

Clinical Study

Video-Assisted Thoracoscopic Surgery and Minimal Access Spinal Surgery Compared in Anterior Thoracic or Thoracolumbar Junctional Spinal Reconstruction: A Case-Control Study and Review of the Literature

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There are no published reports that compare the outcomes of video-assisted thoracoscopic surgery (VATS) and minimal access spinal surgery (MASS) in anterior spinal reconstruction. We conducted a retrospective case-control study in a single center and systematically reviewed the literature to compare the efficacy and safety of VATS and MASS in anterior thoracic (T) and thoracolumbar junctional (TLJ) spinal reconstruction. From 1995 to 2012, there were 111 VATS patients and 76 MASS patients treated at our hospital. VATS patients had significantly ($p < 0.001$) longer operating times and significantly ($p < 0.022$) higher thoracotomy conversion rates. We reviewed 6 VATS articles and 10 MASS articles, in which there were 625 VATS patients and 399 MASS patients. We recorded clinical complications and a thoracotomy conversion rate from our cases and the selected articles. The incidence of approach-related complications was significantly ($p = 0.021$) higher in VATS patients. The conversion rate was 2% in VATS patients and 0% in MASS patients ($p = 0.001$). In conclusion, MASS is associated with reduction in operating time, approach-related complications, and the thoracotomy conversion rate.

1. Introduction

Video-assisted thoracoscopic surgery (VATS) and minimal access spinal surgery (MASS) have been considered primarily as minimally invasive surgery (MIS) for anterior thoracic (T) and thoracolumbar junction (TLJ) spine surgery [1]. VATS was first described by Mack et al. in 1993 [2]; it allows for biopsy, anterior release, abscess drainage, and discectomy [3, 4]. VATS has been used to treat anterior thoracic diseases at our hospital since 1995. Over the next 10 years, we used VATS in many spinal procedures: decompression, corpectomy, reconstruction, and stabilization. The microsurgical min-open anterolateral approach was first introduced in 1997 by

Mayer [5] for minimally invasive anterior lumbar interbody fusion. Kossman et al. [6] reported in 2001 that the anterior column of the thoracic spine could easily be assessed and reconstructed using a minithoracotomy and a table-mounted retractor. At that time, we developed a new VATS approach [7–10], which we called the “extended manipulating channel method.” It allowed us to use a combination of conventional spinal instruments and VATS to enter the chest cavity and to manipulate those instruments as we would for standard open surgical procedures. Furthermore, at our hospital, a refined MASS has been evolving since 2000 from our extended manipulating channel method without VATS [11, 12]. MASS has been used to treat vertebral metastasis, osteomyelitis, and

fractures. It is generally believed that because MASS allows direct three-dimensional vision of the surgical field, which seems to make the procedure familiar to spine surgeons used to standard open surgical procedures, it has become more popular than VATS. Thus, we compared the outcomes of MASS in anterior T and TLJ spinal reconstruction and fusion with those of VATS.

2. Patients and Methods

2.1. Patients. We identified, in our hospital's Spine Operation Registry, all patients who underwent VATS (Figures 1 and 2) and MASS (Figure 3). We previously published reports which described both VATS [7, 8, 10, 13] and MASS [12, 14] techniques for anterior T or TLJ spinal reconstruction between 1995 and 2012 and retrospectively reviewed their records. The inclusion criteria were anterior intervertebral fusion after a discectomy with a partial or a total corpectomy for treating spinal fractures, vertebral malignancy, infectious spondylitis, thoracic disc herniation, and degenerative spinal diseases. Patients with pediatric scoliosis, a discectomy without fusion, or a biopsy were excluded from the study. All included patients had undergone minimally invasive anterior spine reconstruction performed by one senior surgeon (T. J. Huang). We reviewed the patients' medical records and recorded data on operating time, estimated blood loss, need for intensive care, conversion to standard open thoracotomy, and complications in patients with T and TLJ spinal disorders. Approval for this study was obtained from the Ethics Committee and Institutional Review Board of our hospital (IRB number 101-1238B).

2.2. Review of Published Literature. The English language literature published between 1995 and 2012 was systematically reviewed. The Cochrane Review Database, EMBASE, Medline, PubMed, and Google Scholar were searched. The reference lists of the selected articles were checked. Search terminology included *miniopen*, *MASS*, *VATS*, *anterior T spinal surgery*, *TLJ (T11-L2) spinal surgery*, and *anterior spinal fusion*. We excluded studies associated with pediatric spine surgery, disc excision without fusion, and anterior lumbar surgery (L3-L5). Technical notes, case reports, anatomical descriptions, or a combined surgery of thoracoscopic surgery and thoracotomy was not included. The articles were screened and selected by two independent reviewers (Y. Y. Li and C. C. Cheng) based on the inclusion and exclusion criteria. Disagreements were resolved by discussion or by a consultation with a third reviewer (Ching-Yu Lee). The data of the selected articles were extracted and analyzed in detail by two independent reviewers (M. H. Wu and Chien-Yin Lee). Because data on the surgical complications were going to be analyzed, the interrater agreement about these data was analyzed using the kappa statistic. Disagreements were resolved by discussion or by a consultation with a senior spine surgeon (T. J. Huang).

