The clinical and radiographic outcomes of stand-alone Oblique Lateral Interbody Fusion in Treatment of Adult Degenerative Scoliosis

Chen Liu
Yijishan Hospital of Wannan Medical College
Xin Ge
Yijishan Hospital
Yu Zhang
Yijishan Hospital
Liang Xiao
Yijishan Hospital
Hongguang Xu (xuhgyjsyy@163.com)

Research article

Keywords: Stand-alone OLIF, Adult degenerative scoliosis, Coronal cobb angle, Lumbar lordosis

Posted Date: August 9th, 2019

DOI: https://doi.org/10.21203/rs.2.12545/v1

Abstract

Background The minimally invasive treatment for adult degenerative scoliosis has become more and more popular. The purpose of this study was to evaluate the efficiency of stand-alone oblique lateral interbody fusion for the treatment of adult degenerative scoliosis in terms of clinical and radiological outcomes. Methods A total of 18 patients with ADS who underwent stand-alone OLIF in our hospital from July 2017 to May 2018 were enrolled in the study. Clinical evaluations were performed with visual analogue scale (VAS) and Oswestry Disability Index (ODI). Radiographic outcomes were recorded in terms of coronal Cobb angle and lumbar lordosis. Results Mean patient age was 62.4 years, 50% of patients were female. Average follow up was 18.4 months. The average operative duration was 87.4 minutes, whilst the mean estimated blood loss was 45.6 ml. Mean coronal Cobb angle corrected from preoperative 15.2° to the final follow-up 6.8° ($p < 0.05$); and mean lumbar lordosis improved from preoperative 30.0° to 39.4° ($p < 0.05$). Mean disc height increased from preoperative 0.7 cm to 1.1 cm at final follow-up ($p < 0.05$). Mean VAS improved from 5.5 to 2.2 ($p < 0.05$). The mean preoperative and the final follow-up Oswestry Disability Indices were 27.8% and 13.1% respectively ($p < 0.05$). Conclusions Stand-alone OLIF could be regarded as an efficient and safe option in the treatment of ADS for careful selected patients.

Background

Adult degenerative scoliosis (ADS) is a common clinical disease characterized by a Cobb angle more than 10° in the coronal plane, which affects approximately 6% of people over 50 years old[1]. The disease was mainly caused by the asymmetrical degeneration and hyperplasia of the facet joint, leading to the pathological changes such as spinal instability and deformity[2]. It is widely accepted that surgeries should be performed for patients with severe low back pain and progressive exacerbation of neurogenic symptoms which seriously affects quality of life, or imaging abnormalities of lumbar lordosis, thoracolumbar kyphosis and lateral sliding, and rapid development of spinal deformity[3-4]. At present, the surgical treatment for ADS include posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF) and anterior lumbar interbody fusion (ALIF). As for the PLIF and TLIF, the surgery has more neurological complications and paraspinal muscle stripping and dural adhesion may seriously affect postoperative outcomes[5]. The ALIF process may increase the risk of injury to the vascular and superior hypogastric plexus near the aortic bifurcation which may lead to excessive blood loss and retrograde ejaculation[6-7]. During the last decade, the extreme/direct lateral interbody fusion (D/XLIF) has attracted more and more attention in the appliaction of deformity correction in ADS. The previous studies has found that XLIF/DLIF could effectively restore coronal balance[8-9]. However, XLIF/DLIF achieved the intervertebral disc with a lateral approach passing through psoas major, which will cause damage to the psoas muscle during operation resulting in postoperative pain and paresthesia of the lower limbs segment[10]. In 2012, Silvestre[11] first reported the oblique lumbar interbody fusion (OLIF), which is through the anterior peritoneal approach between the front of the psoas muscle and the vascular sheath, thus avoiding direct damage to the psoas major and lumbar plexus. Although OLIF technology has been applied to the treatment of a serious kinds of lumbar degenerative diseases, the efficiency of OLIF technology for the treatment of ADS has not been thoroughly studied by now. Beng evaluated the effect of interbody distraction by OLIF with cortical bone trajectory screws fixation for the treatment of adult spinal deformity of 28 patients and found OLIF technique had the potential to correct misalignment in adult spinal deformity[12]. Besides, Nitin Agarwal[13] considered stand-alone LLIF was a safe and effective surgical procedure by investigating 55 patients with a 10-year follow-up. Herein, we analyze the clinical outcomes and radiographic correction of coronal deformity and lumbar lordosis in patients with ADS using stand-alone OLIF technology.

Methods

2.1 Patient population

We retrospectively reviewed the files of all patients with ADS who were treated with stand-alone OLIF technology from July 2017 to May 2018, and their clinical and radiographic results were summarized and analyzed. Inclusion criteria included the following: 1) the degenerative scoliosis Was mainly located in L1-L5; 2) Lenke-Silva grade was I ~ V and there was no need for posterior osteotomy surgery; 3) patients who experienced chronic low back pain with or without lower limb radiative pain and conservative treatments had no effect after at least 3 months; 4) the follow-up was more than one year. Exclusion criteria included:patients combined with severe osteoporosis with bone density T values less than -2.5; 2) patients who were diagnosed with scoliosis for inflammation, tumor or trauma; 3) previous lumbar fusion surgery .

