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Comparative Study - Retrospective Cohort

Oblique lateral interbody fusion combined percutaneous pedicle screw fixation in the surgical treatment of single-segment lumbar tuberculosis: A single-center retrospective comparative study

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ABSTRACT

Objective: To evaluate the clinical efficacy of oblique lateral interbody fusion combined posterior percutaneous pedicle screw fixation in the treatment of single segment lumbar tuberculosis.

Methods: Patients who underwent surgical treatment for single segment lumbar tuberculosis from 2015 to 2018 in our department were retrospectively included in this study. The included patients were divided into two groups, namely oblique lateral interbody fusion combined percutaneous pedicle screw fixation (OLIF) group and traditional posterior transforaminal or transpedicular approach debridement and pedicle screws fixation (PTA) group, according to the surgical methods. Outcomes including operative time, operative blood loss, hospital stay, visual analogue scale (VAS) score, Oswestry disability index (ODI), erythrocyte sedimentation rate (ESR), C reactive protein (CRP), Cobb angle correction and loss, bone fusion time, ASIA grade and complications were all recorded and compared.

Results: A total of 60 patients were included in this study, involving 23 patients in the OLIF group and 37 patients in the PTA group. The OLIF group had less operative time, blood loss and shorter hospital stay compared with the PTA group ($P < 0.05$). Both the two groups achieved significant improvements in ESR, CRP and ASIA grade at the last follow-up ($P < 0.05$), but no significant differences were found between them ($P>0.05$). There were no significant differences in Cobb angle correction and loss between the two groups ($P > 0.05$), but the bone graft fusion time of the OLIF group was significantly shorter than the PTA group ($P < 0.05$). The two groups achieved similar improvement in VAS score and ODI at 12 months postoperative and the last follow-up, however, OLIF group had a lower VAS score and ODI at 1 month, 3 months and 6 months postoperative ($P < 0.05$). No significant difference was found in complications between the two groups ($P > 0.05$) and all patients were cured after active treatment.

Conclusions: Both OLIF and PTA can achieve satisfactory clinical efficacy in the surgical treatment of single segment lumbar TB, but OLIF has the advantages of less surgical trauma, faster postoperative recovery and shorter bone fusion time.

1. Introduction

Spinal tuberculosis (TB) is the most common extra-pulmonary TB, accounting for about 50% of osteoarticular TB [1]. Anti-TB chemotherapy is the cornerstone of the treatment of spinal TB, but surgery plays an important role in patients with spinal instability, progressive nerve injury or severe kyphosis [2]. There are mainly three kinds of surgical methods for spinal TB [3]. Anterior surgery has the advantage of debridement under direct vision, but with large surgical trauma and high risk of vascular or viscera injury [4]. Posterior surgery has good ability of deformity correction and stability reconstruction, but it is a non-direct TB debridement with the risk of bringing TB bacteria from the anterior column to the posterior column [5]. Although anterior combined posterior surgery both has the advantages of radical debridement and strong internal fixation, it is of more surgical traumatic and not conducive to postoperative recovery [6].

Oblique lateral interbody fusion (OLIF) is a minimally invasive technique of lumbar anterior approach. During OLIF surgery, the psoas

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is pushed back to place the operative channel through the space between the aorta and the psoas to reach the target vertebra or intervertebral space [7]. Compared with traditional posterior lumbar fusion surgery, OLIF has been confirmed with better clinical efficacy in the treatment of lumbar degenerative diseases [8,9]. Moreover, we previously treated 7 patients of lumbar polymicrobial spondylodiscitis with OLIF technique and achieved satisfactory efficacy without complications of nerve injury [10]. However, there are no studies to evaluate the clinical efficacy of OLIF in lumbar TB surgery.

Percutaneous pedicle screw fixation (PPSF) is a minimally invasive technique of inserting pedicle screws under X-ray. PPSF does not require the traditional large posterior incision, extensive dissection and traction of the paravertebral muscle, it can reduce the postoperative pain and recovery time [11]. In recent years, PPSF has been widely used in the treatment of spinal degenerative diseases and fracture, and reported with satisfactory results [12,13].

In this study, OLIF combined PPSF was applied to treat single-segment lumbar TB, in an attempt to obtain a satisfactory clinical efficacy using the advantages of the two minimally invasive techniques. The objective of this study was to compare the clinical efficacy of OLIF combined PPSF and traditional posterior approach debridement and pedicle screws fixation in the treatment of single-segment lumbar TB, in order to provide evidence-based medical evidence for the clinical application of OLIF technique.

2. Materials and methods

This study was approved by the Ethics Committee of our hospital. All of the participants provided their written informed consent to participate in this study before their data were stored in the hospital database and used for research purposes. The work has been reported in line with the STROCSS criteria [14].