2.3. Data Analysis. The perioperative parameters of our included sample were operating time, estimated blood loss, complications, conversion to standard thoracotomy, and the

need for postoperative admission to the intensive care unit. They were recorded and compared between our VATS and MASS patients. The perioperative data of the selected articles were average operating time, average estimated blood loss, complication rates, and conversions to thoracotomy.

Data of clinical complications and conversions to standard thoracotomy, which were recorded from our cases and the selected articles, were compared between VATS and MASS patients. A minor complication was defined as *a minor risk event with no treatment, with medical treatment, or with intraoperative repair but without long-term sequelae*. A major complication was defined as *a life-threatening or irreversible event requiring invasive treatment or revision surgery*. Death was *mortality because of associated perioperative complications*.

An approach-related complication was defined as *intercostal neuralgia, pleural effusion, or air leakage causing subcutaneous emphysema or pneumothorax* [15, 16].

3. Statistical Methods

All statistical analyses were done using SPSS 12.0 for Windows. An independent Student *t*-test was used for numerical data. An χ^2 analysis or a Fisher exact test was used for categorical data. Significance was set at $p < 0.05$. The observed interrater agreement for the data extracted from the selected publications was analyzed using the kappa statistic.

4. Results

We reviewed the medical records of 187 patients who had undergone minimally invasive surgery (MIS) for anterior T or TLJ spinal fusion at our hospital between 1995 and 2012. VATS was used in 111 patients, and MASS was used in the other 76 patients (Table 1). Operating time was longer in the VATS group than in the MASS group ($p < 0.001$). There was a significantly higher incidence of conversion to standard open thoracotomy in the VATS group than in the MASS group ($p = 0.022$). There were no significant differences in average blood loss or the need for postoperative admission to the intensive care unit (ICU).

5. Literature-Reported Results

There were 16 articles about MIS for anterior T/TLJ spinal fusion (Table 2): 6 VATS articles [17–22] and 10 MASS articles [6, 23–31]. Of the 6 VATS articles, the median average operating time was 223 minutes (range: 155–347 minutes), the median average estimated blood loss was 585 mL (range: 310–1117 mL), the median complication rate was 25.9% (range: 9.4–34%), and the median conversion rate was 0.5% (range: 0–6.2%). Of the 10 MASS articles, the median average operating time was 170 minutes (range: 101–210 minutes), the median average estimated blood loss was 423 mL (range: 290–912 mL), the median complication rate was 14.9% (range: 0–33%), and there were no conversions to standard open procedure.

Perioperative complications were collected from 187 patients of our institute and 1024 patients of the 16 selected

