Comparison of Unilateral and Bilateral Polymethylmethacrylate-augmented Cannulated Pedicle Screw Fixation for Management of Lumbar Spondylolisthesis with Osteoporosis

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Abstract

Background: Many studies have shown that cannulated pedicle screw (CPS) augmented by polymethylmethacrylate (PMMA) can obtain a satisfactory clinical efficacy in the treatment of lumbar spondylolisthesis with osteoporosis. However, accurate application of CPSs will help to avoid the difficulty of screw revision and reduce the incidence of PMMA related complications. This study aims to investigate the mid-term efficacy of CPS comparing unilateral and bilateral application in this common lumbar degenerative disease.

Methods: Between May 2011 and May 2018, 50 patients with posterior fixation and fusion using traditional pedicle screw or CPSs for lumbar spondylolisthesis with osteoporosis were included in the study. Patients were divided into 2 groups: those with unilateral PMMA-augmented CPSs (group UC n=29) and those with bilateral PMMA-augmented CPSs (group BC, n=21). Operation time, blood loss, average hospitalization time, PMMA leakage and other complications were recorded. Visual Analog Scale (VAS) and Oswestry Disability Index (ODI) scores were used to evaluate the recovery of symptoms. Radiographic results were compared for the intervertebral fusion and screw loosening.

Results: There were no significant differences in the baseline data of the 2 groups.

VAS and ODI scores were improved significantly after surgery ($P<0.05$), with no differences between the groups ($P>0.05$). The operation time and blood loss in group UC were significantly lower than those in groups BC ($P<0.05$). However, the loss of intervertebral disc height and Taillard index had no difference in group UC compared with group BC. And the rates of PMMA leakage in group UC and BC were 7.0% and 11.9%, respectively ($P<0.05$). Bony fusion was achieved in all groups without screw loosening at the last follow-up. And only one patient experienced superficial infection in both groups, meanwhile two patients of cerebrospinal fluid leakage was observed in group BC.

Conclusions: Unilateral application of PMMA-augmented CPS may provide adequate clinical safety and effectiveness in surgical treatment of lumbar spondylolisthesis with osteoporosis.

Background

Lumbar spondylolisthesis is a common spinal disease due to lower back pain, radiation pain of lower limbs and intermittent claudication in elderly people. When conservative treatment has been ineffective, surgical treatment for decompression, reduction, and reconstruction of spinal stability may be required. Pedicle screw fixation is the main technique applied to maintain the stability and biomechanical characteristics of the spine in this disease (1). However, the pedicle screw stability is greatly decreased in osteoporotic cases combined with lumbar spondylolisthesis, which might lead to adverse events such as screw loosening and extraction or even breakage (2, 3) and ultimately lead to failure of bony fusion.

Many researchers have devoted to solving this problem, and cannulated pedicle screw (CPS) augmented by polymethylmethacrylate (PMMA) is recognized as the most effective method developed to date (4, 5).

They have primarily focused on increasing stability by improving the side hole design of the screw (6, 7) and optimization PMMA dosage in surgery (8, 9). Generally, the safety and effectiveness of CPSs have been partially confirmed in previous studies (4, 5). However, the PMMA related complications, arising in clinical application, have drawn more and more attentions from surgeons such as PMMA leakage, allergic reaction, venous or pulmonary embolism, and difficulty in CPSs revision (10–13). Clear guidance should be given for the reasonable application to decrease the risk of these complications. Up to now, there is no consensus on the best application mode for PMMA-augmented CPSs. The CPSs fixation should just meet the requirements for firm fixation while the used quantity should be minimized. In briefly, accurate and reasonable application for CPSs fixation during surgery not only promotes the effectiveness of surgery but also minimizes the risk of complications related to PMMA.

To explore the suitable application mode of PMMA-augmented CPSs, this study may provide a comparison for unilateral or bilateral application of CPSs in lumbar spondylolisthesis with osteoporosis. We retrospectively reviewed the data of 50 consecutive patients treated with CPSs, and summarized the clinical outcomes and imaging findings of PMMA augmentation.

Methods

Patients

Between May 2011 to May 2018, transforaminal lumbar interbody fusion (TLIF) using CPSs for lumbar spondylolisthesis with osteoporosis was performed in consecutive 50 patients, which comprising 12 males and 38 females. Inclusion criteria were as follows: 1. Patient age > 55 years; 2. Single level lumbar spondylolisthesis (X-ray, degree I or II); 3. T-score < -2.5 standard deviation (SD) on dual-energy x-ray absorptiometry (9); and 4. No surgical contraindications. Exclusion criteria were as follows: 1. Allergy to the implant; 2. Normal BMD; 3. Presence of other spine diseases; and 4. Infections, blood system-related diseases, or other surgical contraindications. All of the patients were treated with conservative methods initially, but low back pain gradually progressed with resulting neurological symptoms. None of the patients received medication for osteoporosis by local physicians before surgery.

