Int J Clin Exp Med 2019;12(8):9926-9934
www.ijcem.com /ISSN:1940-5901/IJCEM0089223

Original Article

Clinical observation of "mobile window" muscle space approach for treatment of multiple lumbosacral tuberculosis

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Received November 30, 2018; Accepted May 7, 2019; Epub August 15, 2019; Published August 30, 2019

Abstract: Due to the complex anatomy and biomechanics of the affected region, surgical approaches and stabilization methods in patients with lumbosacral tuberculosis remain a clinical challenge. The current study aimed to explore the clinical effects of the "moving window" muscle space approach for debridement and bone grafting, combined with posterior pedicle screw fixation, for treatment of multiple lumbosacral tuberculosis. This study, retrospectively, analyzed a series of 41 patients with multiple lumbosacral tuberculosis, treated by posterior pedicle screw fixation combined with anterior retroperitoneal debridement and bone graft fusion. A total of 25 patients were treated using the anterior "moving window" muscle approach (Modified Group), while 16 patients were treated with the traditional retroperitoneal approach (Traditional Group). All lesions were involved in the L4-S1 segment. There were no significant differences in operation times, bleeding during the operation, hospitalization times, ESR, CRP recovery times, and fusion times between the two groups (P>0.05). The length of abdominal incision in the modified group was 18.08±2.66 cm, significantly better than that in the traditional group. Visual pain scores in the modified group were lower than those in the traditional group at 24 hours. Moreover, 48 hours after the operation, differences were statistically significant. There were no significant differences in visual pain scores at 72 hours after the operation between the two groups (P>0.05). Treatment of multiple lumbosacral tuberculosis with the "moving window" muscle space approach for debridement and bone grafting, combined with posterior pedicle screw fixation, can significantly reduce surgical trauma, gastrointestinal interference, and complications, without increasing operation times and bleeding. Therefore, this method demonstrates clinical operability and practicability.

Keywords: Lumbosacral tuberculosis, modified incision, bone graft fusion

Introduction

Lumbosacral tuberculosis accounts for approximately 10% of all cases of spinal tuberculosis [1]. Due to the complex anatomy and biomechanics of the affected region, surgical approaches and stabilization methods in patients with lumbosacral tuberculosis remain a clinical challenge. In most previous reports, the lateral retroperitoneal approach and transverse longitudinal incisions via an extraperitoneal approach were applied [2]. These incision types often produce unpleasant results, including sever surgical trauma for the abdominal muscles, more bleeding, disturbance for gastrointestinal function, and higher incidence of incisional hernias [3]. In addition, there have been few studies concerning anterior approach incisions for patients with multiple lumbosacral tuberculosis in the lower lumbar and sacral vertebra. Achievement of simultaneous exposure of the lumbar and sacral vertebra with minimal invasion remains unresolved. In recent years, patients have been treated with multiple lumbosacral tuberculosis with inverted L-shape incisions. Using this method, the lumbar and sacral tuberculosis could be exposed with a "moving window" in different intermuscular spaces.

The current retrospective study analyzed a series of 41 patients with L3-S2 multiple lumbosacral tuberculosis, treated by posterior pedicle screw fixation combined with an anterior retroperitoneal approach for debridement and bone grafting. Patients were treated from Jan-

Table 1. Preoperative general information of patients

	Modified Group	Traditional Group	Test Value	*P* Value
Cases (n)	25	16		
Gender (m/f)	15/10	11/5	χ^2=0.044	0.834
Age (y)	44.20±15.63	44.00±15.99	*t*=0.040	0.969
ESR before therapy (mm/h)	54.60±12.28	52.19±10.93	*t*=0.640	0.526
CRP before therapy (mg/l)	39.14±21.15	34.15±16.13	*t*=0.805	0.426
Follow-up duration (m)	39.20±11.32	42.50±9.43	*t*=0.040	0.338
Preoperative VAS grade	3.44±1.044	3.375±0.885	*t=0.206*	0.838

uary 2009 to October 2016. A total of 25 patients were treated with the "mobile window" muscle space approach (Modified Group), while 19 patients were treated with the traditional lateral retroperitoneal approach (Traditional Group). The present study aimed to explore safety and feasibility levels of modified inverted L-shape incisions via an extraperitoneal approach, as well as relative surgery matters and operation points.