2.1. Patients selection

Medical records of hospitalized patients diagnosed with spinal TB in our department from 2015 to 2018 were retrospectively analyzed.

Inclusion criteria: (1) Preoperative diagnosis of single-segment lumbar TB (L2-L5) and confirmed by postoperative pathological examination. (2) Age>18 years. (3) The surgical method was OLIF combined PPSF (OLIF group) or traditional posterior transforaminal or transpedicular approach debridement and pedicle screws fixation (PTA group). (4) The follow-up time was more than 12 months. (5) The clinical and imaging data during the follow-up were completed.

Exclusion criteria: (1) Patients with a previous history of spinal surgery. (2) Recurrent spinal TB. (3) Spinal TB with active pulmonary TB or intestinal TB. (4) Patients with severe cardiovascular disease or malignant tumor, etc.

2.2. Preoperative management

All patients underwent X-ray, CT and MRI examination, to evaluate the destruction degree of the vertebral body, narrowing of intervertebral space, cold abscess formation or not and spinal cord compression. The preoperative sagittal Cobb angle was also measured on lateral X-ray. All patients were treated with regular anti-TB chemotherapy before the surgery (rifampicin 450 mg/d, isoniazid 300 mg/d, pyrazinamide 1500 mg/d and ethambutol 750 mg/d) for 2–4 weeks before surgery. Surgery was taken when the symptoms of TB poisoning (such as low fever, night sweats, wasting, etc.) were relieved, the ESR returned to normal or had a significant decrease and the basic diseases such as diabetes, coronary heart disease, hypertension were under control [15]. For patients with neurological defects, early surgery (only 5–7 days of anti-TB chemotherapy) was taken to save neurological function [16].

2.3. Surgical methods

The choice of surgical method was mainly based on the following principles: (1) OLIF group: a) single segmental lumbar TB (L2-L5), and b) preoperative MRI or CT showing an appropriate operative window between the psoas and abdominal aorta [17], and c) the bony destruction was less than 50% of the height of the vertebrae. (2) PTA group: single segmental lumbar TB (L1-S1): a) preoperative MRI or CT showed a narrow operative window between the psoas and abdominal aorta, or b) the bony destruction was exceeding 50% of the height of the vertebrae.

OLIF group: After general anesthesia, the patient was placed in the lateral supine position (on the side with obvious bone destruction). C-arm X-ray was used to identify the operative segments. Then a 4 cm incision was made in the lateral ventral region parallel to the external oblique. The external abdominal oblique, internal abdominal oblique and transverse abdominal muscles were separated layer by layer. After carefully pushing away the extraperitoneal fat with fingers, the anterior margin of psoas was found with Cobb periosteal stripper. Then place an S-shaped retractor to protect the sheath of the abdominal great vessels, push back the psoas with the Cobb periosteum stripper, and place an OLIF right-angle retractor. The lesion intervertebral space was exposed between the vessel sheath and the anterior margin of the psoas and then a positioning needle was inserted. The lesion segment was confirmed by C-arm X-ray. Step by step, different expanders were placed along the probe to expand the channel to 22 mm, and the appropriate retracting baffle was selected to fully expose the operative segments. It was confirmed again that there were no vessels, nerves and other structures in the channel, and the stable nail was placed. The OLIF channel used in this study is OLIF 25 Access (Medtronic, USA). Then, the abscess, granulation tissue, caseous necrotic material and necrotic intervertebral disc were completely removed. According to the measurement of the height of the intervertebral space after the debridement, a polyetheretherketone (PEEK) Cage filled with granular bone was implanted. Then, the drainage tube was placed and the incision was closed layer by layer. Adjust the patient to the prone position and did posterior internal fixation with percutaneous pedicle screw instrumentation. C-arm X-ray confirmed the screws were in a good position. Finally, rinse the wound and close it layer by layer.

PTA group: After general anesthesia, the patient was placed in the prone position with a posterior median approach incision. According to preoperative imaging data, the side with obvious vertebral body destruction was used as the decompression side. Strip the sacrospinous muscle, expose the lamina and articular facet joints of the diseased vertebra and its adjacent vertebra, and then insert the pedicle screw. For the contralateral side, the facet joints were exposed via the Wiltes approach, and pedicle screws were implanted to maintain spinal stability during TB lesion debridement. The inflammatory granulation tissue, necrotic intervertebral disc, dead bone and caseous tissue were completely removed via the transforaminal or transpedicular approach as we described in our previous study [18]. Harvest an iliac bone with three sides of the cortex, prune the size suitable and implant it into the vertebral body or fill the crushed bone block into a suitable titanium mesh and implanted into the vertebral body. The posterior screw system was properly pressurized to correct kyphosis and a C-arm X-ray was used to confirm the kyphosis correction. The surgical wound was rinsed and hemostasis was carefully performed. Hemostatic gauze soaked in streptomycin 1.0 g and isoniazid 300 mg was placed inside the lesion. Drainage tubes were placed in the incision and then the incision was closed layer by layer.