These enrolled patients were divided into 2 groups according to the application mode of CPSs used in the treatment. Group UC performed TILF with unilateral application of CPSs, consisted of 29 patients (7 males and 22 females), with ages ranging from 57 to 80 years (mean, 71.8 ± 7.7 years). The bone mineral density (BMD) of lumbar spine ranged from − 2.5 to − 4.4 SD, with a mean of -3.62 ± 0.7 SD. According to the Meyerding classification of spondylolysis (14), 19 cases had degree I, and 10 cases had degree II. In contrast, group BC included 21 patients (5 males and 16 females), with their ages ranging from 56 to 82 years (mean, 68.4 ± 8.5 years). T-score of BMD ranged from − 2.5 to − 4.7 SD, with a mean of − 3.3 ± 0.6 SD. 13 cases had degree I, and 10 cases had degree II. General information of patients is presented in Table-1. The study was approved by the Daping Hospital ethics committee (IRB, 2019149). All methods were performed in accordance with the relevant guidelines and regulations. And all patients included in this study gave their informed consent.

Surgical method

TLIF or minimally invasive TLIF was routinely performed. PMMA augmentation was performed in accordance with the surgeon's manual findings during surgery. When the insertional torque during tapping was less than usual (15), unilateral PMMA-augmented CPSs were used, and bilateral PMMA-augmented CPSs were added if screw was not stable enough. Patients in group UC were implant CPSs at unilateral superior and inferior pedicles according to the surgeon's selection in operation, while the other side of pedicles were implanted traditional screws (Fig. 2). CPSs were implant into all of the four pedicles at both sides in group BC (Fig. 3). Specially, laminectomy was needed prior to PMMA injection so that the cement could be removed when PMMA leakage occurred. PMMA powder and water agent were mixed, and then, injected by a special device during a dough-like mass viscosity. The amount of PMMA not more than 2 ml was determined by intraoperative monitoring of intravertebral PMMA dispersion (16). The surrounding tissue of intervertebral disc space was loosened after the injection procedure completed. Slipped vertebrae were reset by CPSs when PMMA cement had completely hardened. A suitable cage was filled with crushed autologous bone for fusion, then rods were installed and nuts were locked. In this study, a new type of PMMA-augmented CPS named bone cement-injectable cannulated pedicle screw (CICPS) was developed by authors for reduction and fixation, a system introduction of which was reported in detail in previous literatures (17–20).

Postoperative management

Patients were routinely treated with antibiotics to prevent surgical site infection in the first 24 hours after surgery. Drainage tubes were removed when the amount of drainage fluid was less than 50 ml. Three days after the surgery, all patients were encouraged to perform rehabilitation exercises by wearing a thoracolumbar brace for 3 months, and anti-osteoporosis treatment should be supplemented as soon as possible after operation.

Radiographic and clinical assessment

Operation time, blood loss, and hospitalization time were recorded to evaluate the basic condition of the surgery. A review was carried out at 3 months, 6 months, 1 year, and every half-year after surgery. Moreover, lumbar X-ray films were obtained to evaluate bony fusion, and screw loosening or pull-out related imaging indicators including intervertebral disc height and screw displacement. Intervertebral disc height was the average distance between the anterior and posterior edges of the vertebral body and the endplates (H1/2 + H2/2, Fig. 1A) (19). The Taillard index were measured to assess the degree of slipping of the vertebral body (L-x2/L-x1, Fig. 1B) (21). Visual Analog Scale (VAS) and Oswestry Disability Index (ODI) scoring systems were used to evaluate pain and functional recovery in lower limbs, respectively. Complications such as wound infection, cerebrospinal fluid leakage, and PMMA leakage were recorded.

Evaluation criteria for spinal fusion on X-ray films (19. 22): (1) Passage of trabecular bone through the bone graft area; (2) Vertebral movement between flexion and extension X-ray film < 3 mm or change in the intervertebral space angle < 5 degrees; and (3) Bone growth through the intervertebral disc space.

The method of measuring the screw displacement: The loosening and displacement of the screws was reflected by the distances from the screw tip to the anterior margin (X) and superior endplate (Y) of the vertebral body (Fig. 1C). A displacement of 1 mm in the screw-bone interface at the final follow-up (X-f, Y-f) compared with the postoperative value (X-p, Y-p) was defined as screw loosening, as described by Moon et al. (23).