2.2 Surgical procedure

The patient underwent general anesthesia and no neuromonitoring was required during the procedure. A transverse skin incision of 4 cm was made at the left lateral abdomen, which was in the same horizontal plane as the target intervertebral disc. For multilevel cases, the incision was centered between the surgical levels. The abdominal wall muscles were are bluntly separated. The retroperitoneum was entered by blunt separation with the fingers, then the psoas was retracted posteriorly and the abdominal vessels were retracted anteriorly; a guidewire was inserted in the middle of the target intervertebral disc with the help of a C-arm. Sequential dilators were placed over the guidewire, then a lighted retractor was placed over the dilatorsand fixed to the vertebral body with a pin, and the operation field was exposed; The annulus fibrosus and the nucleus pulposus was removed with the nucleus pulposus clamp; then, the cartilage endplates were resected for exposure of the bony endplates; a wide and lordotic intervertebral fusion cage (Medtronic Clydesdale, Memphis, Tennessee) packed with allograft bone was inserted into the target disc with the guidance of C-arm. Then, the incision was closed layer by layer. All patients were not received posterior internal fixation and no drainage tube was placed after surgery.

2.3 Assessment of clinical and radiographic outcomes

The operation time, the amount of intraoperative blood loss, hospital stay and complications were recorded. Moreover, the coronal Cobb angle, disc height (DH = mean value of the leading and trailing edge height of the intervertebral disc) and the lumbar lordosis (LL) of the patient before the operation and the final follow-up were measured. The Visual analog scale (VAS) score and the Oswestry disability index (ODI) score of the patients before the operation and the final follow-up were compared to evaluate the clinical efficacy.

2.4 Statistical analysis

Statistical analysis was performed using SPSS18.0 software (IBM Corp, Armonk, NY). All data were expressed as mean ± standard deviation (SD). Paired t-test were performed to compare outcome. P-value less than 0.05 was considered statistical significance in all analyses.

Results

3.1 Patient Demographics and Operative Data

Eighteen patients (9 females, 50%) with the average age 62.4 years (range 35-75 years) were enrolled in the study. A total of 25 lumbar levels were treated including 11 single level and 7 double levels. The mean operation time was (87.4±19.7) min per surgery (range 50-120 min) and 63.0 minutes per interbody fusion level. The intraoperative blood loss was estimated from 30 ml to 60 ml, with an average of (45.6±9.1) ml, while every each segment of OLIF averaged 32.8 mL The length of hospital stay was 6-14 days, with an average of (9.3 ± 2.2) days.

3.2 Clinical outcomes

The 18 patients were followed up for 12-21 months, with an average follow-up time of (18.4±2.4) months. The VAS score (2.2±0.5 points) and ODI index (13.1%±2.5%) of the final follow-up were both significantly lower compared to those observed before the surgery (VAS score: 5.5±0.7 points; ODI: 27.8%±6.2%) **(Figure 1)**. The difference between the groups was statistically significant ($P<0.05$).

3.3 Complications

Among all the patients, there were no intraoperative complications such as abdominal organ injury, vascular injury and ureteral damage. Two of the patients had postoperative pain and numbness in front of the left thigh. And the symptoms were relieved after one week of the treatment with drugs. Four patients was found to have the cage subsidence, which is the most common complication of stand-alone OLIF technology. The evaluation criteria for the subsidence of the cage are as described by Abdala[14]. The degree of cage subsidence was classified from grade 0 to grade III based on loss of postoperative disc height using the following scale: Grade 0 was defined as 0–24% loss of postoperative disc height; Grade I was 25-49%; Grade II was 50-74%; and Grade III was 75-100% in lateral X-ray of the lumbar spine. In this study, the cage subsidence of the four patients was regarded as grade 0, and no posterior pedicle screw internal fixation and decompression was performed in the second stage. Besides, those patients were successfully treated after conservative therapy during the follow-up.

3.4 Spinal deformity correction

The mean preoperative coronal Cobb angle of all the patients was 15.2°±4.8°(range13.1°-21.4°), which was corrected to which

was corrected to an an average of 6.8°±4.3° (range 1.1° -15.7°) of the final follow-up **(Figure 2)**. The difference in Cobb angle before the surgery and the final follow-up was statistically significant ($P < 0.05$), indicating that the coronal balance was significantly corrected. Postoperative indications showed an improved correction of the sagittal imbalance after surgery. In addition, the lumber lordosis was significantly increased from preoperative average 30.0°±16.5°(range 2.5°-58.5°) to the final follow-up mean 39.4°±14.3°(range 5°-61.5°)**(Figure 3)**. The difference in LL was statistically significant ($P < 0.05$). Immediately after surgery, Mean disc height was significantly increased from 0.7±0.3 mm preoperatively to 1.3±0.2 mm immediately postoperatively and 1.1±0.2 mm at final follow-up**(Figure 4)**. Although the height of the intervertebral disc was decreased at final follow-up, it was still higher compared with preoperatively. The difference was statistically significant ($P<0.05$).