2.4. Postoperative management

Prophylactic use of antibiotics for the first 3 days after surgery. Incision drainage was removed when drainage volume was less than 40 ml/d, and an X-ray examination was checked after extubation. After one week, patients could get out of bed wearing braces and the brace was applied for postoperative 3–6 months. Patients were supervised to continue the anti-TB chemotherapy for 18–24 months after operation by video directly observed therapy (VDOT) [19]. X-ray, ERS, CRP, hepatic and renal function, CT and MRI (if necessary) were followed up to 1,3,6, 12 months postoperatively. The postoperative and follow-up sagittal Cobb angle were measured on the lateral X-ray.

2.5. Outcome indexes

Clinical outcomes: (1) Operative time, operative blood loss and postoperative hospital stay. (2) Erythrocyte sedimentation rate (ESR) and C reactive protein (CRP) were recorded preoperatively and at the last follow-up. (3) Visual analogue scale (VAS) score and Oswestry disability index (ODI) were recorded at 1, 3, 6, 12 months postoperatively and the last follow-up. (4) Neurologic function: ASIA grade was evaluated preoperative and at the last follow-up. (5) Complications were recorded during the follow-up.

Imaging outcomes: (1) Cobb angle: the angle between the upper endplate of the upper vertebral body and the inferior endplate of the inferior vertebral body is defined as the Cobb angle. The Cobb angle of preoperative, postoperative and last follow-up were all measured on the lateral X-ray respectively. (2) Bone graft fusion time: according to the CT scan during the follow-up, the criterion of bone graft fusion reported by Bridwell et al. was used to evaluate whether bone fusion has been achieved [20]. Grade I and Grade II were defined as bone graft fusion in this study.

2.6. Statistical analysis

Quantitative data were represented in mean ± standard deviation (SD). Student t-test and paired *t*-test were used for inter-group and intra-group comparison of quantitative data, respectively. Inter-group comparison of disordered qualitative data was performed by the X^2 test. The Mann-Whitney rank-sum test was used for the comparison of ordered qualitative data. SPSS 19.0 software was used for statistical analysis. $P < 0.05$ was considered to be a significant difference.

3. Results

A total of 60 patients were finally included, including 37 patients in the PTA group and 23 patients in the OLIF group. No significant differences were found in age ($P = 0.304$), gender ($P = 0.500$), body mass index (BMI) ($P = 0.940$) and ASA grade ($P = 0.951$) between the two groups. The OLIF group had less operative time ($P = 0.002$), operative blood loss ($P = 0.027$), posterior fixed segments ($P < 0.001$) and shorter hospital stay ($P = 0.006$) compared with the PTA group. No significant difference was found in the follow-up time between the two groups ($P = 0.963$). (Table 1).

No significant differences were found in preoperative and last follow-up ESR and CRP between OLIF group and PTA group (preoperative: $P = 0.428$ and 0.185, respectively; last follow-up: $P = 0.977$ and 0.877, respectively). At the last follow-up, ESR and CRP were both significantly improved in the two groups when compared with those preoperative ($P < 0.001$ for both the two outcomes). (Fig. 1).

There were no significant differences in preoperative and last follow-up ASIA grade between the two groups ($P = 0.720$ and 0.118, respectively). Compared with preoperative ASIA grade, both the two groups achieved significant improvements at the last follow-up ($P = 0.003$ and 0.004, respectively). (Table 2).

No significant differences were found in preoperative, postoperative and last follow-up Cobb angle between OLIF group and PTA group ($P = 0.398$, 0.854 and 0.962, respectively). Postoperative Cobb angle was significantly corrected in the two groups compared with those preoperative ($P < 0.001$ for both groups), and all had a certain degree of Cobb angle loss during the follow-up ($P < 0.001$ for both groups). There were no significant differences in Cobb angle correction and loss between the two groups ($P = 0.167$ and 0.190, respectively). The bone graft fusion time of OLIF group (7.7 ± 2.7 months) was significantly shorter than PTA group (5.3 ± 0.9 months) ($P < 0.001$). (Fig. 2).

There were no significant differences in VAS score and ODI between the OLIF group and the PTA group at preoperative, 12 months postoperative and last follow-up (VAS score: $p = 0.439$, 0.570 and 0.087, respectively; ODI: $P = 0.380$, 0.332 and 0.265, respectively). However, compared with the PTA group, the OLIF group had a lower VAS score and ODI at 1 month, 3 months and 6 months postoperative (VAS score: $P = 0.001$, 0.038 and 0.006, respectively; ODI: $P = 0.007$, 0.001 and 0.016, respectively). (Fig. 3).

