

Is the Effect of Intervertebral Foramen Endoscopic Surgery on Adjacent Segmental Degeneration Better Than That of Open Surgery?

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Abstract

Background To compare the clinical outcomes of transforaminal lumbar interbody fusion (TLIF) and endoscopic discectomy in the treatment of postoperative adjacent segment degeneration in patients with lumbar disc herniation.

Methods From 2014 to 2017, 87 patients who were diagnosed with single-level lumbar disc herniation (LDH) and received surgery of TLIF (group X, n = 43) or endoscopic discectomy (group F, n = 44) were retrospectively analyzed. X-ray, MRI, CT and clinical symptoms were recorded before operation and at the last follow-up. The neurological function was originally evaluated by the (JOA) score of the Japanese Orthopaedic Association. Radiological evaluation included the height of intervertebral space (HIS), intervertebral foramen height (FH), intervertebral foramen area (FA), lumbar lordosis (CA) and intervertebral disc degeneration pfirrmann score.

Results There was no significant difference in average operation age, JOA improvement rate, reoperation rate and complications between the two groups. The average blood loss, average hospital stays and average operation time in group F were lower than those in group X. During the last follow-up, HIS, CA and FA decreased in both groups, and the changes in group X were more significant than those in group X ($P < 0.05$). There was no significant difference in postoperative FH between the two groups, but it decreased more in group X ($P < 0.05$).

Conclusion Both TLIF and endoscopic surgery can achieve good results in the treatment of LDH, but the risk of lumbar adjacent segment degeneration after intervertebral foraminal surgery is lower.

Background

Adjacent segment degeneration (ASD) after lumbar fusion has been a given enough attention, and the relationship between ASD and spinal fusion surgery has been reported in many literatures [1]. ASD is defined as imaging degeneration of adjacent intervertebral disc after surgical treatment, regardless of symptoms[2]. In recent years, endoscopic technology has been widely used in clinic. Compared with open surgery, for example transforaminal lumbar interbody fusion (TLIF), endoscopic surgery has advantages of less trauma, less postoperative pain and more rapid recovery, and the curative effect is equivalent to that of open surgery [3, 4]. However, there is a lack of exact data or knowledge about ASD after endoscopic surgery. Although various new operations developed may avoid adjacent segmental degeneration (especially for motion-preserving surgery) [1, 5], their efficacies are still controversial. The purpose of this study was to compare the difference of ASD between lumbar intervertebral foramen endoscopy and fusion, and to analyze the risk factors affecting ASD, so as to provide basis for clinical treatment.

Methods

The study has been approved by the hospital's board of directors and informed consent through institutional review, including details of the operation, including treatment mechanisms, predicted outcomes, and potential risks and adverse effects.

Patients' population

This study enrolled patients undergoing TLIF or endoscopic surgery for treating LDH involving single-level from June 2014 to June 2017 at our hospital. Patients were included in this study if they (1) clinically diagnosed as L5/S1LDH. (2) to meet the indications of PTED or lumbar fusion surgery, conservative treatment is ineffective for 3–6 months. (3) complete imaging data (X-ray, CT, MRI) were obtained in our hospital before operation and at the last follow-up. Patients were excluded from this study if they (1) accompanied by other segmental intervertebral disc problems. (2) there are serious medical diseases or surgical contraindications. (3) previous lumbar surgery. (4) Lumbar disc herniation with other segmental anatomical abnormalities, such as scoliosis, spinal fracture, Instability, spondylolisthesis and so on.(5) Lumbar disc herniation with severe spinal canal stenosis. This study was approved by the ethics committee of our hospital.

Selection of surgical procedure

TLIF group: Endotracheal intubation under general anesthesia, the patient took a prone position and raised the waist bridge. A 10–12 cm median incision was performed and peeled off layer by layer along the bilateral subperiosteum of the spinous process.

Fully expose the lamina and articular process. The inferior articular process and part of the upper joint. Chisel off the process and hyperplastic osteophyte and bite off the ligamentum flavum, such as bilateral symptoms. If it is heavy, the contralateral decompression is carried out in the same way. Cage rack placement and connection of titanium. Place cage rack and connect titanium. Indwelling 1 negative pressure drainage tube. Suture incision layer by layer.