Discussion

As we know, most cases of ADS present in the elderly who often have osteoporosis and underly multiple medical comorbidities, which maybe better to receive a minimally invasive operation. At present, minimally invasive surgery such as XLIF/DLIF with or without posterior internal fixation has become a widely accepted surgical solution for the treatment of ADS and prohibited satisfactory efficiency[15-16]. However, the incidence of postoperative complications such as lumbar plexus nerve and psoas muscle injury is 10% to 20% which led to abnormalities, thigh pain, and gluteal motor weakness after DLIF/XLIF operation even if with the help of intraoperative electrophysiological monitoring during the surgery[17]. In the contrast, the OLIF approaches the intervertebral disc via a corridor between anterior border of the psoas muscle and abdominal major vessels[18], which could effectively reduce the complications of postoperative thigh pain, paresthesia and other lumbar plexus injury. Anatomically, OLIF technology could be regarded as a unique advantage in the treatment of ADS because the ideal exposure space for OLIF technology is L2-L5 where ADS mainly occur. Coronal Cobb angles in ADS patients are usually mild[19]. For example, Paterakis[20] investigated the safety and efficacy of XLIF with or without supplemented instrumentation in the treatment of ADS and found that the mean preoperative Cobb angle was 21.6°. In our study, the average Cobb angle of all the patients before operation was 15.2° range from 13.1° to 21.4°. The OLIF technology could directly manage in the intervertebral disc and be applied to larger sizes than conventional posterior surgery. In this group of cases, the height of the OLIF cage is 10-14 mm and the length is usually 45-55 mm. Therefore, the coronal cobb angle can be effectively corrected by the parallel insertion of the OLIF cage with the intervertebral disc distracted. The correction of coronal cobb angle was obtained from preoperative average of 15.2°±4.8° to the final follow-up average 6.8°±4.3° in our study. What’s more, The LL increase from preoperative average 30.0°±16.5° to average 39.4°±14.3° of the final follow-up. The result may contribute to the anterior reconstruction with OLIF cage **(Figure 5)**. The same result was also seen in Jin's study[21], which showed that a significant increase insegmental lordosis and disc height with OLIF.

Biomechanical studies have shown that the recovery of LL was beneficial to increase the tension of the anterior longitudinal ligament, which could improve the intervertebral fusion rate and reduce the rate of degeneration of adjacent segments[22]. Another study[23] also found that the key to the recovery of the sagittal balance of the lumbar spine was to restore LL. The recovery of the sagittal balance can reduce the adjacent segmental degeneration caused by the compensated sagittal imbalance and improve the patient's symptoms.

Up to now, it has been a major controversy whether it is necessary for posterior internal fixation for OLIF technology in the treatment of ADS or not. Some scholars recommend the use of posterior screw internal fixation immediately, and some scholars suggested single-stage internal fixation[24]. They concerned that the absence of posterior pedicle screw fixation may cause the cage subsidence, which in turn affects clinical outcomes due to the loss of disc height. In my opinion, OLIF technology maintained the spinal stability without damaging the paraspinal muscles, anterior and posterior longitudinal ligaments and facet joints compared with traditional posterior approach such as PLIF and TLIF. In addition, lateral cage bone graft window is much bigger than the traditional PLIF/TLIF which could improve the fusion rate. After the large-sized cage was implanted, it could be tightly fixed to the epiphysis ring by the help of the tightened anterior and posterior longitudinal ligaments. Steffen[25] has shown that a wider cage placed in the periphery of the endplate has lower incidence to occur implant subsidence compared to a narrower implant owing to its efficiency in providing segmenal stability. Moreover, There were also reports of stand-lone ALIF and stand-alone LLIF, which showed good clinical efficacy. For instance, Rao[26] reported an overall clinical success rate of 93% for 27 patients diagnosed as low grade lumbar spondylolisthesis with stand-alone ALIF procedure. Ahmadian[27] evaluated the efficacy and clinical outcomes of 59 patients who underwent stand-alone lateral interbody fusion, 18 patients with ADS included. The results showed that stand-alone MIS-LIF was an available choice for carefully selected patients. Our data showed that DH was higher than postoperatively immediately after surgery, although DH decreased at the final follow-up, it was still higher than preoperative DH. In addition, it was also believed that the presence of radiographic subsidence does not directly correlate to clinical outcomes[28]. The VAS and ODI scores were statistically lower relative to preoperatively, which indicated that patients were received significant improvement of life quality in the current study. Zhang[29] also found that the cage subsidence in a total of 15 fused segments of the patients who underwent stand-alone OLIF, but symptoms in these patients had been alleviated during follow-up. However, it is worth noting that stand-alone has its own indications. We believe that bone density is an important factor that should be considered. Tempel[30] found that the incidence of cage subsidence in patients with bone density T values from -1.0 to -2.4 was significantly higher than the patients with bone density T values > -1.0, so they suggested that patients whose bone density T value less than -1.0 should be treated with posterior pedicle screw fixation. We also do not recommend stand-alone OLIF technology for patients who suffered from osteoporosis (T < 2.5) because the incidence of cage subsidence increases significantly. Besides, it is necessary to carry out adequate communication with the patients before stand-alone OLIF surgery that posterior decompression and internal fixation may be performed once clinical symptoms occurred again after surgery.

There are also some limitations in the study. The study was retrospectively reviewed and the results confirmed that OLIF technology can achieve good clinical results in patients with ADS, but there is still a lack of randomized controlled trials with XLIF/DLIF and PLIF. Secondly, the number of patients enrolled in this study is small, and the follow-up time is short, so its long-term efficacy and complications remain to be further observed and summarized.