A total of 4 patients had postoperative complications in the OLIF group, including 2 patients of hepatic function damage, 1 patient of renal function damage and 1 patient of abdominal pneumatosis. While 6 patients of postoperative complications were found in the PTA group, including 2 patients of hepatic function damage, 2 patients of renal function damage, 1 patient of sinus tract formation and 1 patient of urinary tract infection. No significant difference was found in the complications rate (16.2% vs 17.4%) between the two groups ($P > 0.05$) and all patients were cured after active treatment.

Table 1
Baseline data and clinical results of included patients.

Items	PTA group (n = 37)	OLIF group (n = 23)	*P*-value
Age (year), *mean ± SD*	45.1 ± 10.6	42.0 ± 12.3	0.304
Gender (n), *Male/Female*	16/21	12/11	0.500
BMI (kg/m^2), *mean ± SD*	21.7 ± 1.9	21.6 ± 2.0	0.940
ASA grade (n)			0.951
I	24	14	
II	10	8	
III	2	1	
Operative time (hour), *mean ± SD*	247.9 ± 59.8	200.0 ± 43.3	0.002
Operative blood loss (ml), *mean ± SD*	605.4 ± 454.9	369.6 ± 260.5	0.027
Posterior fixed segments (n), *mean ± SD*	4.2 ± 1.1	2.5 ± 0.7	<0.001
Hospital stay (day), *mean ± SD*	15.5 ± 6.7	11.2 ± 3.2	0.006
Follow-up time (month), *mean ± SD*	28.3 ± 8.4	28.2 ± 8.9	0.963

4. Typical cases

Typical cases were shown in Figs. 4 and 5.

5. Discussion

The treatment of spinal TB mainly includes anti-TB chemotherapy and surgery. Anti-TB chemotherapy is based around four drugs namely rifampicin, isoniazid, pyrazinamide, and ethambutol, and has been recommended as the mainstay of treatment of spinal TB, which should be taken through the whole treatment process [21]. Spinal deformity, mechanical instability and neurological deficit are the most common indications of spinal TB surgery [2]. Moreover, surgery also can be used for TB abscess decompression or diagnostic biopsy if interventional radiology techniques are not available.

In this study, we did not find larger surgical trauma in the OLIF group, although the OLIF technique operated in a manner similar to the traditional anterior combined posterior approach surgery. On the contrary, we found that PTA had longer operative time and more blood loss than OLIF, which may be owing to the following reasons: (1) At least one side paravertebral muscle needed to peel off in the PTA group, while neither in the OLIF group [10,18]. (2) In the OLIF group, surgeons could directly reach the anterior TB lesion and do debridement under direct vision, while the PTA group TB did not [22,23]. (3) The posterior fixed

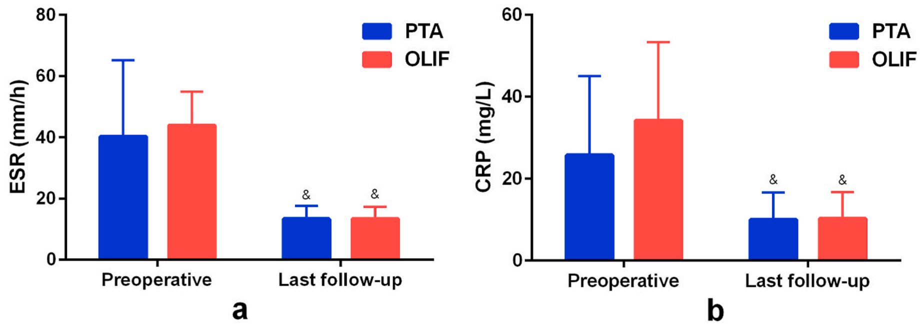


Fig. 1. Comparison of ESR (a) and CRP (b) between the two groups. ($^{\&}$ Compared with preoperative, $P < 0.05$).

Table 2
Comparison of ASIA grade of the two groups.

ASIA grade	PTA group (n = 37)	OLIF group (n = 23)	P-value
Preoperative ASIA grade			0.720
A	0	1	
B	0	0	
C	2	3	
D	9	3	
E	26	16	
Last follow-up ASIA grade[a]			0.118
A	0	0	
B	0	1	
C	0	0	
D	1	2	
E	36	20	

[a] Compared with preoperative, P-values of the two groups were 0.003 and 0.004, respectively.

segment of the PTA group was longer than that of the OLIF group. The hospital stay of the OLIF group was shorter than that of the PTA group, which may also be related to the greater surgical trauma of the PTA group.

At the last follow-up, ESR and CRP of patients in both the OLIF group and the PTA group were significantly reduced compared with those before surgery, and there was no difference between the two groups. We think the possible reasons were as follows: (1) All patients received effective and regular anti-TB drug therapy before and after surgery [24]. (2) Patients in both groups underwent effective and radical TB lesion debridement during surgery [25]. (3) Posterior pedicle screw fixation was performed in both groups, and this reconstruction of spinal local stability contributed to the stabilization and healing of the TB lesion [26].