PETD group: Prone position, chest and ilium cushion soft pillow raised to make the abdomen empty, fully expand the intervertebral foramen and reduce the intervertebral foramen plastic operation. Determine the puncture path: Mark the outline of the ilium and determine the hand under fluoroscopy. The operative segment, and then determine the puncture distance according to the patient's body size, in order to match the vertebrae. The horizontal gap is marked by a diagonal line with an angle of about 30 °, and the puncture point is the line and the distance. The point of intersection of parallel lines at a predetermined distance from the rear median line. Disinfect and spread towels. After that, the local anesthetic diluted to 1% was applied to the skin and subcutaneous of the puncture point. Fascia infiltration anesthesia, and then the 18G puncture needle was punctured slowly until there was obvious obstruction force, that is, at the fascia of the lumbar dorsal muscle, the puncture needle is slightly retracted and blocked by local anaesthesia. Continue to deepen the puncture needle to the tip of the superior articular process and replace 0.5% lidoca. Due to the anaesthesia of the facet joint, the puncture needle was withdrawn slightly to increase and deepen the tilt of the head. Through the safety triangle puncture along the direction of the

spinal canal, it is confirmed that the needle tip is located in the right position. The midline of the spinous process is connected with the posterior edge of the vertebral body laterally. After cutting the skin with a sharp knife, insert it. Enter the guide wire, then use the step-by-step sleeve to expand the soft tissue, and then the fourth-stage ring. Saw to enlarge the intervertebral foramen step by step (each step is done under fluoroscopy, ring saw. Do not exceed the inner edge of the pedicle), and finally the working sleeve is placed smoothly and the fluoroscopy is accurate. It is recognized that it is located at the predetermined target position. Turn on the imaging system and carefully identify. Microscopic structure, separation and adhesion, removal of protruding nucleus pulposus tissue, surrounding. Decompression of the walking nerve root and detection of the pressure of the superior exit nerve root. Until the nerve root pulses with the pulse can be seen under the microscope, and the fibers are treated by radiofrequency thermocoagulation. The ring is formed, and the skin is sutured after careful hemostasis.

Clinical and radiological assessment

Patient demographics including patient age, sex, duration of symptoms, BMI, osteoporosis, blood loss, operation time and length of stay were evaluated to figure out baseline differences between groups. Patients were followed-up for at least 36 months after surgery. Radiologic data, including the following parameters.

The Cobb angle of the whole lumbar lordosis: measuring the connection of the anterior and posterior edge of the upper endplate on the standing lateral X-ray film L1. The angle between the line and the point of the front and rear edge of the upper end plate of S1.

Cross-sectional area (FA) and height (FH) of intervertebral foramen.

On the sagittal section of the intervertebral foramen, the line around the corresponding intervertebral foramen on the sagittal section forms an area and the height of the upper and lower edges [6].

The height of the anterior edge of the intervertebral space (AH) is the distance between the leading edge of the upper and lower vertebrae.

The height of the anterior edge of the intervertebral space (MH) is the distance between the midpoint of the upper and lower vertebrae.

The height of the posterior edge of the intervertebral space (PH) is the distance between the last edge of the upper and lower vertebrae.

Intervertebral disc degeneration was evaluated by Pfirrmann score.

Nervous system function was obtained using Japanese Orthopedic Association Score System (JOA Score). Alleviation of original symptoms, re-operation rates, complications were counted.

The data of preoperative and last follow-up were measured in all patients.

Statistical analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 23.0 (IBM Armonks, NY, USA). Continuous variables were recorded as mean values \pm standard deviation (SD), and categorical variables were expressed by proportions (%). The unpaired 2-tailed Student t test or Mann-Whitney U test were performed to compare the mean values or data distribution of continuous variables. And categorical variables were compared with the χ^2 (chi-square) test or Fisher exact test, as appropriate. The data measured before and after the last follow-up were statistically analyzed. Paired t-test was used for the last comparison before operation, and independent sample t-test was used for the comparison between groups. A P value of < 0.05 was considered statistically significant.

Results

A total of 87 patients were enrolled in our study the patients were divided into F group (n = 44) and X group(n = 43), including 24 males and 20 females in Foraminal group with an average age of 51.75 ± 3.65 years and 25 males and 18 females in TLIF group with an average age of 53.89 ± 5.21 years. The demographic characteristics of patients were summarized in Table 1 and baseline characteristics were well balanced between the two groups, including age, gender, and basic physical condition. but the blood loss, operation time, length of stays in group F were lower than those in group X($p < 0.001$).

Table 1
Baseline Demographic information of patients with LDH

Variable	F group (n = 44)	X group (n = 43)	P Value
Age	51.75 ± 3.65	53.89 ± 5.21	.335
Female	20 (45.45%)	18 (41.86%)	.735
Duration of symptoms	22.57 ± 5.36	21.98 ± 4.47	.506
BMI	20.48 ± 2.85	21.05 ± 2.77	.213
Osteoporosis	15(34.09%)	13(30.23%)	.700
Blood loss (mL)	145.30 ± 10.80	20.35 ± 9.87	< 0.001
Operation time (min)	64.65 ± 11.03	77.65 ± 7.80	< 0.001
Length of stay (days)	1.58 ± 0.22	4.18 ± 0.73	< 0.001

The date of the height of intervertebral space are summarized in Table 2. Before surgery, there was no statistical significance between group F and group X regarding ADH, MDH, and PDH. but the mean HIS was significantly higher in group X. At the final follow-up the mean HIS decreased in two group ($p < 0.05$). Noticeably, the change of ADH, MDH, PDH and average height in group F was all lower than that in group X (all $p < 0.05$). (Fig. 1–2).