Conclusions

The goal of this study was to evaluate the clinical and radiographic outcomes of stand-alone OLIF in treatment of ADS.

Significant improvement of disc height, VAS scores,reductions in ODI, the sagittal and coronal balance were observed at latest follow-up compared to preoperative scores. In our experience, stand-alone OLIF could be seen as a safe and efficient technique in the treatment of ADS patients with mild coronal plane deformity by indirect decompression and arrest curve progression.

Abbreviations

ADS Adult degenerative scoliosis

PLIF Posterior lumbar interbody fusion

TLIF Transforaminal lumbar interbody fusion

ALIF Anterior lumbar interbody fusion

D/XLIF Extreme/direct lateral interbody fusion

OLIF Oblique lumbar interbody fusion

DH Disc height

LL Lumbar lordosis

Declarations

Acknowledgment

N/A

Authors’ contributions

CL: project conceptualization, data collection and validation, result interpretation, editing, and final approval of the version to be submitted. XG: data collection and validation and final approval of the version to be submitted. YZ: result interpretation. LX: result interpretation. HX: project conceptualization, result interpretation, final approval of the version to be submitted, and the guarantor of the article. All authors have read and approved the manuscript.

Funding

The study was supported by the The National Natural Science Foundation of China（81572185，81702158）；The Natural Science Foundation of Anhui Province of China（1708085MH185，1708085QH205，1808085QH275）；The Foreign Cooperation and Technology Foundation of Anhui Province of China（1704e1002229）；Funding of “Peak” Training Program and “Panfeng” Innovation Team Project for Scientifc Research of Yijishan Hospital, Wannan Medical College（GF2019T02，GF2019G07，GF2019G12 ，PF2019007）.

Availability of data and materials

The final dataset will be available from the corresponding author.

Ethics approval and consent to participate

All the patient in the study were informed that data would be submitted for publication and the provided written consent. All procedures performed in the study were approved by the ethics committee of Wannan Medical college affiliated Yijishan Hospital.

Consent for publication

The patient was informed that data concerning the case would be

submitted for publication, and he provided consent.

Competing interest

The authors declare no conflicts of interest.

References

1 Cho K J, Kim Y T, Shin S, et al. (2014) Surgical treatment of adult degenerative

scoliosis[J]. Asian spine journal, 8(3): 371-381.

2 Isaacs R E, Hyde J, Goodrich J A, et al. (2010) A prospective, nonrandomized,

multicenter evaluation of extreme lateral interbody fusion for the treatment of adult degenerative scoliosis: perioperative outcomes and complications[J]. Spine, 35(26S): S322-S330.

3 Fu K M G, Bess S, Shaffrey C I, et al. (2014) Patients with adult spinal deformity

Treated operatively report greater baseline pain and disability than patients treated

nonoperatively; however, deformities differ between age groups[J]. Spine, 39(17): 1401-1407.

4 Paulus M C, Kalantar S B, Radcliff K. (2014) Cost and value of spinal deformity

surgery[J]. Spine, 39(5): 388-393.

5 Mobbs R J, Phan K, Malham G, et al.(2015) Lumbar interbody fusion: techniques,

indications and comparison of interbody fusion options including PLIF, TLIF, MI-TLIF, OLIF/ATP, LLIF and ALIF[J]. Journal of Spine Surgery, 1(1): 2

6 Härtl R, Joeris A, McGuire RA. (2016) Comparison of the safety outcomes

between two surgical approaches for anterior lumbar fusion surgery: anterior lumbar

interbody fusion (ALIF) and extreme lateralinterbody fusion (ELIF). Eur Spine J.

25(5): 1484-1521.

7 Rao PJ, Loganathan A, Yeung V, Mobbs RJ. (2015) Outcomes of anterior lumbar

interbody fusion surgery based on indication: a prospective study. Neurosurgery.

76(1): 7-23; discussion 23-4.

8 Dahdaleh N S, Smith Z A, Snyder L A, et al. (2014) Lateral Transpsoas Lumbar Interbody Fusion[J]. Neurosurgery Clinics, 25(2): 353-360.

9 Phillips F M, Isaacs R E, Rodgers W B, et al. (2013) Adult degenerative scoliosis treated with XLIF: clinical and radiographical results of a prospective multicenter study with 24-month follow-up[J]. Spine, 2013, 38(21): 1853-1861.

10 Lykissas M G , Aichmair A , Hughes A P , et al. (2014) Nerve injury after lateral

lumbar interbody fusion: a review of 919 treated levels with identification of risk

factors[J]. The Spine Journal, 14(5):749-758.

11 Silvestre C, Mac-Thiong J M, Hilmi R, et al. (2012) Complications and morbidities of mini-open anterior retroperitoneal lumbar interbody fusion: oblique lumbar interbody fusion in 179 patients[J]. Asian spine journal, 6(2): 89-97.

12 Beng T B, Kotani Y, Sia U, et al. (2019) Effect of Indirect Neural Decompression with Oblique Lateral Interbody Fusion Was Influenced by Preoperative Lumbar Lordosis in Adult Spinal Deformity Surgery[J]. Asian spine journal

13 Agarwal N, Faramand A, Alan N, et al. (2018) Lateral lumbar interbody fusion in the elderly: a 10-year experience: Presented at the 2018 AANS/CNS Joint Section on Disorders of the Spine and Peripheral Nerves[J]. Journal of Neurosurgery: Spine, 29(5): 525-529.