Materials and methods

Inclusion and exclusion criteria

Inclusion criteria: Corresponding to diagnosis standards of spinal tuberculosis and surgical indications; Multiple lumbosacral tuberculosis, involving L4-5 and L5-S1 segments; Received treatment via lumbar posterior fixation, combined with anterior debridement in Zhejiang Chinese Medicine and Western Medicine Integrated Hospital/Hangzhou Red Cross Hospital; Aged from 18-70 years old; Provided informed consent and were compliant to treatment; Follow-up times were more than 24 months.

Exclusion criteria: Tuberculosis involving upper lumbar spinal and skip multiple lumbosacral tuberculosis; Combined with immune system diseases and other related complications; Drug resistant tuberculosis and the effectiveness of anti-TB therapy was undefined; History of abdominal operations and increased difficulty of the extraperitoneal operation; Insufficient information and lost to follow-up.

General information

According to inclusion and exclusion criteria, this retrospective study analyzed a series of 41 patients with multiple lumbosacral tuberculosis, hospitalized in the Orthopedics Department of Hangzhou Red Cross Hospital, from January 2009 to October 2016. There were 26 males and 15 females, with an average age age of 44±15.99 years old (range 19-72 years). Lesions involved L_4-S_1 in 30 cases, L_3-S_2 in 6 cases, and L_3-L_1 in 5 cases. Bone lesions were all involved in L_4-S_1 segments. All patients had symptoms of lumbosacral pain and difficulty bending. A total of 13 cases were complicated with nerve root symptoms, while 6 cases showed caudal equine symptoms. Neurological function assessed using the Frankel scoring system. Results showed that 23 patients were grade E, 13 patients were grade D, and 5 patients were grade C. All patients were followed up for 24-70 months, with an average of 40.49±10.63 months.

According to different incisions of the anterior approach, the patients were divided into the "mobile window" muscle space approach (Modified Group) and traditional lateral retroperitoneal incision group (Traditional Group). Preoperative general information concerning patients is shown in **Table 1**.

Therapeutic methods

Supportive anti-TB therapy before surgery: Preoperative routine examinations were performed. Malnutrition, such as anemia and hypoproteinemia, was corrected. Patients without operative indications received Rifampician (0.45-0.6 g/d), Isoniazid (0.3 g/d), Ethambutol (0.75 mg/d), and Pyrazinamide (1.5 g/d), as a standardized and effective anti-TB therapy. Therapy was sustained for 3-4 weeks. Surgical treatment was advised when general conditions were improved and the erythrocyte sedimentation rate, as well as the CRP index, steady declined. Patients with huge cold abscesses also received surgery when toxic symptoms improved after anti-TB therapy, although decreases in erythrocyte sedimentation rates (ESR) were not obvious.

Surgical procedure: Patients in the two groups were treated with posterior-anterior approach surgery. The posterior approach was performed under general anesthesia. Fixed segments

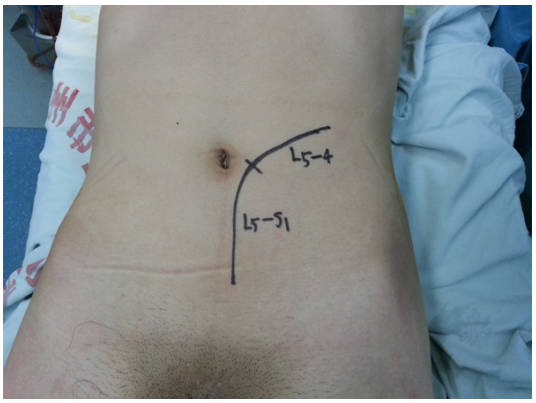

Figure 1. Preoperative localization of skin incision.