In our study, no differences in Cobb angle correction and loss were found between the two groups. The possible reasons were as follows: (1) The Cobb angle correction mainly depends on the compression of the posterior internal fixation [27], which was performed in both groups. (2) Although the structure of granular bone is loose, its supporting force will be enhanced when it is filled into a PEEK Cage. (3) Although PTA group had more damage to the local stability of the spine (strip the paraspinal muscle and remove the articular process or pedicle) and might lead Cobb angle loss [28], the posterior fixed segment of PTA group was longer than that of OLIF group, this balance between spinal stability and internal fixation results in no significant difference in the correction and maintenance of Cobb angle between the two groups [26]. (4) Patients in both groups obtained satisfactory bone graft fusion at the last follow-up, and our previous study had concluded that once bone graft fusion was obtained, the Cobb angle loss was very slight [29].

During the follow-up, OLIF group showed shorter bone fusion time than PTA group, and this may be associated with the following reasons: (1) In OLIF group, the anterior column reconstruction was performed by a PEEK cage filling with granular bone, while in PTA group, iliac bone graft or titanium mesh bone graft was used. And our previous study found that the fusion time of granular bone graft was shorter than that of iliac bone graft and titanium mesh bone graft [30]. (2) The PEEK cage used in the OLIF group was larger than that used in the traditional posterior lumbar fusion surgery, the larger bone graft area may be conducive to bone graft fusion [31]. (3) Central ischemia of iliac block and subsidence of titanium mesh may also cause a negative effect on bone graft fusion [32,33].

In our study, the OLIF group showed a lower VAS score and ODI at 1 month, 3 months and 6 months postoperative compared with the PTA group, but no significant differences were found at 12 months postoperative and last follow-up. The possible reasons were as follows: (1) OLIF group had less damage to paraspinal muscles and facet joints [34,35], so in the short term (in 12 months) after surgery, low back pain and lumbar function of OLIF group patients were better than PTA group. (2) One year after the surgery, all patients had reached the state of bone graft fusion, and the paravertebral muscles were also in the recovery stage. The above results also confirmed that OLIF has the advantages of less surgical trauma and faster postoperative recovery compared with PTA. At last follow-up, ASIA grade were both significantly improved in

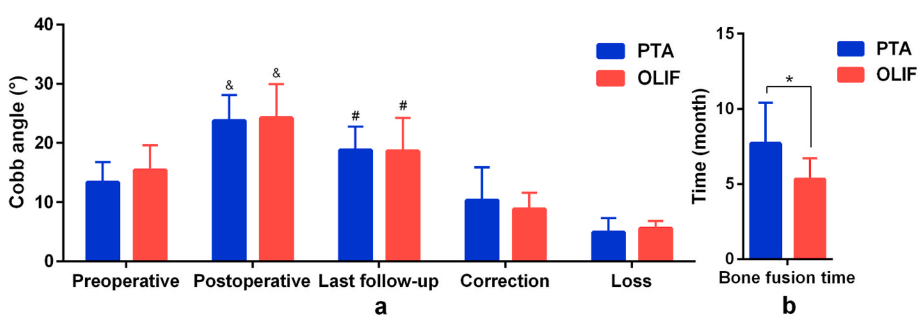
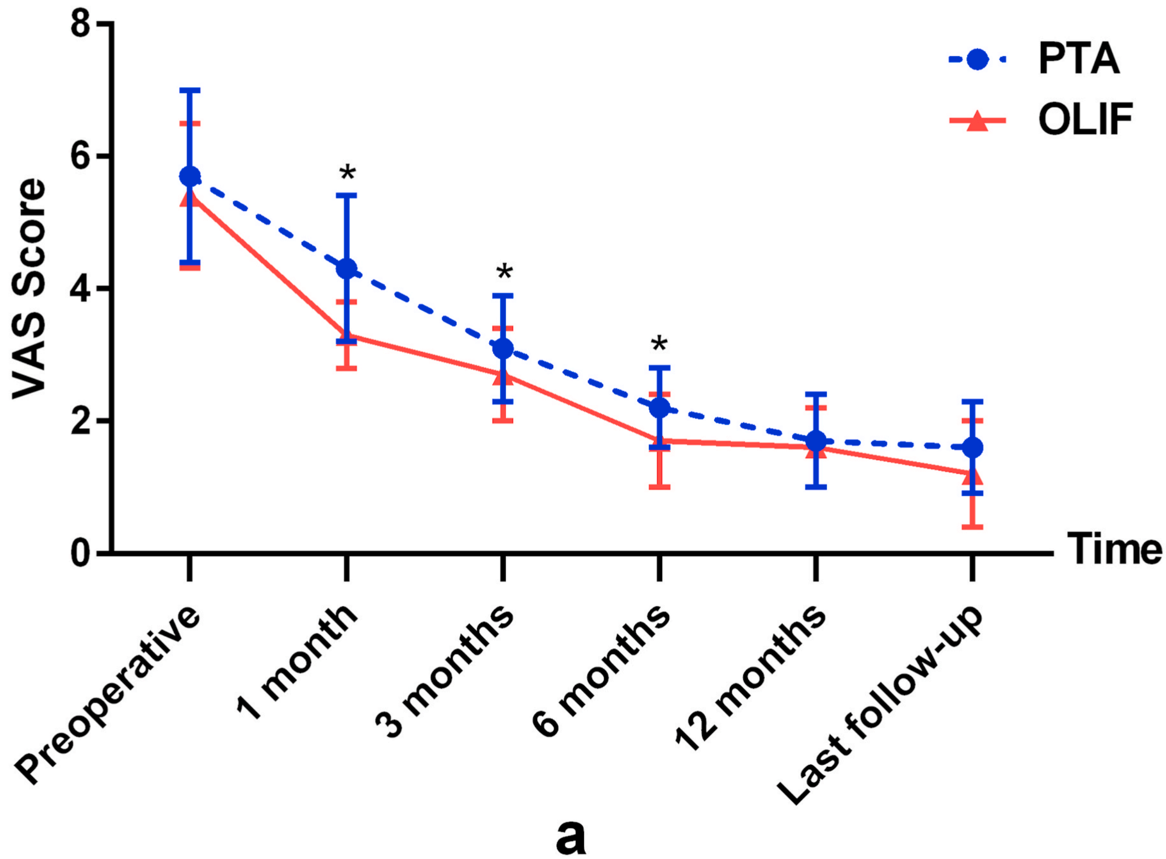