All measurements were made by the same orthopedic surgeon with extensive experience in spine surgery. The mean of 3 measurements obtained at different time points, with intervals of half a month in between, was determined to reduce measurement error.

Statistical analysis

SPSS 25.0 statistical software (SPSS, Inc., Chicago, IL USA) was used for analyses. All measurement data were expressed as mean and SD. Pre- and postoperative measurement data were compared using a paired t-test. Statistical analyses between the 2 groups were performed using chi-square test or Fisher's exact test for count data and Student's t-test for measurement data. $P < 0.05$ was considered to indicate a statistically significant difference.

Results

There were no statistically significant differences in general data (age, sex, displaced segment, degree of displacement and bone mineral density) between the 2 groups (Table 1). The follow-up period ranged from 6 to 96 months, with a mean of 29.1 months in group UC and 32.4 in group BC. The operation time (186.1 ± 38.6 minutes) in the UC group was significantly lower than that in the BC group (204.4 ± 27.1 minutes; $P < 0.05$). Blood loss in the UC group (183.0 ± 23.6 ml) was significantly lower than that in the BC group (236.4 ± 50.5 ml; $P < 0.05$). There was no significant difference in the hospitalization time between group UC (5.5 ± 0.5 days) and group BC (5.4 ± 0.7 days; $P > 0.05$). In group UC, 58 of CPSs were implanted in 29 patients, and PMMA leakage during surgery occurred in 4 screws with an incidence of 7.0%. In group BC, 84 of CPSs were implanted in 21 patients, and 10 of PMMA leakage occurred an incidence of 11.9%. In all cases, PMMA leakage into the paravertebral vein and intervertebral disc space during the operation, no serious complications such as nerve injury or pulmonary embolism were observed. Superficial infection was noted in each group, which was under control after an intravenous drip of antibiotics. Cerebrospinal fluid leakage occurred both in group UC (1 case) and group BC (2 cases), which healed completely after the drainage tube removed following two week of bed rest.

Table 1
Baseline characteristics and clinical parameters of the 50 patients with lumbar spondylolisthesis with osteoporosis.

	UC (n = 29)	BC (n = 21)	P
Sex (male: female)	7:22	5:16	0.651
Age (years)	71.8 ± 7.7	68.4 ± 8.5	0.728
Bone mineral density (T-score)	-3.6 ± 0.7	-3.3 ± 0.6	0.873
Surgical segment(L3:L4:L5)	1:15:13	1:9:10	0.635
Degree of displacement (I: II)	19: 10	13: 8	0.921
Operation time (min)*	186.1 ± 38.6	204.4 ± 27.1	0.034
Blood loss (ml)*	183.0 ± 23.6	236.4 ± 50.5	0.045
Hospitalization time (days)	5.5 ± 0.5	5.4 ± 0.7	0.098
Follow-up time (months)	29.1 ± 17.9	32.4 ± 15.7	0.234
Complications			
Superficial infection	1(3.4%)	1(4.8%)	0.387
PMMA leakage/Total quantity of CPSs*	4/58(7.0%)	10/84(11.9%)	0.014
Cerebrospinal fluid leakage*	1(3.4%)	2(9.6%)	0.041
Fusion rate	100%	100%	0.173

Values presented are the mean ± SD.

*Significant if $P < 0.05$.

CPS: cannulated pedicle screw. PMMA: polymethylmethacrylate; UC: unilateral PMMA-augmented CPSs; BC: bilateral PMMA-augmented CPSs

The VAS and ODI score immediately after the operation and at the final follow-up were significantly lower than the respective preoperative readings in both groups ($P < 0.05$). In both groups, VAS and ODI scores at the final follow-up were significantly lower than those immediately after the operation ($P < 0.05$). However, no significant difference was found in either VAS or ODI between the 2 groups at post-operation and final follow-up ($P > 0.05$). The data of patients in both groups are shown in Tables 2–3.

Table 2
Comparison of the VAS between 2 groups preoperatively, immediately after surgery, and at final follow-up.

Group	n	Preoperatively	Immediately after surgery	Final follow-up
UC	29	8.4 ± 1.1	2.5 ± 0.7*	2.2 ± 0.8*, **
BC	21	8.0 ± 0.8	3.0 ± 0.4*	2.8 ± 0.5*, **, ***
Statistics		t = 0.245, P = 0.756	t = 4.253, P = 0.076	t = 1.723, P = 0.546

* P < 0.05 vs. preoperatively values; ** P < 0.05 vs. immediately after surgery values; *** P > 0.05 vs. final follow-up values of UC group. Values presented are the mean ± SD. Significant if P < 0.05.