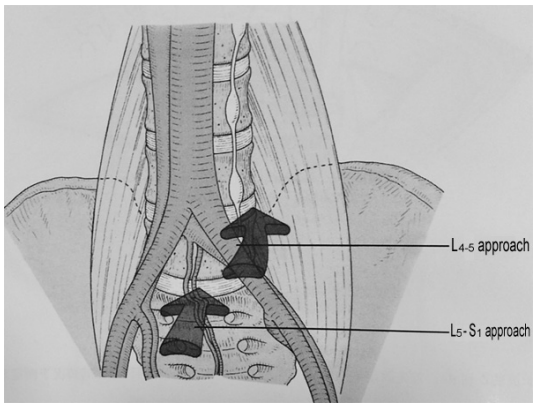

Figure 2. Distribution of blood vessels before the vertebral body and the schematic diagram of the exposure approach.

were selected according to the lesion segment, completing lumbosacral pedicle screw placement, lesion segment fixation, and spinal orthotics. The vertebral body and vertebral numbers for pedicle screw fixation were decided by the destruction of tuberculosis lesions. Fixed segments are better when they are short rather than long. If the L4 vertebral body was destroyed to an extent that it was difficult to place the screw, then the L3 vertebral body was chosen. However, screw placement on the lesion vertebral body cannot be ignored [4]. Sacral vertebrae were fixed by screw placement via inward or outward tilting. Iliac screw placement was selected when the destruction of the sacral vertebrae was severe. Additionally, facetectomies and fusion of the facet joints in L4-5 and L5-S1 were performed.

Modified group: Patients were placed in the supine position after posterior transpedicular screw system internal fixation was completed. A median longitudinal straight incision, about 8-10 cm, was made through the abdominal skin below the umbilicus. The skin and fascia were dissected to expose the linea alba. The anterior rectus sheath was dissected about 0.5 cm to the left side of the linea alba (partial retention of the rectus sheath for suturing *in situ*) to expose the rectus abdominis. Next, there was a dissection along the side of the inner edge of the rectus abdominis, exposing the posterior rectus sheath and dissect, including the posterior rectus sheath in the arcuate line, exposing the peritoneum. If the peritoneum was damaged in the process of extraperitoneal separation, it was repaired in time. The parietal peritoneum was bluntly dissected to anterior psoas major muscles in the posterior peritoneum. The peritoneum and its contents were slightly pushed inward to expose the L5 and S1 pyramid, abdominal aorta, and vena, internal, and external iliac arteries and veins, as well as its bifurcations. The vascular wall of arteria ilica communis was thick and separated easily, while the vascular wall of venae iliaca communis was thin, especially when located against the left side of the L5 pyramid. The location of venae iliaca communis was lower, compared to the arteria ilica communis, and descended clinging to L5 pyramid. The tuberculous focus was accompanied with angiosynizesis, therefore, it needed to protect the venae iliaca communis from traction injury. After exposure of the L5-S1 interval, an L-shaped incision was made by extending the longitudinal incision towards the left, about 6-8 cm (**Figure 1**). Under the same incision and "mobile window", along the muscle fiber in the outer edge of rectus abdominis, the obliquus external abdominis, obliquus internal abdominis, and transversus abdominis muscles were bluntly dissected to the front-left of the L4-5 pyramid from the left side of abdominal aorta and above venae ilica communis. It then dissected the prevertebral fascia and properly pushed aside the abdominal aorta and venae ilica communis. Finally, effective exposure of L4-5 and lumbosacral vertebrae under "moving windows" in different intermuscular space was completed through the same incision (**Figures 2**, **3**). Debridement of multiple lumbosacral tuberculosis in L4-5 and L5-S1 was then conducted, along with bone grafting.