Table 2
Change of the height of intervertebral space of patients in the two groups

Variable	F group (n = 44)	X group (n = 43)	P Value
mean ± SD, mm			
Pre. ADH	12.02 ± 2.09	12.74 ± 2.28	.131
FU. ADH	10.81 ± 1.99*	9.55 ± 1.77*	.002#
Change. ADH	1.21 ± 0.73	3.19 ± 2.13	<0.001#
Pre. MDH	12.01 ± 2.33	13.02 ± 2.83	.072
FU. MDH	10.86 ± 2.24*	9.60 ± 1.73*	.004#
Change. MDH	1.15 ± 1.14	3.43 ± 2.35	< 0.001#
Pre. PDH	10.31 ± 2.47	11.24 ± 2.73	.002#
FU. PDH	9.24 ± 1.79*	8.16 ± 1.36*	.127
Change. PDH	1.07 ± 1.45	3.07 ± 1.97	< 0.001#
Pre. Average height	11.45 ± 1.96	12.33 ± 2.07	.043#
FU. Average height	10.30 ± 1.79*	9.10 ± 1.41*	.001#
Change. Average height	1.14 ± 0.70	3.23 ± 1.37	< 0.001#
ADH, anterior disc height; MDH, middle disc height; PDH, posterior disc height; the average value of the three heights. # Comparison of parameters between the two groups * p < 0.05, comparison of parameters within the same groups before surgery and final follow-up			

Table 3 demonstrates the changes of imaging outcomes between the two groups. We did not find any statistical difference in the comparison of FH, Pfirrmann score, Cobb angle and FA within the two groups before surgery (all p > 0.05). However, the change of Cobb angle, FH and FA was significantly larger in group X at the last follow-up (p < 0.05). As regards Pfirrmann score, no significant difference was observed between the two groups. (Fig. 3–6).

Table 3
Imaging outcomes of patients in the two groups

Variable	F group (n = 44)	X group (n = 43)	P Value
Pre. PS	2.98 ± 0.76	3.00 ± 0.72	.887
FU. PS	3.14 ± 0.59(0.279)	3.49 ± 0.70*	.013 [#]
Change. PS	-0.16 ± 0.96	0.49 ± 1.10	.141
Pre. CA (°C)	33.97 ± 6.72	34.18 ± 6.74	.890
FU. CA (°C)	30.90 ± 6.40(0.095)	26.09 ± 5.52*	< 0.001 [#]
Change. CA (°C)	3.07 ± 1.49	8.09 ± 4.90	< 0.001 [#]
Pre. FH (mm)	23.86 ± 1.23	23.36 ± 1.77	.126
FU. FH (mm)	23.76 ± 1.25(0.650)	22.75 ± 1.73(0.060)	.186
Change. FH (mm)	0.10 ± 1.45	0.61 ± 2.07	.026 [#]
Pre. FA (mm ²)	211.01 ± 12.47	210.09 ± 12.75	.735
FU. FA (mm ²)	197.32 ± 13.92(0.124)	185.43 ± 20.24*	.002 [#]
Change. FA (mm ²)	13.69 ± 12.84	24.66 ± 18.50	.002 [#]
PS Pfirrmann score; CA Cobb angle; FH, foraminal height; FA, foraminal area;			
[#] Comparison of parameters between the two groups			
* p < 0.05, comparison of parameters within the same groups before surgery and final follow-up			

The clinical results were summarized in Table 4. The JOA score improved from 14.90 ± 2.20 to 24.12 ± 2.40 in F group, and 14.55 ± 1.98 to 25.71 ± 2.12 in X group. No significant difference was observed in JOA score between the two groups at the final follow-up. There were 40 (90.90%) patients who acquired significant alleviation of original symptoms in group F, whereas in group X, 41 (95.35%) patients had symptom alleviation. No difference was observed between the peri-operative complications, three patients in group X experienced surgery-related complications: one with lumbar haematoma, one with surgery site infection and one with CSF leakage. In group F, the number of patients with complications was one: one with CSF leakage. All patients received timely symptomatic treatment and all were cured. The re-operation rates were 4.55% (2/44) in F group (two patients underwent open surgery because of the protruding of the operative segment.), and 2.33% (1/43) in X group (One patient underwent endoscopic revision because of adjacent segmental degeneration) at the final follow-up.