VAS: visual analog scale; UC: unilateral PMMA-augmented CPSs; BC: bilateral PMMA-augmented CPSs

Table 3
Comparison of the ODI between 2 groups preoperatively, immediately after surgery, and at final follow-up.

Group	n	Preoperatively	Immediately after surgery	Final follow-up
UC	29	51.9 ± 10.4	10.0 ± 6.1*	9.8 ± 0.8*, **
BC	21	54.0 ± 10.9	11.3 ± 0.4*	10.5 ± 0.5*, **, ***
Statistics		t = 0.717, P = 0.395	t = 5.143, P = 0.176	t = 1.003, P = 0.246

* P < 0.05 vs. preoperatively values; ** P > 0.05 vs. immediately after surgery values; *** P > 0.05 vs. final follow-up values of UC group. Values presented are the mean ± SD. Significant if P < 0.05.

ODI: Oswestry Disability Index; UC: unilateral PMMA-augmented CPSs; BC: bilateral PMMA-augmented CPSs

Illustrative cases of group UC and BC are shown in Figs. 2 and 3. The intervertebral disc height and degree of spondylolisthesis (Taillard index) in the 2 groups was significantly restored after operation (P < 0.05). The intervertebral disc height and Taillard index were not statistically significant as time went by, while compared the data at the last follow-up, there was no significant difference of correction loss between the two groups (P = 0.672 and P = 0.289) (Tables 4). In group UC and BC, the displacement distances (X and Y) after operation and at the last follow-up had no significant difference (P > 0.05). The absolute values of the differences in the X (X-f minus X-p) and Y (Y-f minus Y-p) were less than 1 mm for all patients in this 2 groups, which meant that no screw loosening was observed (Table 4).

Table 4.
Radiographic Characteristics in the 2 Groups.

Group	UC (n=29)	BC (n=21)	P	
Intervertebral disc height (mm)				
Preoperatively	9.1±3.9	8.9±2.4	0.046	
Immediately after surgery*	14.1±2.4	13.5±3.6		0.192
Final follow-up*, **	13.5±3.0	12.8±2.5		0.098
Loss of correction	1.4±0.8	1.9±0.9		0.672
Taillard index (%)				
Preoperatively	29.8±10.4	30.5±9.1		0.958
Immediately after surgery*	7.4±6.3	6.8±7.8		0.091
Final follow-up*, **	7.0±5.9	6.5±7.9		0.193
Loss of correction	0.3±0.4	0.3±0.2		0.289
Screw displacement (mm)				
X-p	8.2±4.4	7.4±6.3		0.093
X-f**	8.3±4.7	7.8±4.1		0.321
Y-p	8.5±2.9	8.9±4.7		0.447
Y-f**	8.1±1.8	8.1±5.1		0.632

* P<0.05 vs. preoperatively values; ** P>0.05 vs. immediately after surgery values; Values presented are the mean ± SD. Signifificant if P<0.05.

X: distance between the screw tip and the anterior surface of the vertebral body; Y: distance from the screw tip to the superior endplate of the vertebral body. -p: Immediately after surgery; -f: final follow-up. UC: unilateral PMMA-augmented CPSs; BC: bilateral PMMA-augmented CPSs

Discussion

Lumbar spondylolisthesis with osteoporosis has great requirements for the biomechanical stability of pedicle screws fixation system (11, 24). Studies have shown that CPSs augmented by PMMA to reconstruct the displaced vertebral body and perform bony fusion is still the main surgical method for these patients (19, 20, 24–28). Theoretically, the more CPSs used the greater holding force supplied by the internal fixation. However, overuse of CPSs may increase the risk of complications related to PMMA leakage including allergic reaction, venous or pulmonary embolism, and difficulty in revision. There are very few reports on the accurate and reasonable application guidelines of CPSs to improve the rationality in clinical practice. We reviewed the published literatures and fund that some studies using CPSs in

bilateral sides (25–28), while other studies using in unilateral side partially (17, 19, 20). Therefore, it has great clinically value to explore whether unilateral PMMA-augmented CPSs can provide adequate stability compared with bilateral PMMA augmentation, as well as whether any difference exist in the effectiveness and complications between the two methods.

