}\pm s$)	4.6±0.7	5.1±0.3	.006
Poor incision healing [n (%)]	12.9%	18.5%	—
Cerebrospinal fluid leak [n(%)]	9.6%	11.1%	—
Transient radicular pain [n(%)]	6.5%	14.8%	—
Transient precordial Discomfort [n(%)]	9.7%	14.8%	—
Pulmonary infection [n(%)]	0.0%	3.7%	—
Proximal junction kyphosis [[n(%)]	3.2%	7.4%	—

3.3. Clinical results

There were significant differences in LL, PT, SS ($P<.05$). (Table 3)

3.4. Complication

Complications among the limited-correction group included: Proximal junction kyphosis (PJK), 1 case; poor incision healing, 4 cases; cerebrospinal fluid leakage, 3 cases; transient radicular pain, 2 cases; transient precordial discomfort, 3 cases. Complications in the control group included: PJK, 2 cases; pulmonary infection, 1 case; poor incision healing, 5 cases; cerebrospinal fluid leakage, 3 cases; transient radicular pain, 4 cases; transient precordial discomfort, 4 cases. (Table 2)

4. Discussion

Surgical methods of DS have been gradually gaining attention in recent years.[6,7] The development of pedicle screw technology makes it possible to correct spinal deformity in older patients.[8] Due to the complexity of this disease, the key point of surgical treatment is to relieve clinical pain and improve the quality of life. Scoliosis pain in the convex side is usually caused by muscle fatigue or spasm, while pain in the concave side is usually related to disc herniation or articular process joint hyperplasia. The treatment of DS is an ongoing debate.[9,10] The Lenke-silva[11] classification serves as a guide for treatment. Zeng divided DS patients into 2 groups: those with symptoms caused by nerve compression, and those with symptoms caused by spine deformity. The former group could be treated by segment decompression with or without local spinal fusion, and the other group needed deformity correction with or without neurological decompression.[12]

The study showed that 81% of DS patients have a loss of LL. Compared with coronal imbalance, sagittal imbalance is more related to clinical symptoms. Loss of LL or kyphosis, and tilting of the pelvic are the main reasons for pain.[13,14] Therefore, for patients with severe lower back pain, maintaining the sagittal balance is the main goal of the surgery. Many scholars[5–7] suggested that the sagittal plane of the spine should be corrected to the normal range to better release symptoms and gain better clinical outcomes: PI can be used to evaluate the optimal LL (LL=PI±9). Patients with DS were commonly associated with rotatory olisthesis, lateral translation and osteophytosis, which contributed to the stiffness of their spine. As a result, SPO or even PSO is necessary to restore the LL to normal. However, DS patients often experience post-surgical complications. The average postoperative complication rate is 39% and increases with aging. The risk factors included operation time, blood loss, and the osteotomy techniques which sacrificed more spine structure to restore the normal curvature of the spine yet increased the incidence of complications.[15–17]

In our study, DS patients with limited correction experienced LL change from −19.2°± 8.1° to −37.5°± 4.6°. Meanwhile, for the control group, LL was changed from -21.0°±10.1° to −46.8° ±4.3°. The correction of LL was relatively smaller which meant less damage for spine structure, less or no osteotomy, less operation time and less blood loss. There were no significant differences in Cobb angle, apical vertebral translation and coronal balance between the 2 groups at the final follow-up. Although there was a significant difference between PT and SS at the final follow-up, there was no significant difference in ODI and JOA scores, which indicated that both groups had similar clinical outcomes. The limit group was advantageous over the control group in the average blood loss and operative time. In our study, the differences were statistically significant: the blood loss was 910±330 mL and 1180±410 mL (P=.025), and the operation time was 4.6±0.7 hours and 5.1±0.3 hours (P=.006). Furthermore, the complication of the limited group was less than that of the control group, which indicated that limit correction can effectively decrease the injury.

PJK is the most common complication of surgical treatment of the DS and is associated with many risk factors.

Among them, the degree of correction of the LL is an important consideration. Recently, Yagi et al[18] proved that PJK may be related to the maintenance of the overall sagittal balance, and excessive correction of LL may cause progressive thoracic kyphosis. This means that limited correction of LL plays an important role in reducing the occurrence of PJK. Unlike other scholars who advocated recovering to the normal LL, Yagi et al believe that elderly patients usually have positive sagittal balance, and that recovery of normal LL may lead to progressive postoperative thoracic kyphosis. Therefore, limited correction of LL may be a potential method to prevent the occurrence of PJK.