Traditional Group: Patients were placed in the lateral position after posterior transpedicular

Figure 3. Schematic diagram of the focus exposure during the operation.

screw system internal fixation was completed. A traditional lateral retroperitoneal incision, about 20-25 cm, was made. The skin and subcutaneous tissue were cut open and dissected off the muscle fibers of obliquus external abdominis, obliquus internal abdominis, and transversus abdominis muscles. After exposure of the peritoneum, the posterior peritoneum was separated inward. The posterior peritoneum and intestinal canal were pushed aside. A traditional S-shaped retractor was used during surgery, exposing the psoas major muscle. It was then bluntly longitudinal dissected along the muscle fibers to expose the vertebrae. Debridement was then performed. According to patient body types and exposure of focus, incisions could be properly extended toward both ends during surgery.

After debridement and bone grafting, the two groups received repetitious irrigating with PVP-iodophors and normal saline. The bone graft bed was established with autologous cortical iliac bone or artificial bone, completing the bone grafting. C-arm X-ray equipment was used to confirm that the location of bone grafting was good. Next, the wounds were washed and bleeding was stopped. Finally, streptomycin powder (2.0 g) and isoniazide injections (1.2 g)

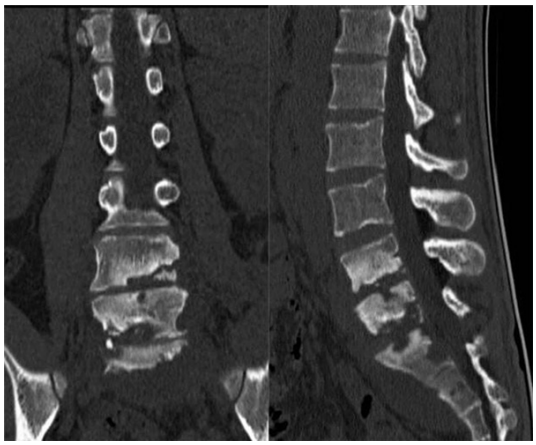

Figure 4. Preoperative CT reconstruction of lumbar vertebra.

were locally administered. A drainage tube was also inserted. The sheath of the rectus and the incision were sutured layer by layer.

Postoperative management: After surgery, patients were routinely administrated antibiotics for 1 week. They were fasted routinely at early stages, then switched to a liquid diet after passage of gas through the anus. The drainage tube was removed when the volume was less than 20 mL/h. Strict bed rest was recommended for 3-4 weeks. Afterward, patients were encouraged to walk with the effective support of braces. After surgery, patients resumed treatment with oral anti-TB drugs (Rifampician 0.45-0.6 g/d, Isoniazid 0.3 g/d, Ethambutol 0.75 mg/d, Pyrazinamide 1.5 g/d). Pyrazinamide was stopped 3-6 months after surgery, according to ESR and CRP. Regular triple anti-tuberculosis medicine was continued for 18 months, accompanied with liver protection drugs.

Surgical evaluation and recorded data: Operation duration times, blood loss of the anterior approach, suture length of incisions, and drainage volume of anterior approach incisions were recorded. After surgery, all patients routinely wore electronic analgesia. VAS pain scores, before surgery and 24/48/72 hours after surgery, were recorded. The time of first passage of gas by the anus was recorded, evaluating the recovery of gastrointestinal function. Regular checks of blood routine examinations, hepatorenal function, erythrocyte sedimentation rates (ESR), and C-reactive protein after the operation were performed (**Figures 4**-**6**). X-rays and CTs were repeated every three months, while MRIs of lumbar vertebra were repeated every

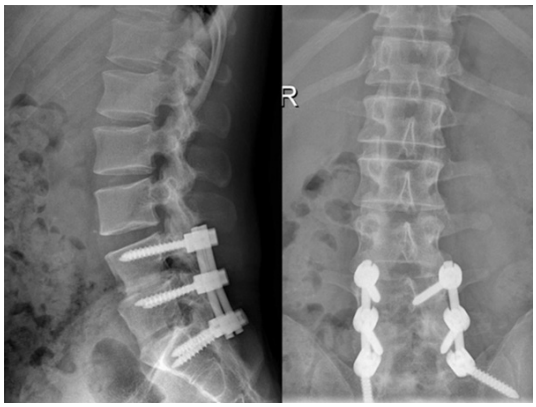

Figure 5. X-ray radiography of the lumbar vertebra 18 months postoperatively.