In this study, a clinical finding was broadly shown. The CPSs augmented by PMMA, unilaterally or bilaterally, could achieve satisfactory improvement of reduction in the postoperative slip degree. This finding could be concluded based on the significant differences in the intervertebral disc height and Taillard index compared preoperative with postoperative in both groups. In the period of follow-up, intervertebral disc height is a key indicator for treatment success. Previous studies have confirmed that reduction can restore physiologic alignment and balance, especially for high-grade spondylolisthesis (29, 30). Furtherly, Chalee-valayer et al (31) and Roussouly et al (32) reported loss of intervertebral disc height is positively correlated with lower back pain. In group UC and BC, the intervertebral disc height was lost in mean value at last follow-up in the present study which was consistent with the literature (27). However, this change is not statistically significant compared to immediately after surgery, and the clinical symptoms of the patients were not aggravated by this loss. The reason for this phenomenon can be explained by physiological progress. Interbody fusion cages are possible to sank after surgery because of osteoporosis. It should be noted that unilateral and bilateral fixation were equally effective in maintaining disc height by comparing the loss of intervertebral space height between group UC and group BC.

Taillard index is another key indicator to evaluate the maintenance of spinal reduction. Floman et al (33) and Goyal et al (34) suggested that displaced vertebral body should be anatomically restored as much as possible for lumbar spondylolisthesis, so as to increase the area of intervertebral fusion. Kim et al (35) and Wang et al (36) reported CPSs had better ability to restored displaced vertebral body than traditional screws. Similarly, our results showed that PMMA-augmented CPSs could avoid vertebral body slipping again, and unilateral and bilateral fixations both showed a long-term maintenance of spinal stability after surgery.

Previous studies revealed that screw loosening rate increased in patients with osteoporosis, which might lead to serious consequences such as screw fracture, non-fusion, and pseudarthrosis (37–40). In this study, no screw loosening was observed. It confirmed by screw displacement less than 1 mm at last follow-up in all cases. However, the incidence of complications related to PMMA will increase with the amount of PMMA used in a single vertebral body. It implies that bilateral PMMA-augmented CPSs has a greater risk of PMMA leakage. In fact, the PMMA-leakage rate of CPSs in various studies had great difference, Angel et al (25) and Wang et al (27) reported the rate was in the range of 29.3–36.1% for bilateral augmentation. In the present study, the rate was 11.9% which was lower than that in the previous studies. The reason might be related to the different designs of CPSs in different studies. However, the leakage rate for unilateral augmentation was 7% in group UC, which was significantly lower than that in bilateral cases. Unilateral CPSs may reduce the risk of PMMA leakage by reducing the amount of PMMA used.

The biomechanical properties changes of vertebral body after surgery have attracted the attention of researchers. Baroud et al (41) and Uppin et al (42) demonstrated that PMMA augmentation increased the fracture risk for the vertebral body or the adjacent ones. No significant fractures were observed during follow-up in the present study, and this could be related to the small number of patients enrolled or the relatively short follow-up period. Some effects of alterations to biomechanical properties are difficult to observe in the short term, although they may occur in the long term.

Singh V et al (43) did a systematic analysis for PMMA-augmented cannulated pedicle screw. Their results summarized from published studies indicated that the average VAS score before operation was 8.4 (range 8-9.2) compared to 2.3 (range 1.42–4.8) at the last follow up. The average improvement ODI for assessment of functional recovery was 42.1. In this study, we had similar results, the VAS and ODI score significantly improved after surgery immediately and at the last follow-up ($P < 0.05$) compared with those before operation in both groups. Additionally, there were significant differences of VAS and ODI scores between immediately after surgery and at the final follow-up more than 6 months ($P < 0.05$). The result indicates that satisfactory mid-term clinical outcomes can be achieved in both groups.

The operation time, blood loss, and cerebrospinal fluid leakage in the UC group were significantly lower than those in the BC group ($P < 0. 05$). These results reveal that unilateral PMMA-augmented CPSs is less invasive and can be performed less time than BC. This is especially important for elderly patients with comorbidities. Because lumbar spondylolisthesis usually occurs in adults older than 50 years, the patients in this study were older and may have had many comorbidities and severe osteoporosis; thus, complex surgical methods could not be tolerated.

This study has the following limitations that should be considered. First of all, the measurement is not accurate for showing the changes at the screw tip. The analysis also can be incorrectly measured and subjected highly to individual variants, which is not tested by different radiologists due to the projection or obliquity of the x-rays view. A CT scan would be much superior in analyzing the evidence of screws loosening to obtain a stronger conclusion. Finally, the study was a retrospective study with defects in study design and the sample size of this study was relatively small, which reduced the credibility of the study.