Table 4
Clinical outcomes of patients in the two groups

Variable	F group (n = 44)	X group (n = 43)
Pre. JOA	14.90 ± 2.20	14.55 ± 1.98
Post. JOA	24.12 ± 2.40	25.71 ± 2.12
JOA Recovery rate (%)	75.89	78.64 (0.611)
final follow-up JOA	23.18 ± 2.35	24.31 ± 1.97
Alleviation of original symptoms	40(90.90%)	41(95.35%) (0.414)
Re-operation rates	4.55% (2/44)	2.33% (1/43) (0.570)
Complications		
pulmonary embolism	0	0
Root injury	0	0
Cerebrospinal fluid leakage	1	1
Lumbar haematoma	0	1
Surgery site infection	0	1
Total	1(2.27%)	3(6.98%) (0.295)

Discussion

According to previous reports [7], the prevalence rate of ASD after lumbar fusion surgery was 5–77%, and the combined prevalence rate was 26.6%. However, the literature reported that the incidence of ASD is within four years after lumbar non-fusion was 10% [8], which was lower than that of allogeneic fusion surgery [9]. Adjacent segmental degeneration after spinal fusion is considered to be multifactorial. Many literatures have reported that the degree of intervertebral disc degeneration is closely related to age (over 60 years old), genetic factors, high body mass index (BMI ≥ 25), pre-existing stenosis or degeneration of adjacent segments, lumbar insufficiency, multi-segmental lumbar fixation and fusion [10–12]. Therefore, this study controls these factors, and there is no statistical difference before operation. In addition, the operation itself is also one of the important reasons affecting ASD. Ekman et al found that lumbar fusion accelerated intervertebral disc degeneration at adjacent segments after long-term follow-up [13]. Some scholars reported that the incidence of cephalic adjacent segment degeneration examined by X-ray 2–3 years after lumbar fixation and fusion was 38.5% [14]. This study focuses on the superior adjacent intervertebral disc. Radcliff et al pointed out that the rate of (PLIF) in interbody fusion was significantly higher than that in patients without decompression [15]. They concluded that excessive extension of the fusion cage to the intervertebral space was an important risk factor for ASD [16]. In a retrospective study, Biden et al suggested that floating fusion, in which the lower end of the fusion vertebrae is located at L5,

is a risk factor for ASDis [9]. In addition, floating fusion was more likely to develop ASD in 511 patients with posterolateral lumbar fixation [17].

Although there are many studies related to ASD, the author speculates that surgery may lead to biomechanical changes of the spine is one of the most reasonable mechanisms.

In 1983, Kirkaldy-willis put forward the theory of three-joint complex (composed of intervertebral disc and two posterior facet joints), and believed that this structure plays an important role in maintaining the stability of the spine [18]. Liu et al. After six-year follow-up of L4-5 fusion, the incidence of ASD was the most significant in patients with total laminectomy [19]. Imagama et al followed up 52 patients after L4-5 laminectomy or L4-5 fenestration fusion for five years, revealing that patients with fenestration were less likely to develop ASD [20]. The results show that the preservation of the structure of the posterior column of the lumbar spine is an important factor to avoid ASD. Lumbar fusion requires extensive peeling off of paraspinal muscles, removal of part of ligaments and bony structure, destruction of the stability of the three-joint complex, resulting in abnormal load distribution of the whole spine, prone to vertebral spondylolisthesis or fracture and other diseases [21]. Therefore, it changes the original equilibrium relationship between the diseased vertebral body and the adjacent vertebral body, and aggravates the postoperative adjacent segmental degeneration (ASD) [21–23]. Ma et al. [found in the human cadaver model that the increase in stress on the facet joints after fusion may affect the degeneration of adjacent segments [24]. Through the analysis of three-dimensional finite element model, the biomechanical load of the adjacent vertebral facet joint above the fusion segment is obviously abnormal [25, 26].

Makino et al reported that the incidence of ASD in 41 L4-5 PLIF patients with minimum intervertebral space distraction (12.2%) was significantly lower than that of previous ASD with PLIF distraction (31.8%) [27]. It is considered that the use of a lower fusion cage to minimize the opening of the intervertebral space may prevent ASD. In a biomechanical study of a finite element model fused at the L4 / 5 level, stress on the L3 / 4 vertebral endplate and intervertebral disc increased during flexion / extension movement [28]. In addition, in the cadaveric L3/4 fixation model, Cunningham et al increased the pressure in the L2 / 3 intervertebral disc by 45% during flexion / straightening [29]. It can be seen that the cadaveric experiment showed that the pressure in the proximal intervertebral disc of the adjacent intervertebral disc increased to a fixed level [29].

Therefore, we think that the occurrence of ASD after fusion may be related to some mechanical factors, the destruction and disorder of local structure, the range of motion of its upper adjacent segments and the compensatory load of facet joints.