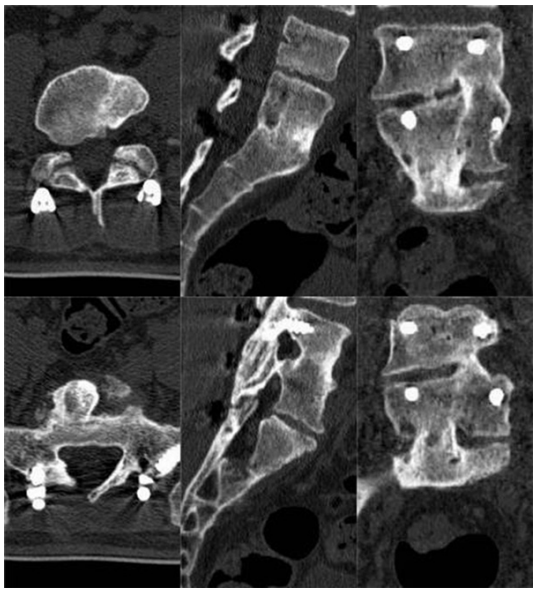

Figure 6. CT reconstruction 18 months postoperatively.

six months. Follow-ups were performed every three months for the first 18 months after the operation. Afterward, follow-ups were performed once a year, up to the final follow-up. Evaluation of ESR and C-reactive protein was conducted for all patients before anti-TB therapy, before the operation, 1 month after the operation, and at last follow-up. Bone grafting was followed up at 3 months, 6 months, and 12 months after the operation [5]. Length of hospital stays was recorded and compared between the two groups of patients.

Statistical analysis

Data was analyzed with SPSS 19.0. Peri operative blood loss, incision lengths, operative duration times, time of passage of gas by the anus, length of hospital stays after the operation, and other measurement data are reported as mean ± SEM ($\bar{x}$ ± s). Comparisons between the two groups were analyzed by t-tests. Enumeration data was compared with χ^2 tests. *P* values <0.05 indicate statistical significance.

Results

General information

The mean follow-up time of modified group patients was 39.20±11.32 months, while that of traditional incision group patients was 42.50±9.43 months. No injuries to large blood vessels, nerves, ureters, or iatrogenic spinal cords occurred. All incisions were primarily healed and all lumbosacral pain symptoms were improved. One patient from the traditional group developed iliac sinuses in the 10 weeks after the operation. This patient was considered to have developed an iliac abscess after further examination. The patient was finally cured after a second operation for catheter drainage. The screw system did not show breakage and grafting bone did not become loos, according to final follow-up data. All patients became free of spinal tuberculosis without relapse.

Intraoperative conditions

There were no significant differences in intraoperative blood loss between the two groups (P>0.05). The anterior approach operative duration of the modified group was longer than the traditional group. This was due to smaller incisions. However, there were no significant differences (P>0.05). Incision lengths of the modified group patients were significantly shorter, compared to traditional group patients (P<0.05, as shown in **Table 2**).

Postoperative conditions

Comparisons of the first passage of gas by the anus, VAS scores, and post-operative hospital stay durations between two groups are shown in **Table 3**. The first passage of gas by the anus for modified group patients was significantly earlier than that in traditional group patients (P<0.05). There were no significant differences in pre-operative VAS scores between the two groups (P>0.05, as shown as **Table 1**). However, at post-operative 24 and 48 hours, VAS scores of modified group patients were significantly lower than those in traditional group

Table 2. Operative duration, incision length, and intraoperative blood loss (n=41)

Group	Patients (n)	Incision length (cm)	Anterior surgery duration(min)	Blood loss (ml)
Traditional Group	19	29.56±2.48	297.50±39.07	521.25±162.55
Modified Group	25	18.08±2.66	313.2047.85	547.60±199.06
T Value		13.843	1.098	0.443
P Value		<0.001	0.279	0.660