Conclusions

Both unilateral and bilateral application of CPSs are clinically safe and effective methods used to augment pedicle screws in lumbar spondylolisthesis with osteoporosis. However, unilateral PMMA-augmentation has the advantage of less blood loss, operation time, and complications for elderly patients with comorbidities. This study could provide evidence-based basis for developing the guidelines of the CPS application, especially in lumbar spondylolisthesis with osteoporosis.

Abbreviations

BMD: Bone mineral density

CICPS: Bone cement-injectable cannulated pedicle screw

CPS: Cannulated pedicle screw

CT: Computed tomography

LSD: Least significant difference

MRI: Magnetic resonance imaging

ODI: Oswestry disability index

PMMA: Polymethylmethacrylate

SD: Standard deviation

TLIF: Transforaminal lumbar interbody fusion

VAS: Visual analog scale

Declarations

Ethics approval and consent to participate

The study was approved by the Daping Hospital ethics committee (IRB, 2019149). All methods were performed in accordance with the relevant guidelines and regulations. And all patients included in this study gave their informed consent.

Consent for publication

All data published here are under the consent for publication. Written informed consent was obtained from all individual participants included in the study.

Data availability

The datasets generated and analyzed during the present study are available from the corresponding author on reasonable request.

Conflict of Interest

The authors declare that they have no conflict of interest.

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Author contributions

Yao-yao Liu, Jun Xiao and Fei Dai designed/performed most of the investigation, data analysis and wrote the manuscript; Fei Dai, Peng Liu and Jian-hua Zhao performed the operations; Jun Xiao and Zhong Wang provided imaging assistance; Jun Xiao, Xiang Yin and Ming-yong Liu contributed to interpretation of the data and analyses. All of the authors have read and approved the manuscript.

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Figures

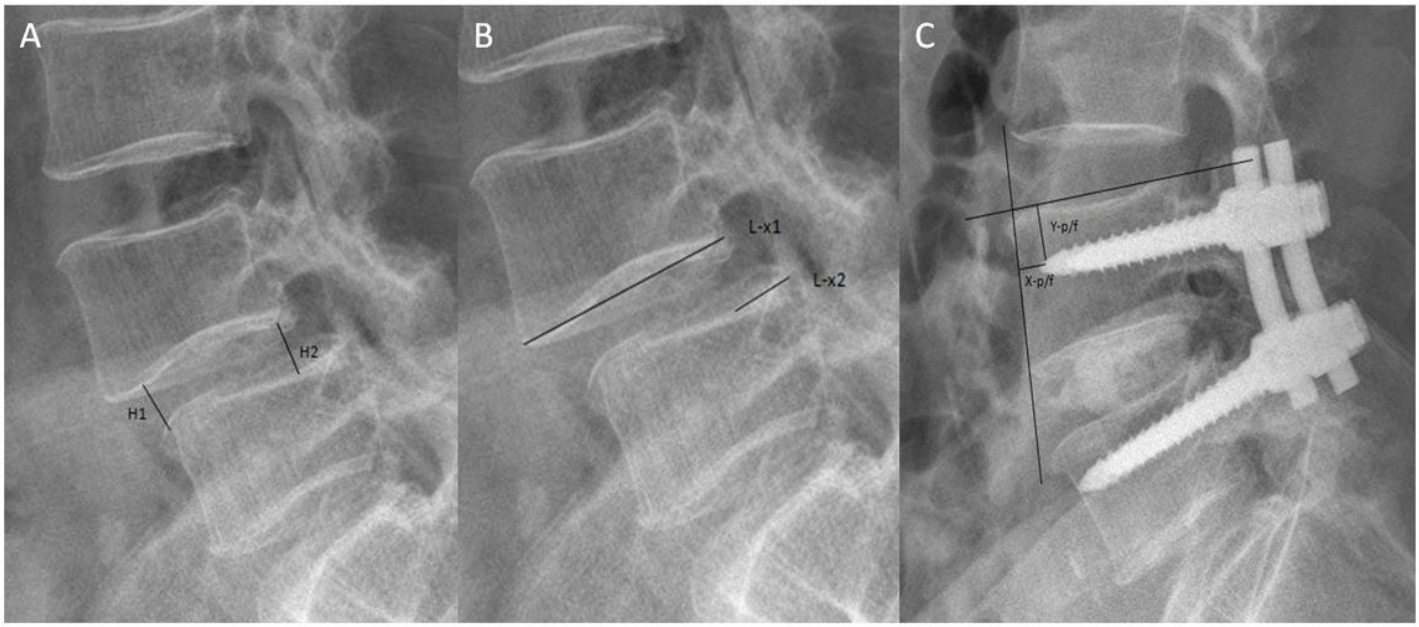

Figure 1

Measurement methods for intervertebral disc height (A, H1/2+H2/2), Taillard index (B, L-x2/L-x1), and screw displacement values (C).