Because the nucleus pulposus tissue is a colloidal semi-liquid substance with flow characteristics, the volume of the intervertebral disc will be further degraded and absorbed over time after nucleus pulposus resection [31]. Therefore, the removal of the nucleus pulposus of PTED leads to the decrease of the bearing capacity of intervertebral disc, which in turn leads to the decrease of the upper vertebral body. At the last follow-up, the height of the intervertebral space in the upper adjacent segment was lower than that before operation, and there was statistical significance ($P < 0.05$). It may be related to the natural

process of aging. However, compared with TLIF, PTED can not only retain more spinal range of motion than fusion, but also retain as much intervertebral disc tissue as possible on the basis of ensuring the curative effect, which provides a pathological basis for self-repair and secondary stability in the later stage, and may reduce the incidence of ASD or delay the occurrence of ASD.

Many studies have shown that the decrease, disappearance or kyphosis of lumbar physiological curvature is closely related to the degeneration of intervertebral disc. Studies have shown that lumbar physiological curvature changes in patients with lumbar disc herniation may be the result of lumbar mechanical structural imbalance caused by lumbar degeneration [32]. Umehara believes that the reduction of lumbar kyphosis will increase the posterior column load and cause changes in the mechanical load of the adjacent segments [33]. Djurasovic et al found lumbar kyphosis deformity or loss after lumbar fusion [34]. In this study, the changes of adjacent segments and Cobb angle in group F were significantly lower than those in group X, indicating that PTED can maintain physiological curvature and mechanical balance of spinal structure to some extent, and reduce the incidence of lumbar degenerative diseases.

Intervertebral disc degeneration can directly and indirectly affect the area of intervertebral foramen. Cinotti et al found that intervertebral disc height loss can lead to intervertebral foramen stenosis by measuring 160 intervertebral foramen in dry cadaver specimens and 50 intervertebral foramen in fresh cadaveric spine [35]. In this study, the cross-sectional area of intervertebral foramen decreased before operation and at the last follow-up, and the change in group F was lower than that in group X. The stenosis of intervertebral space caused by intervertebral disc degeneration can significantly reduce the height of intervertebral foramen, especially the minimum sagittal diameter of intervertebral foramen. It may be due to the natural degeneration of the intervertebral disc or the change of posture during the examination of the patient.

In the past, many scholars have shown that the foraminal endoscope has a definite effect in the early stage, and can significantly improve the pain symptoms of patients [36]. In 588 patients with lumbar disc herniation treated by intervertebral foramen endoscopy and followed up for more than 2 years, the excellent and good rate was 95.3%, and the recurrence rate was 3.6% [37]. Since imaging adjacent segmental degeneration is not necessarily related to symptoms after spinal fusion surgery, there was no significant difference in JOA scores between the two groups at the last follow-up, which is consistent with previous studies that about 1 / 4 of 1 / 3 ASD of patients can progress ASDis [38–40]. At the same time, foraminal endoscopic surgery was performed under local anesthesia, compared with open surgery that requires general anesthesia, the operator can obtain patient feedback well, and there was no need to expose the herniated intervertebral disc by pulling the nerve root and dural sac during the operation, which reduce the risk of nerve injury [41]. Therefore, this study also found that minimally invasive surgery has low complications and a certain recurrence rate.

Limitations

Considering that the treatment of osteoporosis is another technique for preventing ASD. Therefore, the two groups of patients with osteoporosis received conservative drug treatment. However, this study is a retrospective study, with a small sample size, a single center and a short follow-up time. In addition, we strive to reduce systematic errors by establishing and implementing strict inclusion and exclusion criteria in order to maintain the homogeneity of the sample. In order to design standardized surgical procedures, the same surgical team is responsible for the same surgical instruments; the last follow-up symptoms are evaluated by the same spinal surgeon. All imaging parameters were independently measured by three neurosurgeons who turned a blind eye to the study. Therefore, the data of this study is real and the conclusion is reliable.

Conclusion

Both TLIF and endoscopic surgery can achieve good results in the treatment of lumbar disc herniation, but the risk of lumbar adjacent segment degeneration after intervertebral foraminal surgery is lower.

Abbreviations

TLIF

Transforaminal lumbar interbody fusion

PETD

percutaneous endoscopic transforaminal discectomy

BMI

International Consultation on Incontinence Questionnaire Short Form

SPSS

Statistical Package for the Social Sciences

JOA

Japanese Orthopedic Association Score

FU

follow-up

ASDis

Symptomatic adjacent segment disease

Declarations

Ethics approval and consent to participate

All procedures performed in studies involving human participants were in accordance with the ethical standards of the Ethics Committee of Changzheng Hospital and 910th Hospital.

Consent for publication

Informed consent was obtained from all individual participants included in the study.

Availability of data and materials

The datasets used and/or analyzed during the current study are not publicly navailable due to feasibility but are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

"SW analyzed and interpreted the patient data, and was a major contributor in writing the manuscript. KS and AL performed the examination of the data, and substantively revised the manuscript. RZ conducted the acquisition of data. XL have helped draft the work. FZ proposed the idea of study design. JS finished the final assessment of the manuscript. All authors read and approved the final manuscript."