There are some limitations in this study. As for the range of the LL, Schwab[5] calculated that the optimal LL was PI–9°≤ LL<PI

Table 3

Comparison of radiographic parameters and the clinical scores at last follow-up between 2 groups in the limited-correction group and control group at last follow-up.

Item	Limited-correction group (n=31)	Control group (n=27)	P value
Coronal Cobb angle(°)	10.5±9.3	8.3±6.7	.40
LL (° $\bar{x}\pm s$)	−38.2±4.7	−46.9±4.7	<.01
TLK (° $\bar{x}\pm s$)	6.8±6.7	9.8±6.3	.15
JKA (° $\bar{x}\pm s$)	8.0±4.5	9.5±3.4	.24
PT (° $\bar{x}\pm s$)	18.8±5.2	11.1±3.6	<.01
SS (° $\bar{x}\pm s$)	33.7±7.0	41.4±6.1	<.01
SVA (cm, $\bar{x}\pm s$)	2.7±3.3	1.9±2.4	.39
AVT (cm,$\bar{x}\pm s$)	0.9±0.9	0.8±0.7	.70
CB (cm, $\bar{x}\pm s$)	0.1±1.8	−0.5±1.4	.25
Oswestry scores ($\bar{x}\pm s$)	25.6±10.2	26.4±12.1	.82
JOA scores ($\bar{x}\pm s$)	23.6±5.2	22.3±5.7	.45

AVT = apical vertebral translation, CB = coronal balance, LL = lumbar lordosis, PT = pelvic tilt, SS = sacrum slope, SVA = sagittal vertical axis, TLK = thoracolumbar kyphosis, JKA = junctional kyphotic angle.

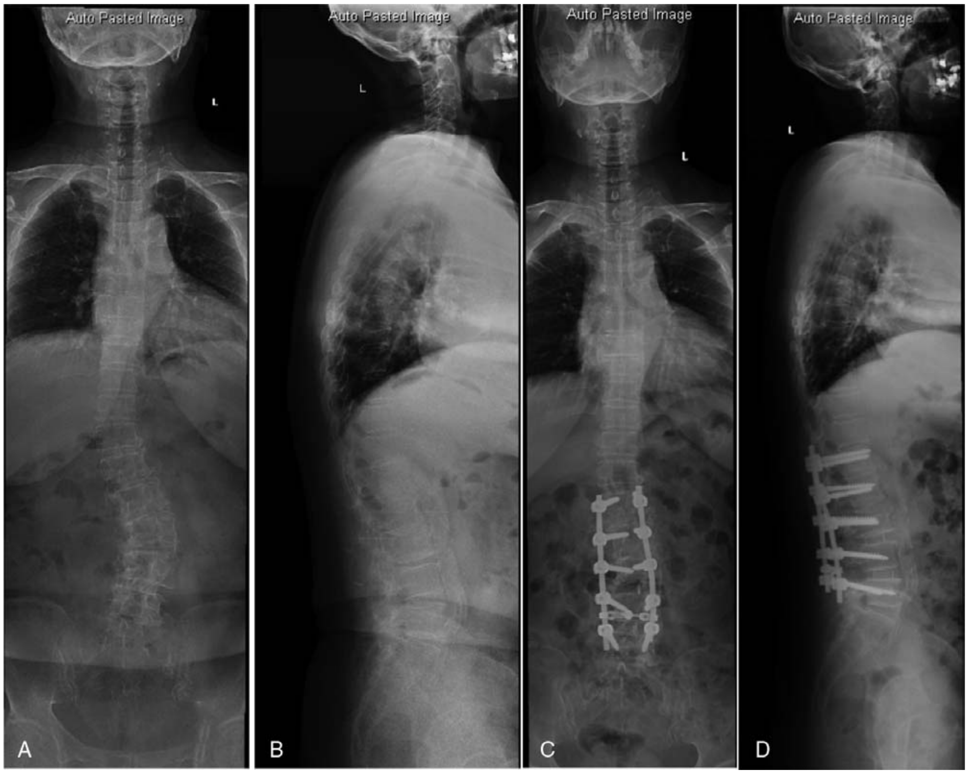

Figure 1. X-ray pictures of patient (limited-correction group, 68 yr old), A, B: preoperative anteroposterior and lateral X-ray; Cobb: 30.2, LL: −27.3, PI: 50.9; C, D: postoperative anteroposterior and lateral X-ray. Cobb: 7.8, LL: -34.5.