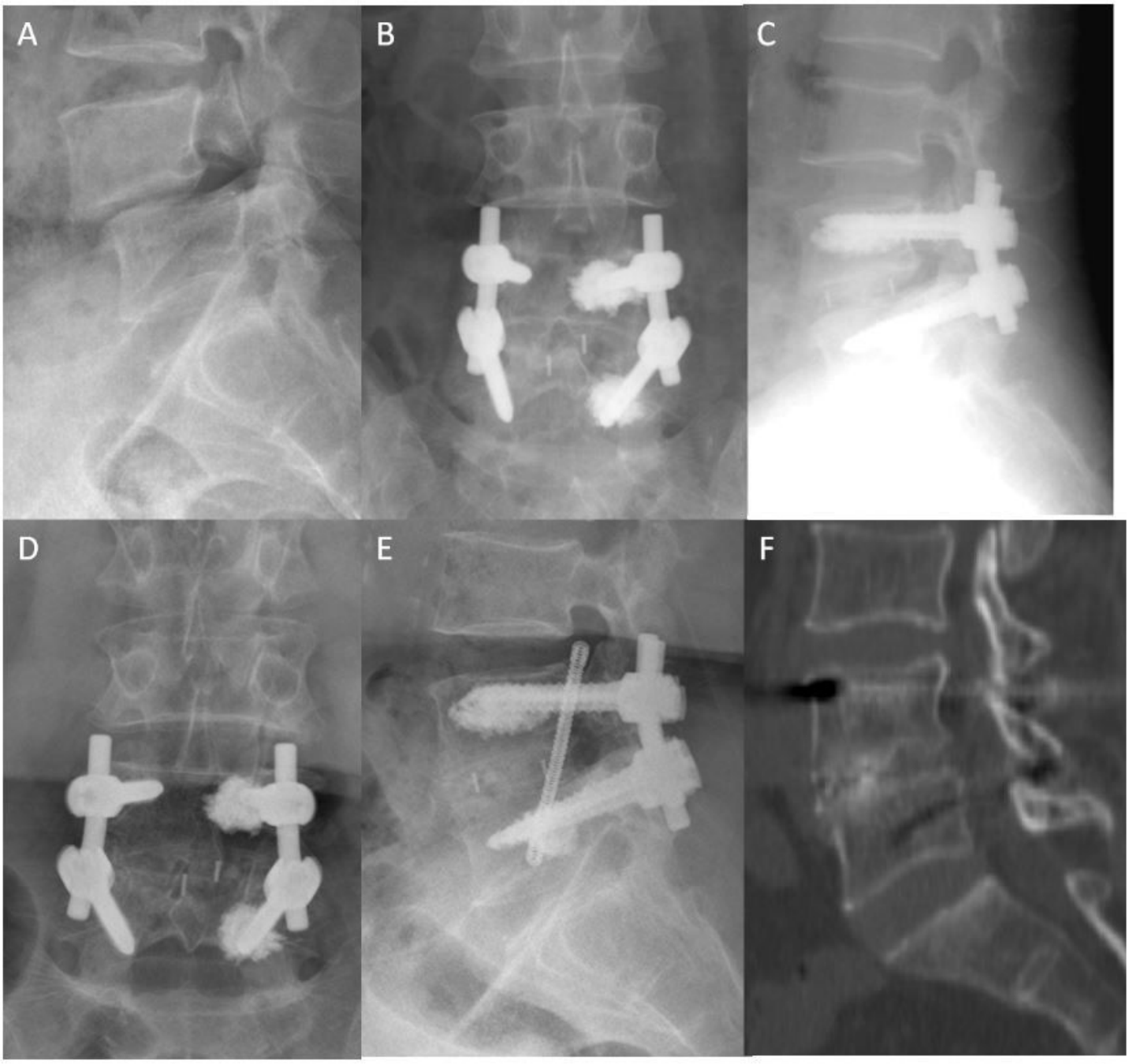

Figure 2

A 65-year-old female diagnosed as spondylolysis at the L4 vertebral body with osteoporosis (T = -3.2). A: Preoperative lateral x-ray showed a grade I lumbar spondylolisthesis. B-C: Unilateral PMMA-augmented CPSs were performed in spinal fixation. Immediately postoperative radiographs showed reconstruction for spondylolisthesis without PMMA leakage. D-E: CPSs was observed in place after 49 months of surgery. F: CT scan showed that bony fusion was achieved.