Table 3. First passage of gas by the anus, VAS scores, and post-operative hospital stays

Group	Patients (n)	VAS Score			The first passage of gas by anus (h)	Postoperative hospital day (d)
		24 h	48 h	72 h		
Traditional Group	16	6.69±1.25	5.88±1.03	4.69±0.70	43.50±5.23	15.47±4.91
Modified Group	25	5.84±1.18	4.68±0.90	4.32±0.80	35.80±4.94	13.56±2.42
t Value		0.219	3.929	1.499	4.759	1.646
p Value		0.034	<0.001	0.147	<0.001	0.108

Table 4. Pre- and post-operative ESR and C-reactive protein

Group	Patients (n)	Postoperative ESR recovery time	Postoperative CRP recovery time	Bone graft fusion number (n)		
				Postoperative 3 months	Postoperative 6 months	Postoperative 12 months
Traditional Group	16	5.38±1.09	5.94±1.18	8	15	16
Modified Group	25	5.68±1.82	6.08±1.68	13	23	25
T Value		*t*=0.603	*t*=0.295	0.015	0.043	-
P Value		0.55	0.77	0.905	0.836	-

patients (P<0.05). Moreover, post-operative hospital stay durations were significantly shorter for the modified group, compared to the traditional group (P<0.05).

Evaluation of tuberculosis outcomes and bone graft fusions

Patients in the two groups experienced relief from the toxic symptoms of tuberculosis, including low-grade fevers, weakness, and night sweats at 3-6 months post-operative. According to criterion of curing tuberculosis [6], the cure rate was 100% in the two groups until the final follow-up. There were no significant differences in ESR and C-reactive protein between the two groups (P>0.05). According to CT three-dimensional reconstruction, trabecular bone bridges were formed by bone graft fusion. Bone graft fusion was achieved in all cases, according to the last follow-up. There were no significant differences in fusion rates between the two groups (P>0.05). No loosening or breaking of the nail-rod system occurred. Moreover, no bone graft displacement occurred in the patients (**Table 4**).

Discussion

Selection of surgical methods for lumbosacral tuberculosis

The purpose of surgical treatment of spinal tuberculosis is to clear the focus, reconstruct the stability of the spine, and correct deformities. Main surgical methods for spinal tuberculosis include the simple posterior approach, simple anterior approach, and combined anterior-posterior approach. Trauma for the simple posterior approach is less, but bone destruction is severe. It is difficult to remove the psoas abscess [7, 8]. Therefore, debridement is not always thorough and recurrence is easy [9]. The simple anterior approach can effectively remove lesions and abscesses in front of the spine. However, because of occlusion of the sacral lordosis and iliac bone, there is no mature fixation device for the lumbosacral anterior approach. When vertebral destruction is more than two, kyphosis deformities and obvious sliding of the vertebral body occurs. Thus, the simple anterior approach cannot provide enough strength for correction and stability. Bone grafting often

causes fractures, shifts, and absorbance, resulting in failure of the operation [10].

For patients with severe lumbosacral tuberculosis, most are subjected to posterior pedicle screw internal fixation combined with anterior debridement and bone grafting [11]. Major indications for lumbosacral tuberculosis posterior-anterior combined surgery include: (1) The anterior and middle column of lumbosacral tuberculosis are badly damaged. Simple posterior fixation cannot completely reconstruct the stability of the spine; (2) With large psoas abscesses, the simple anterior approach cannot remove lesions completely; (3) Nerve function is damaged. MRI examinations suggest that compression of the dura sac is obvious.