Fig. 2. Comparison of preoperative, postoperative and last follow-up Cobb angle, Cobb angle correction and loss (a) and bone fusion time (b) between the two groups. (*Inter-group comparison,$P < 0.05$; $^{\&}$Compared with preoperative, $P < 0.05$; $^{\#}$Compared with postoperative, $P < 0.05$).



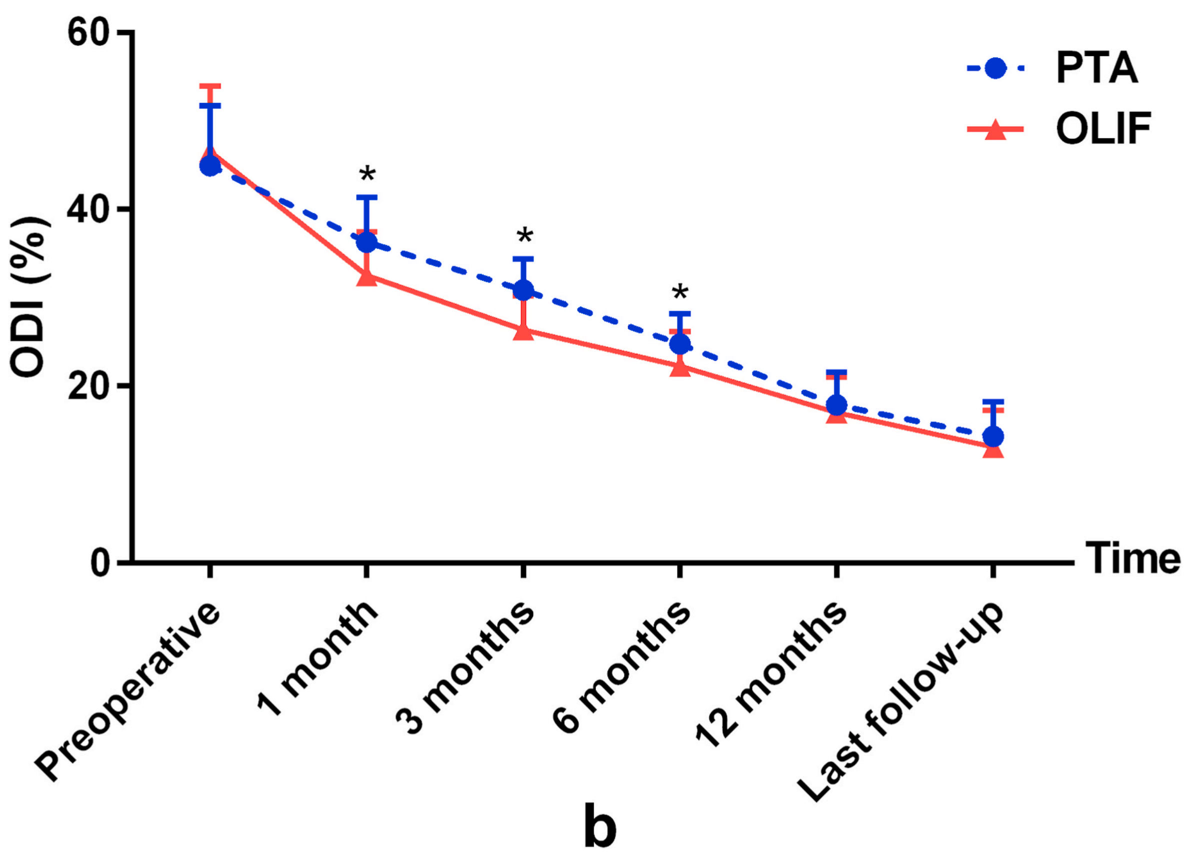


Fig. 3. Comparison of VAS score (a) and ODI (b) between the two groups. (*Inter-group comparison, $P < 0.05$).

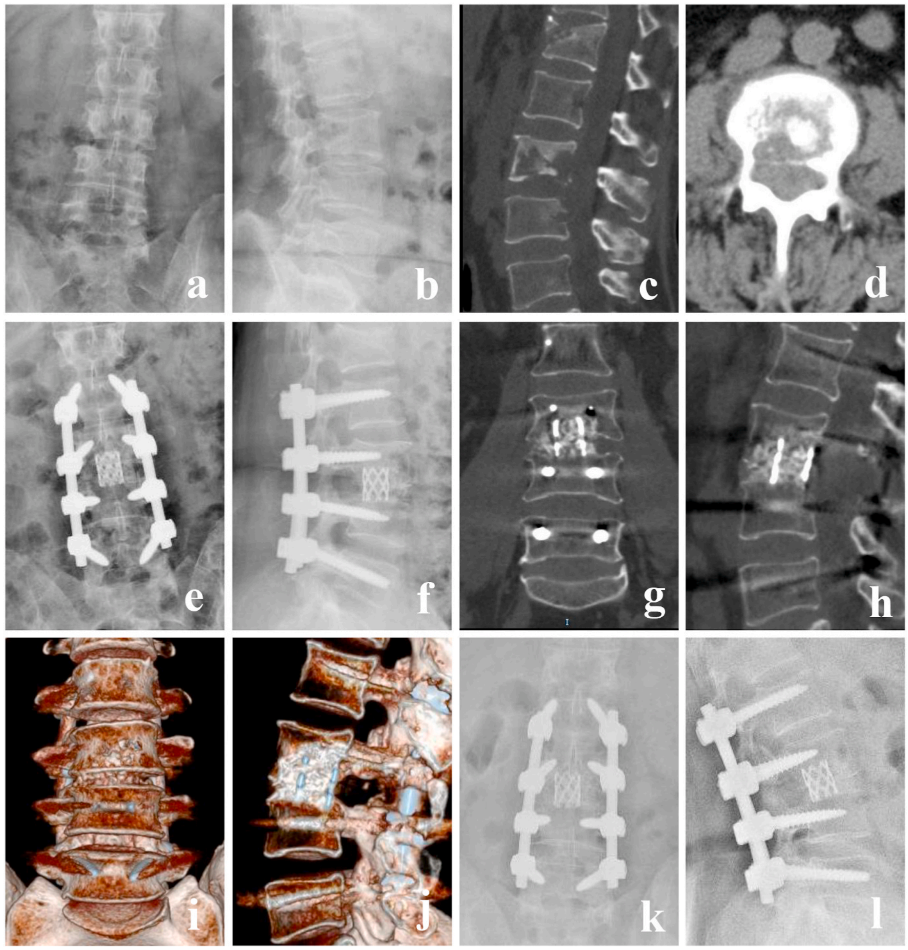


Fig. 4. A 51-year-old female with L3-4 TB in PTA group. (ãd) Preoperative X-ray and CT showed that L3 and L4 vertebra body were destroyed. (e, f) Postoperative X-ray. (g ~ j) CT at 8 months postoperative showed bone fusion between L3 and L4. (k, l) X-ray at 22 months postoperative showed good location of titanium mesh and posterior instrument.

the two groups, this may be due to the effective anti-TB chemotherapy and decompression of the spinal canal [36]. No significant difference was found in complications between the two groups and all complications cases were cured after active treatment, this also indicated the safety of the two surgical methods in the lumbar TB surgery.

We consider that the indications of oblique lateral interbody fusion combined posterior percutaneous pedicle screw fixation for single segment lumbar TB were as follows: (1) Severe back pain with poor response to regular conservative treatment. (2) Progressive aggravation of neurological impairment or paralysis. (3) Progressive exacerbation of local instability or kyphosis. (4) Single segmental lumbar TB (L2-5) with bony destruction not exceeding 50% of the height of the vertebrae and MRI or CT showing an appropriate operative window between the psoas and abdominal aorta. (5) The tuberculosis lesion is mainly in the anterior column and the posterior column was not involved. Moreover, in our experience, OLIF combined PPSF applies not only to lumbar TB, but also to other lumbar instability diseases such as lumbar spondylodisciti [10] and mild lumbar spondylolisthesis (Grade I to II) [37].