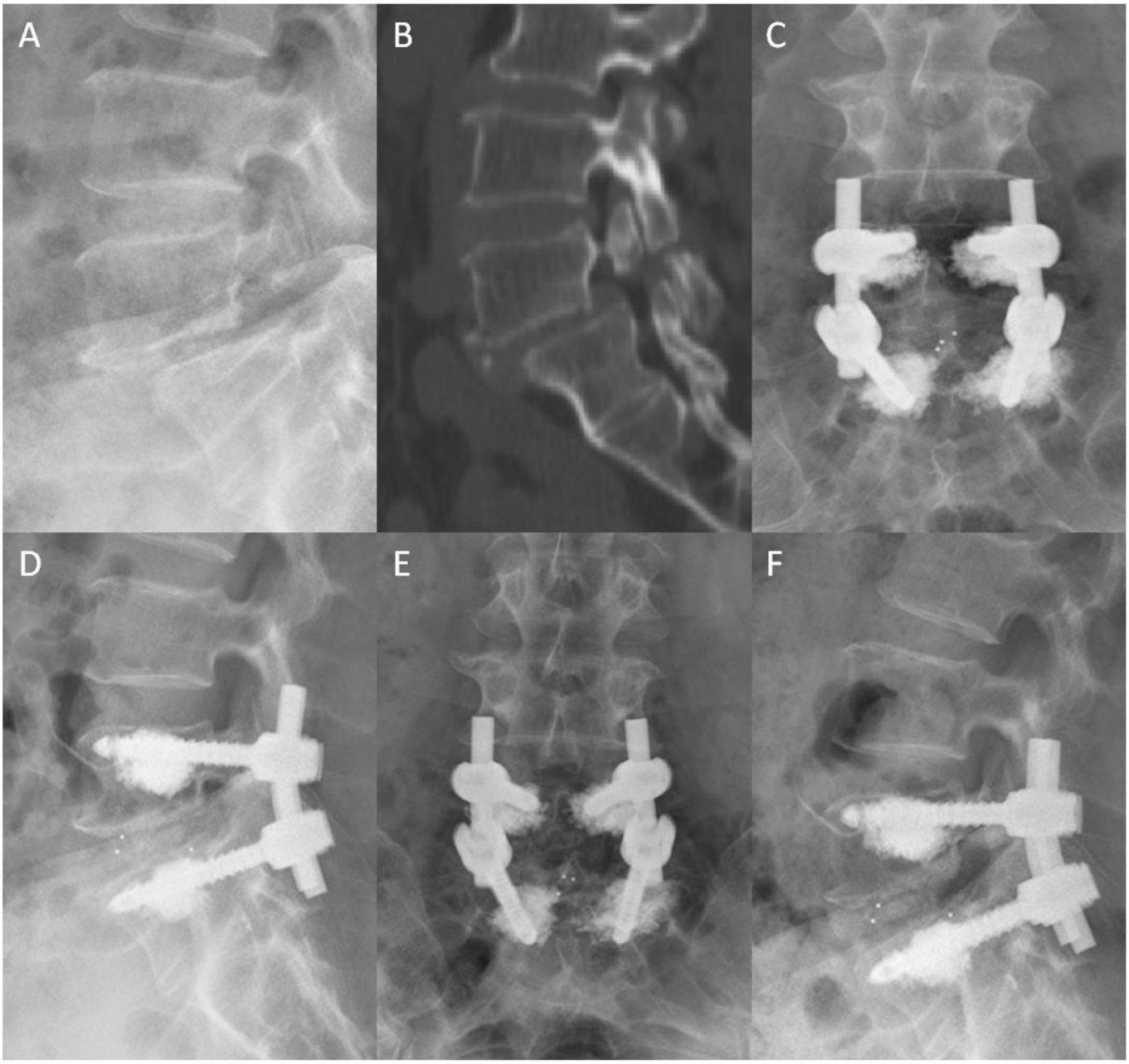

Figure 3

A 72-year-old female diagnosed as lumbar spondylolysis at the L5 vertebral body with osteoporosis (T=-2.8). A-B: Preoperative lateral x-ray and CT scan showed a grade □ ture spondylolisthesis. C-D, Bilateral PMMA-augmented CPSs were performed in spinal fixation. The L5 vertebral body was well corrected, but PMMA leaked into the vertebral vein without any PMMA-related symptoms. E-F, Lateral x-ray and CT scan at the last follow-up showed that no screw loosening occurred, and bony fusion was achieved. Low back pain was ameliorated for this patient.