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Figures

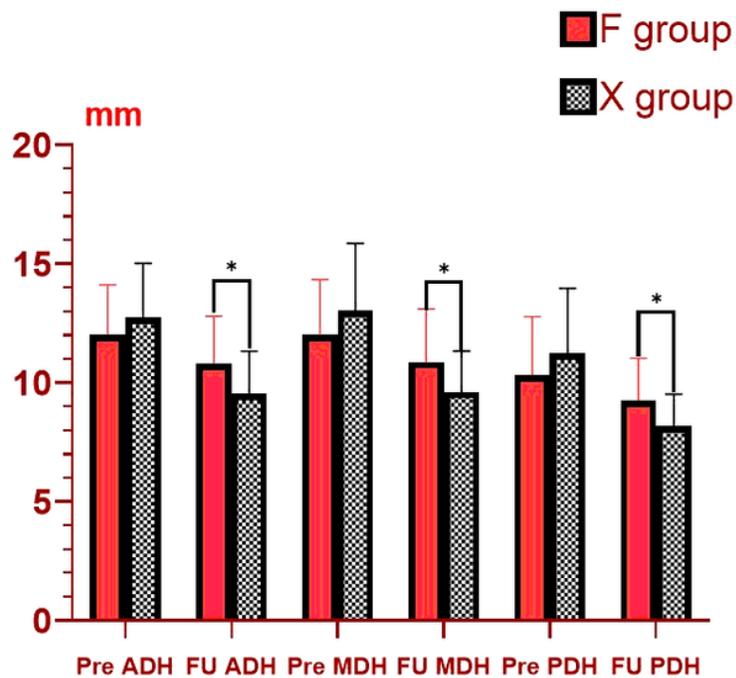


Figure 1

Noticeably, the change of ADH, MDH, PDH and average height in group F was all lower than that in group X (all $p < 0.05$).

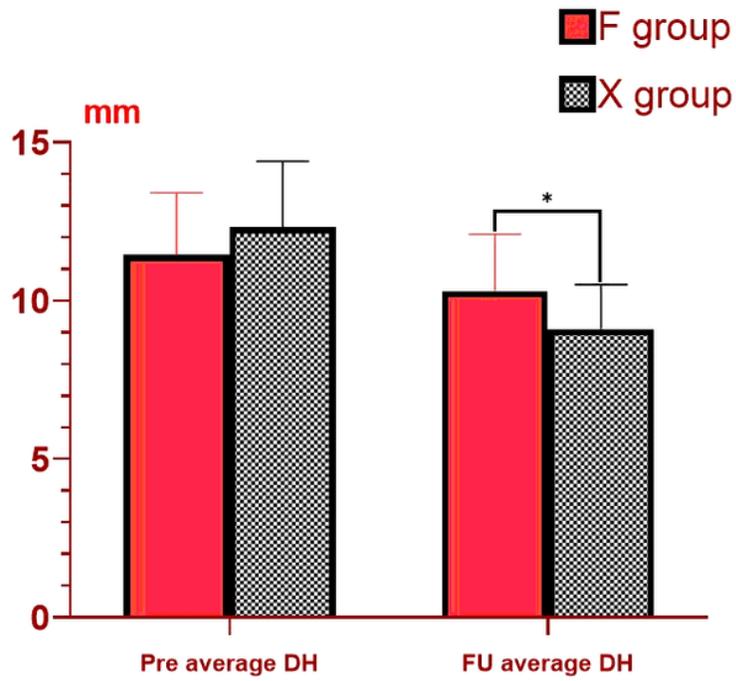


Figure 2

Noticeably, the change of ADH, MDH, PDH and average height in group F was all lower than that in group X (all $p < 0.05$).