This study has some limitations. Firstly, this study is a retrospective study. Secondly, the sample size of this study is small and the follow-up time is short. Thirdly, surgeons may have different experiences in the OLIF technique.

6. Conclusion

Both OLIF and PTA can achieve satisfactory clinical efficacy in the surgical treatment of single segment lumbar TB, but OLIF has the advantages of less surgical trauma, faster postoperative recovery and shorter bone fusion time.

Data statement

I wish to give a statement explaining why I am not linking to or uploading my research data. Data will be made available on request.

Competing financial interests

The author(s) declare no competing financial interests.

Sources of funding

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Provenance and peer review

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CRediT authorship contribution statement

Xing Du: Conceptualization, Data curation, Formal analysis, Methodology, Writing - original draft, Writing - review & editing. **Yun-sheng Ou:** Conceptualization, Methodology, Resources, Supervision, Validation, Writing - review & editing. **Yong Zhu:** Data curation, Formal analysis, Methodology, Resources, Writing - review & editing. **Wei Luo:**

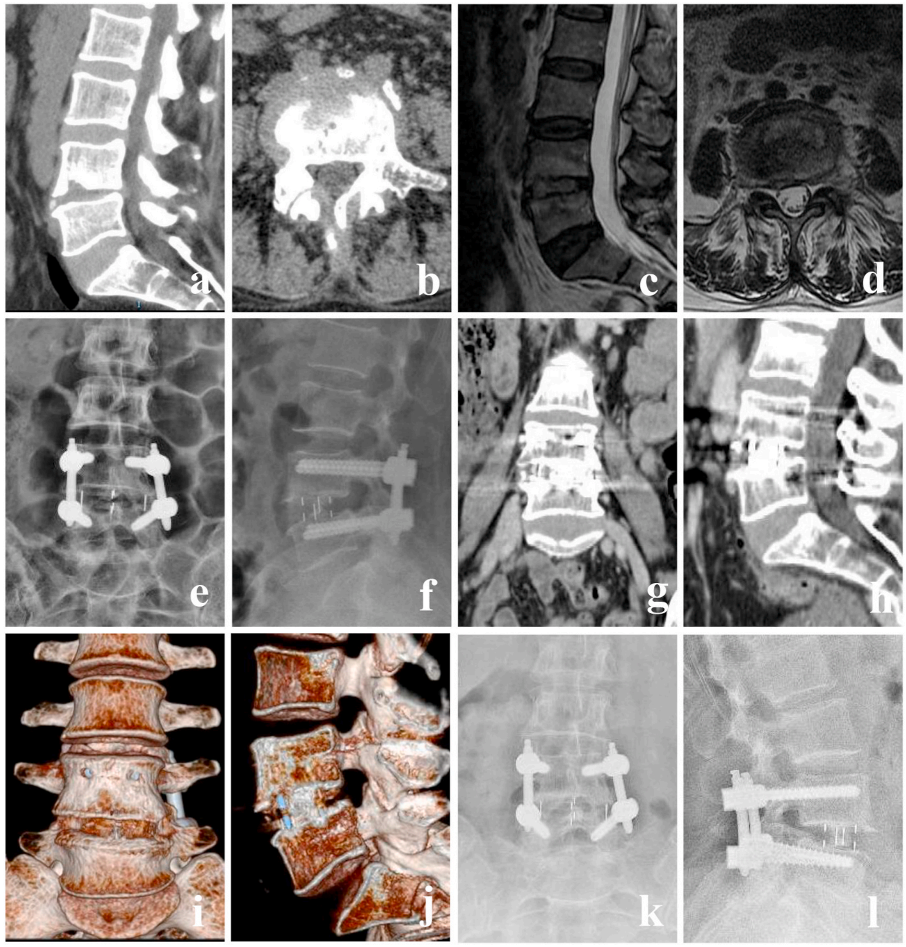

Fig. 5. A 54-year-old female with L4-5 TB in OLIF group. (ãd) Preoperative CT and MRI showed that L4 and L5 vertebra body and the intervertebral disc were destroyed. (e, f) Postoperative X-ray. (g ~ j) CT at 6 months postoperative showed bone fusion between L4 and L5. (k, l) X-ray at 28 months postoperative showed good location of PEEK cage and posterior instrument.

Data curation, Methodology, Resources, Software, Writing - review & editing. **Guan-yin Jiang:** Formal analysis, Software, Writing - review & editing. **Dian-ming Jiang:** Formal analysis, Resources, Software, Writing - review & editing.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijsu.2020.09.012.

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