14 Abdala, Nitamar, Marchi, et al. (2013) Radiographic and clinical evaluation of cage subsidence after;stand-alone lateral interbody fusion Clinical article[J]. Journal of Neurosurgery Spine, 19(1):110-118.

15 Phillips F M, Isaacs R E, Rodgers W B, et al. (2013) Adult degenerative scoliosis treated with XLIF: clinical and radiographical results of a prospective multicenter study with 24-month follow-up[J]. Spine, 38(21): 1853-1861.

16 Dahdaleh N S, Smith Z A, Snyder L A, et al. (2014) Lateral transpsoas lumbar interbody fusion: outcomes and deformity correction[J]. Neurosurgery Clinics, 25(2): 353-360.

17 Blake R W , Gerber E J , Patterson J. (2011) Intraoperative and Early

Postoperative Complications in Extreme Lateral Interbody Fusion : An Analysis of

600 Cases[J]. Spine, 36(1):26.

18 Liu L , Liang Y , Zhang H , et al. (2016) Imaging Anatomical Research on the Operative Windows of Oblique Lumbar Interbody Fusion[J]. Plos One, 11(9):e0163452.

19 Palmisani M , Dema E , Cervellati S. (2013) Surgical treatment of adult

degenerative scoliosis[J]. European Spine Journal, 2013, 8(3):371-81.

20 Paterakis K N, Brotis A G, Paschalis A, et al. (2018) Extreme lateral lumbar interbody fusion (XLIF) in the management of degenerative scoliosis: a retrospective case series[J]. Journal of Spine Surgery, 4(3): 610.

21 Jin C, Jaiswal M S, Jeun S S, et al. (2018) Outcomes of oblique lateral interbody

fusion for degenerative lumbar disease in patients under or over 65 years of age[J].

Journal of orthopaedic surgery and research, 2018, 13(1): 38..

22 Hresko MT, Labelle H, Roussouly P, Berthonnaud E. (2007) Classification of

high-grade spondylolistheses based on pelvic version and spinebalance: possible

rationale for reduction. Spine (Phila Pa 1976). 2007. 32(20): 2208-13.

23 Champagne P O, Walsh C, Diabira J, et al. (2019) Sagittal Balance Correction Following Lumbar Interbody Fusion: A Comparison of the Three Approaches[J]. Asian spine journal, 13(3): 450-458.

24 Ohtori S, Orita S, Yamauchi K, et al. (2015) Mini-open anterior retroperitoneal lumbar interbody fusion: oblique lateral interbody fusion for lumbar spinal degeneration disease[J]. Yonsei medical journal, 56(4): 1051-1059.

25 Steffen T, Tsantrizos A, Fruth I, et al. (2000) Cages: designs and concepts[J].

European Spine Journal, 9(1):S089-S094.

26 Rao P J, Ghent F, Phan K, et al. (2015) Stand-alone anterior lumbar interbody

fusion for treatment of degenerative spondylolisthesis[J]. Journal of Clinical

Neuroscience, 22(10): 1619-1624.

27 Ahmadian A, Bach K, Bolinger B, et al. (2015) Stand-alone minimally invasive lateral lumbar interbody fusion: multicenter clinical outcomes[J]. Journal of Clinical Neuroscience, 2015, 22(4): 740-746.

28 Zhang J D , Poffyn B , Sys G , et al. (2012) Are stand-alone cages sufficient for anterior lumbar interbody fusion?[J]. Orthopaedic Surgery, 2012, 4(1):11-14.

29 Zhang C, Wang K, Jian F, et al. (2019) Efficacy of Oblique Lateral Interbody Fusion in Treatment of Degenerative Lumbar Disease[J]. World neurosurgery, 124: e17-e24.

30 Tempel Z J, Gandhoke G S, Okonkwo D O, et al. (2015) Impaired bone mineral density as a predictor of graft subsidence following minimally invasive transpsoas lateral lumbar interbody fusion[J]. European Spine Journal, 24(S3):414-419