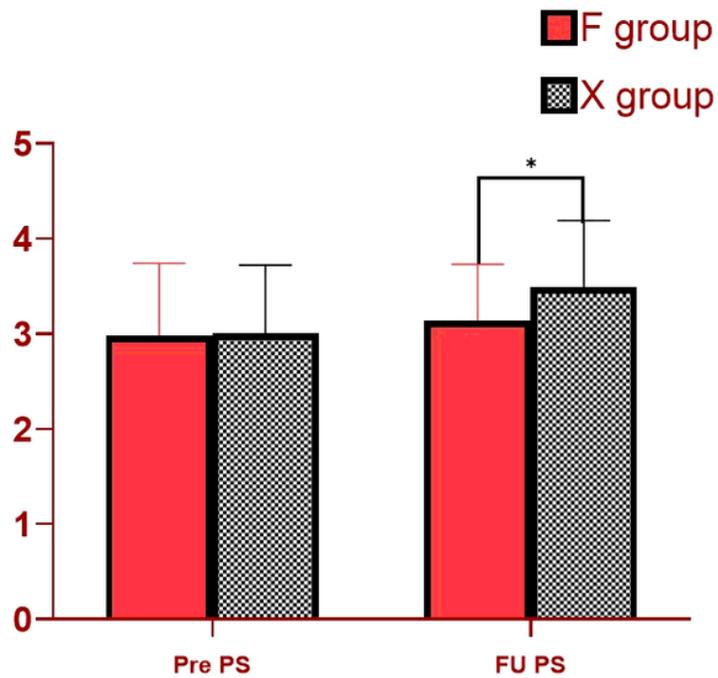


Figure 3

However, the change of Cobb angle, FH and FA was significantly larger in group X at the last follow-up ($p < 0.05$). As regards Pfirrmann score, no significant difference was observed between the two groups.

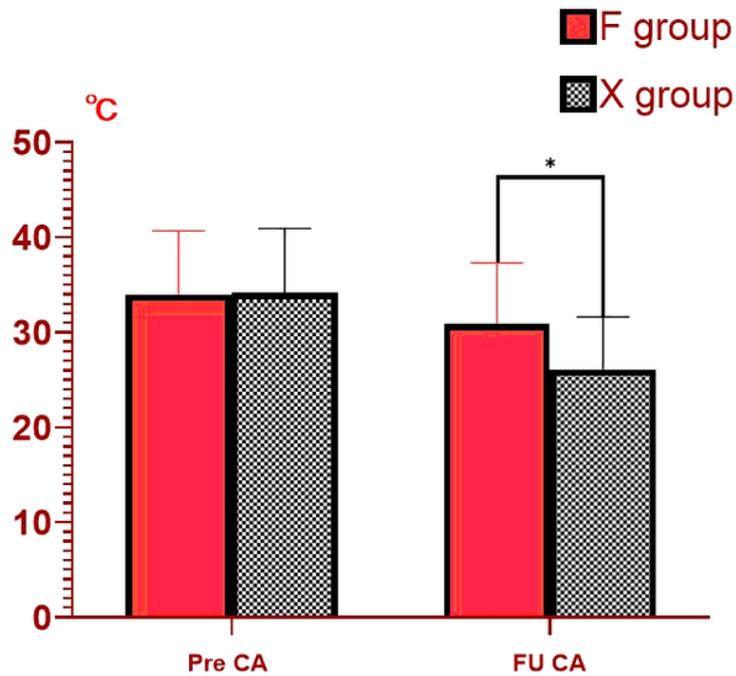


Figure 4

However, the change of Cobb angle, FH and FA was significantly larger in group X at the last follow-up ($p < 0.05$). As regards Pfirrmann score, no significant difference was observed between the two groups.

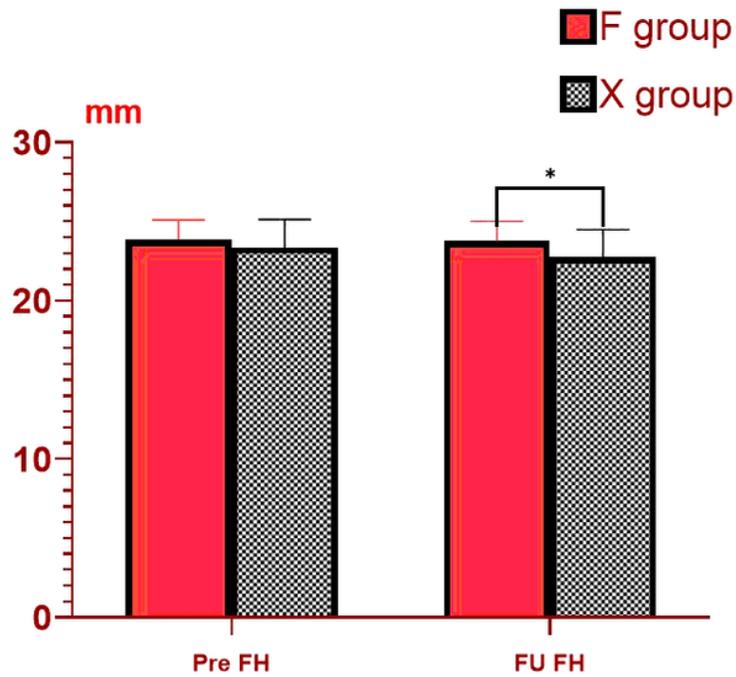


Figure 5

However, the change of Cobb angle, FH and FA was significantly larger in group X at the last follow-up ($p < 0.05$). As regards Pfirrmann score, no significant difference was observed between the two groups.