+9° by using multilinear regression analysis. In our study, we proposed that the optimal LL should be the limited correction decreased by multiples: PI–18°≤ LL<PI–9°. As there were no previous relevant studies, the range of the limited correction was relatively small. Patients with LL<PI-18°were not studied. Larger case studies with long-term observation should be conducted in the future to determine the exact range. Besides, our study was a retrospective study based on a review of clinical

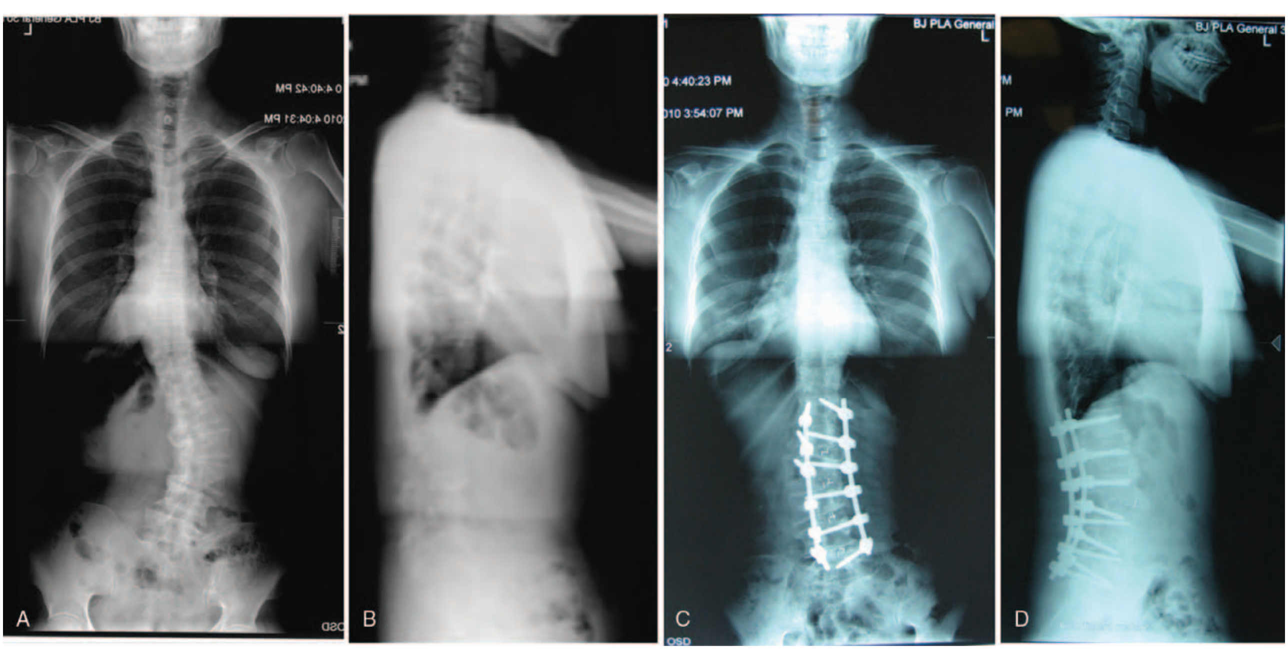

Figure 2. X-ray pictures of patient (control group, 69 yr old), A, B: preoperative anteroposterior and lateral X-ray; Cobb: 30.3, LL: −19.9, PI: 56.4; C, D: postoperative anteroposterior and lateral X-ray. Cobb: 3.8, LL: −42.1, Cobb: Coronal Cobb angle; LL: lumbar lordosis; PI: pelvic incidence.

cases and follow-up. Some of the patients had insufficient LL correction but with satisfactory effects. The data obtained from these patients was called the limited correction of LL. Compared with the traditional strategy, this technique performed less osteotomy and resected less spine tissues. However, due to inadequate intraoperative information in the retrospective study, the difference in intraoperative operation between the 2 groups was not described in details, which can be examined in further studies.

5. Conclusion

In conclusion, for DS patients, limited correction of LL was effective in lumbar coronal Cobb angle correction, ODI scores and JOA scores. It also resulted in less blood loss and less operation time. However, due to the small sample size of our study, further evaluation and study are warranted.

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Author contributions

Yan Liang and Xiangyu Tang carried out the molecular genetic studies, participated in the sequence alignment and drafted the manuscript. Yongfei Zhao, Kai Song participated in the design of the study and performed the statistical analysis. Keya Mao, Haiying Liu and Zheng Wang conceived of the study, and participated in its design and coordination and helped to draft the manuscript. All authors read and approved the final manuscript. Xiangyu Tang and Yongfei Zhao are co-first author.

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