Figures

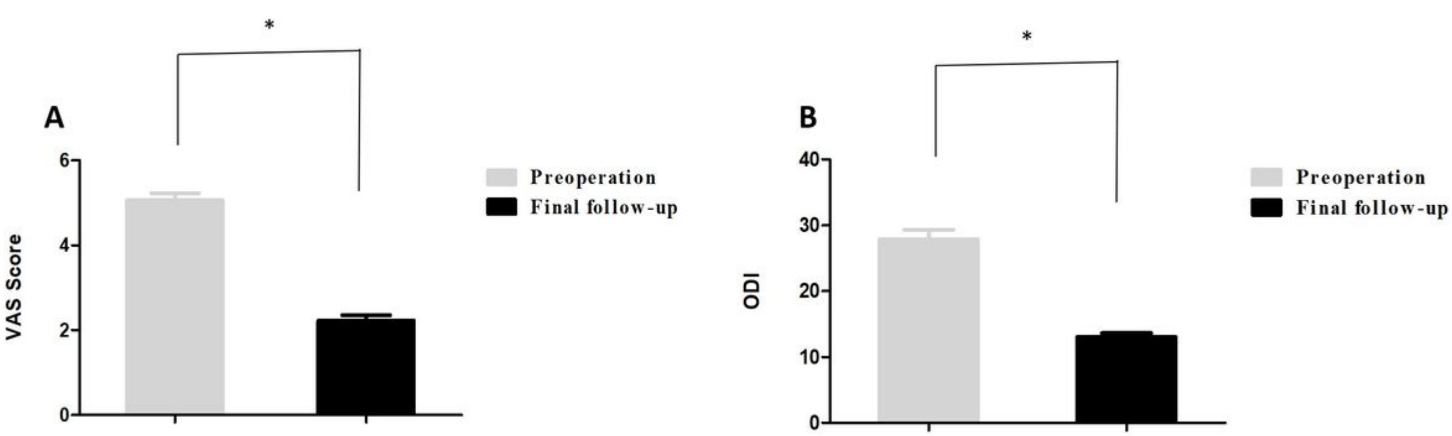

Figure 1

The mean visual analogue scale scores (A) and Oswestry Disability Index scores (B) preoperation and the the final follow-up.

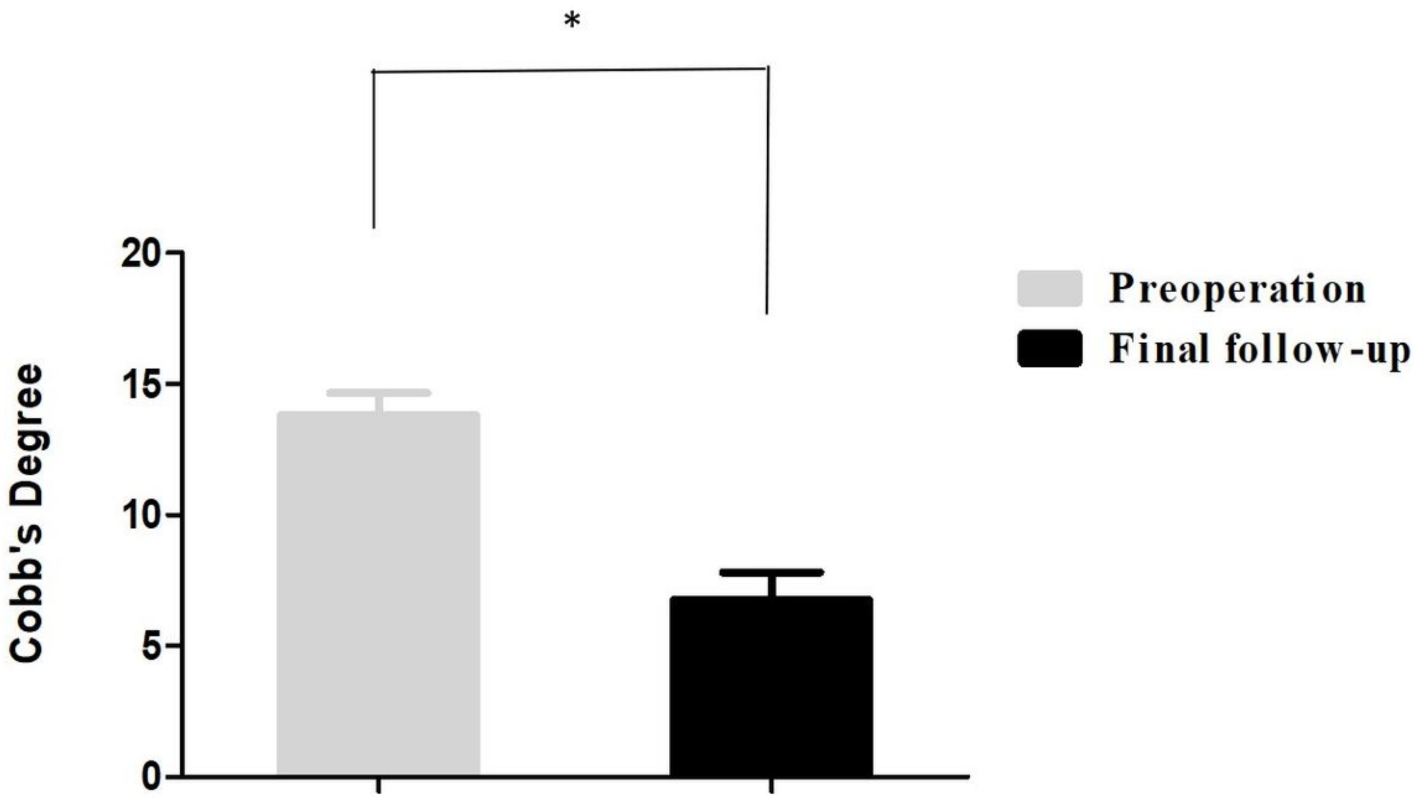

Figure 2

The coronal cobb angle was corrected significantly at the final follow-up.