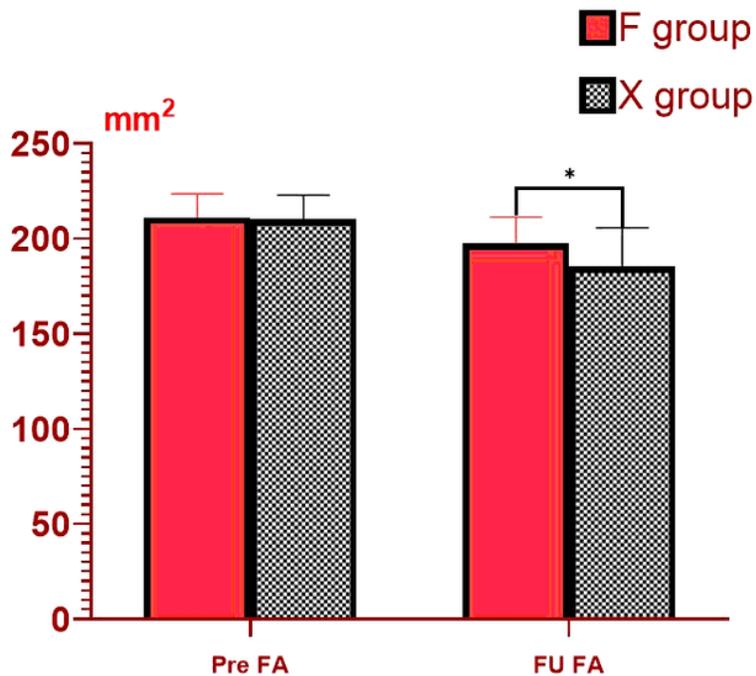


Figure 6

However, the change of Cobb angle, FH and FA was significantly larger in group X at the last follow-up ($p < 0.05$). As regards Pfirrmann score, no significant difference was observed between the two groups.

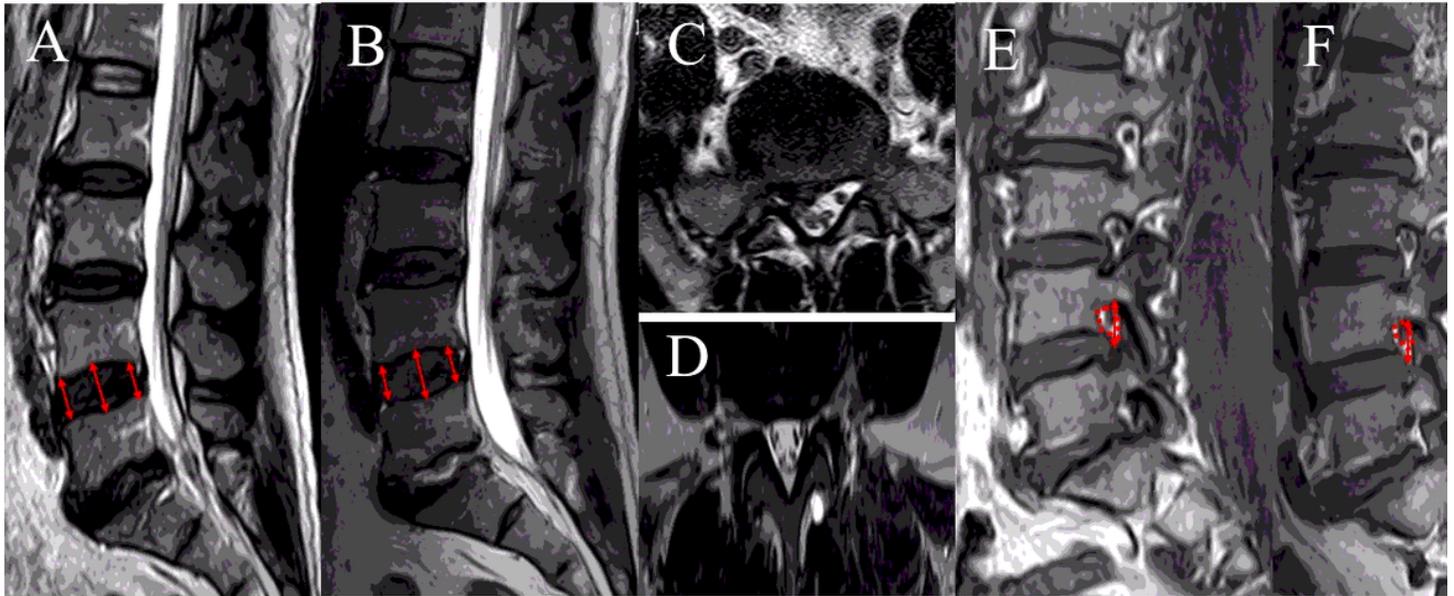


Figure 7

The changes of intervertebral disc height, intervertebral foramen height and area were not serious, and there was a certain natural process. (Preoperative magnetic resonance (ACE) last follow-up (BDF))