Advantages of the modified "mobile window" muscle space approach for treatment of multiple lumbosacral tuberculosis

Regarding treatment of lumbar tuberculosis, lateral retroperitoneal approach incisions have been adopted for the anterior approach, exposing the focus by dividing abdominal wall muscles and cutting open psoas major muscles. In the treatment of lumbosacral tuberculosis, middle incisions at the interior edge of the rectus abdominal muscle have been adopted to expose the focus for debridement and bone grafting [12-14]. This incision is good for exposure of lumbosacral vertebrae below L5, but difficult for multiple lumbosacral tuberculosis patients accompanied with L5 damage and tuberculosis above L5. Therefore, there are no good clinical solutions exposing the multiple lumbosacral tuberculosis at the same time under the same incision.

The current study adopted the "mobile window" muscle space approach, which modified the inverted L-shaped incision. This method provided good exposure for multiple lumbosacral tuberculosis at the same time and under the same incision via moving windows for different intermuscular space approach. For exposure of L5-S1 space, the median abdominal extraperitoneal approach was adopted. This method exposed the space by cutting open the sheath of rectus abdominis and pushing away the peritoneum. For exposure of the vertebral body above the L5 upper hemivertebra, the obliquus external abdominis, obliquus internal abdominis, and transversus abdominis muscles were bluntly dissected along the muscle fiber in the outer edge of rectus abdominis. This was by modified incisions and lengthening the median incision with proper arc, completing the exposure of the intermuscular interspace approach to the multiple lumbosacral tuberculosis.

Patients in the modified group with tuberculosis involved 3 vertebrae and two segments from the L4 to S1. Advantages of this operative method are: ① The incision is small enough to avoid cutting off the abdominal muscle tissue. There are no harmful effects on the abdominal cavity. It reduces incidence of abdominal symptoms after the operation, providing a quick recovery; ② The incision reduces the operation risk and exposes the L4-5 and L5-S1 above and below the common iliac blood vessels, separately. Debridement and bone grafting are conducted, reducing the risk of vascular traction injury; ③ This operation is convenient and curative effects are reliable. Since the focus is removed from two windows, the visual field is clear. Thus, clearing of the focus is clean and thorough. Preparation of the bone grafting bed is thorough, the bone graft is reliable, and the stability of the anterior column is rebuilt. Thus, it is beneficial for anti-tuberculosis treatment and fusion of the vertebral body after the operation [15, 16].

Key points and attention points in the operation using the "mobile window" muscle space approach

It is feasible and practical to use the modified inverted L incision extraperitoneal approach for treatment of multiple lumbosacral tuberculosis. Compared with the traditional approach, it has the advantages of less surgical trauma, clear anatomy, less postoperative complications, and high safety. However, in clinical practice, it needs attention. There are abscesses and adhesions in tuberculosis focus and anatomy that are not clear enough. The macrovascular is always immersed in tuberculosis abscesses and blood vessel elasticity is poor. Moreover, this operation method needs to simultaneously complete debridement and bone grafting for multiple focus in the same incision. When passing obliquely across the common iliac artery and veins at anterolateral of the L5 vertebrae, it needs careful attention to avoid excessive traction, which often causes the tearing of vessel wall and the formation of venous

thrombosis. At the same time, for treatment of lumbar focus, attention should be paid to the protection of genital femoral nerves and ureter. During treatment of the sacral bone graft, the central vessel of the sacrum should be ligated when necessary.

The "mobile window" muscle space approach adopted in this study is characterized by the muscle gap approach. Exposure of multiple segmental vertebral body lesions is achieved through mobile windows under the same incision. However, it also increases traction injuries of rectus abdominis. At the same time, this study was a retrospective study. It did not properly evaluate abdominal muscle fiber damage. The follow-up sample size was small. Thus, long-term effects on muscle function need further observation. Therefore, future multi-center, large sample, and prospective long-term follow-ups should confirm present results.

Acknowledgements

This work was supported by grants from the Zhejiang Provincial Medicine Health Science and Technology Program (2014KYB207, Zhen Lai), Health Science and Technology Project of the Health and Family Planning Commission of Hangzhou Municipality, China (2016A35, Jun Fei) and Agricultural and Social Development Independent Application Project of Hangzhou (20191203B132).

Disclosure of conflict of interest

None.

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