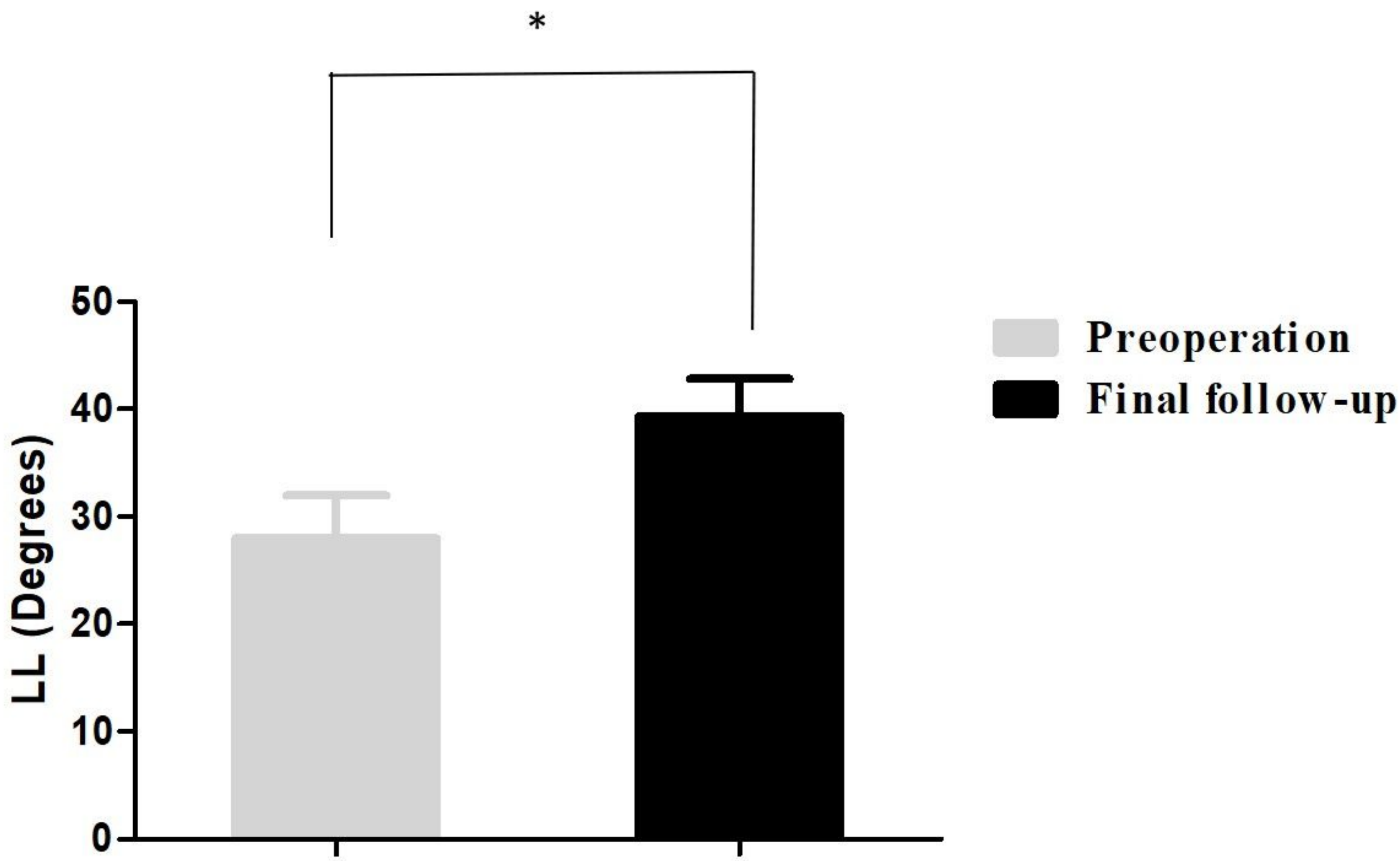

Figure 3

The lumber lordosis improved significantly at the final follow-up.

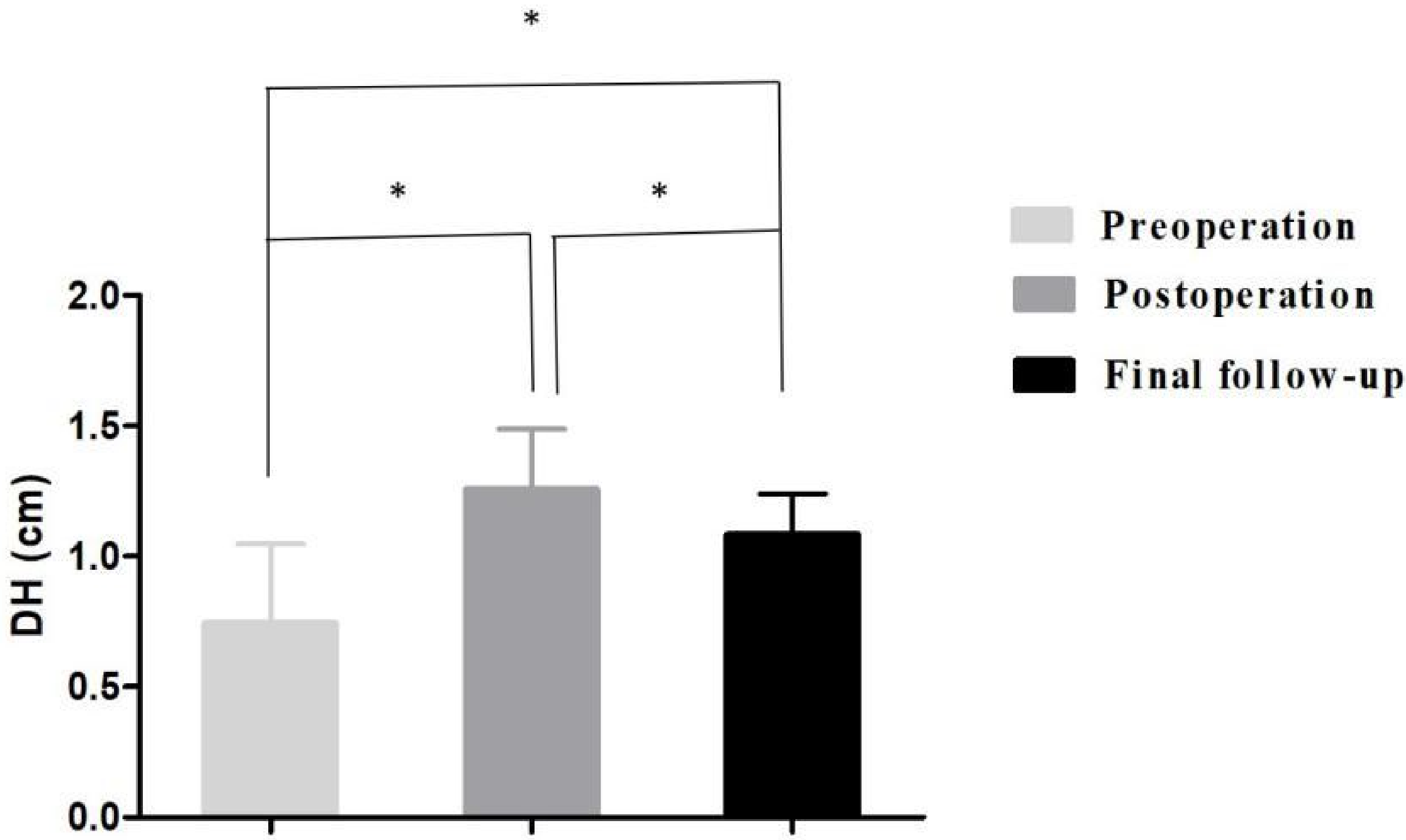

Figure 4

The mean DH increased from 0.7cm preoperatively to 1.3cm postoperatively, and decreased to 1.1 cm at the final follow-up.

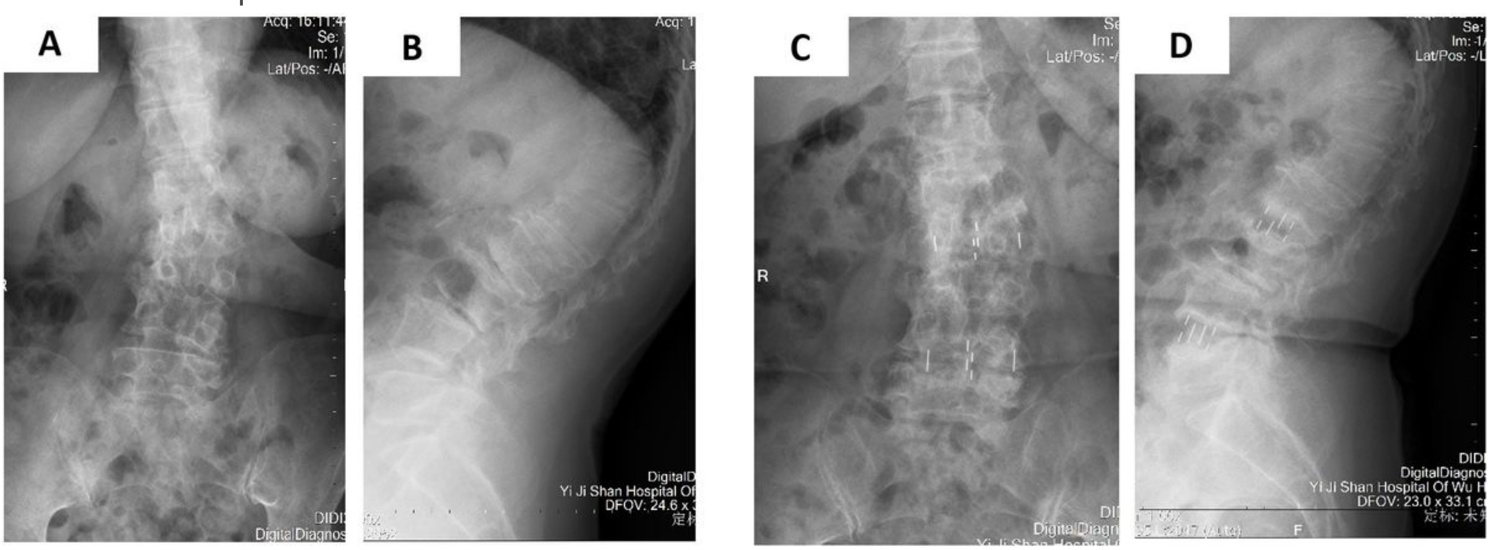

Figure 5

A 74-year-old patient presented with mechanical back pain. The preoperative radiograph indicated degenerative scoliosis (A,B). Postoperative radiograph after one year showed that the coronal and sagittal balance had been corrected (C,D).