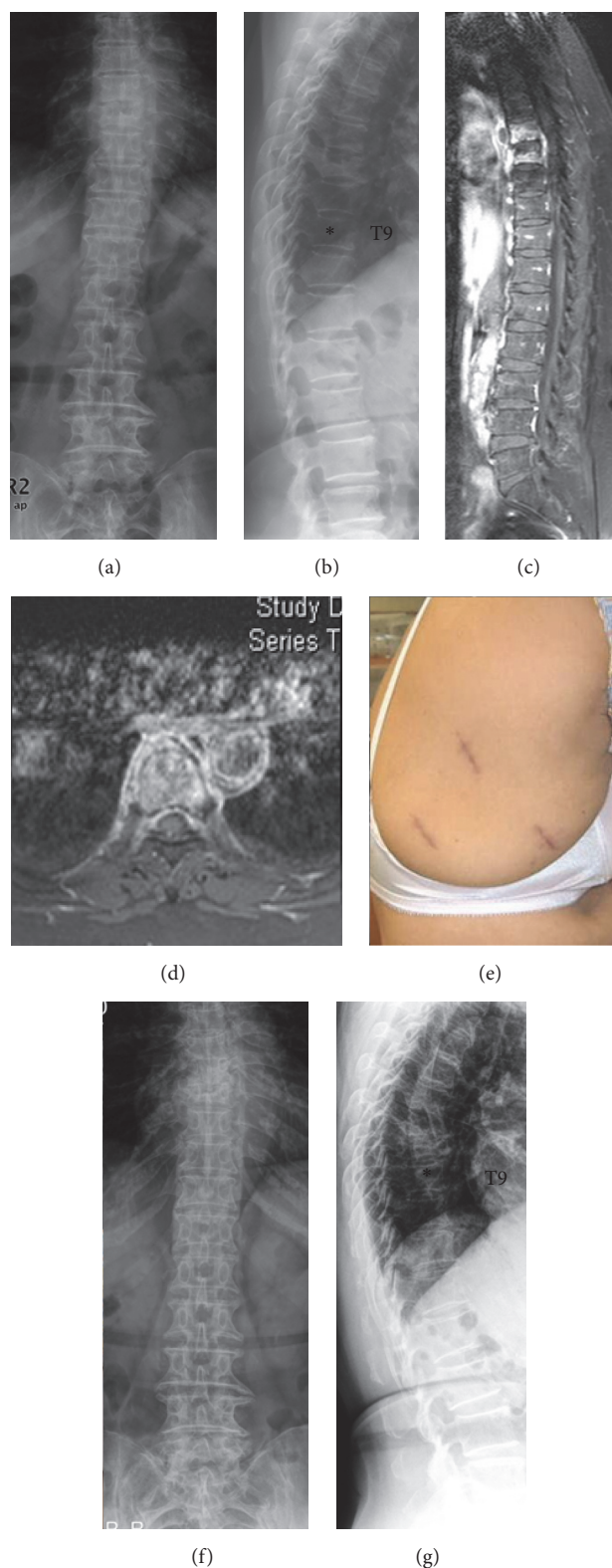


FIGURE 1: Video-assisted thoracoscopic surgery (VATS) for treating tuberculous spondylitis of T7-8 in a 74-year-old woman. (a) and (b) Vertebral destruction and collapse in T8. (c) and (d) Gadolinium-enhanced magnetic resonance imaging (MRI) shows osteomyelitis in T7-8 vertebral bodies and anterior epidural abscess spreading under the anterior longitudinal ligament. (e) The incisional wound was 2.5–3.0 cm long to allow a three-portal video-assisted thoracoscopic debridement, curettage, and harvested tricortical iliac strut bone graft for anterior spinal reconstruction on T7-8. (f) and (g) Solid bone fusion was noticed on T7-8 at the 2-year follow-up.

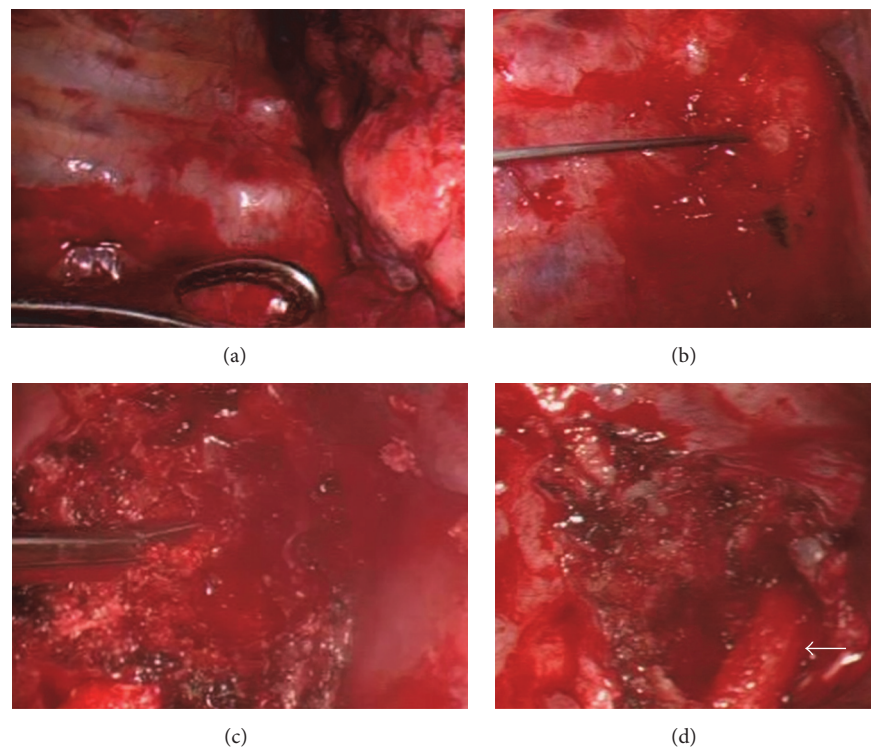


FIGURE 2: Video-assisted thoracoscopic surgery (VATS) spinal approach to tuberculous spondylitis of T7-8. (a) and (b) The lesion site was identified using fluoroscopy and was displayed on the video monitor. The lesion site was initially covered with the visceral pleura because of inflammation. (c) The infected vertebral body and soft tissue were removed using pituitary rongeurs and elongated curettes. (d) Column reconstruction with intervertebral fusion was initiated using an autogenous tricortical iliac strut graft (white arrow).

TABLE 1: MIS for anterior T and TLJ spinal reconstruction in 187 patients at our Institution.

	VATS	MASS	<i>p</i> value
Number of patients	111	76	
Male/female	68/43	39/37	0.177
Mean age (year)	57.1 ± 14.5	60.4 ± 14.8	0.133
Number of pathologic regions			0.085
T	59 (53)	50 (66)	
TLJ	52 (47)	26 (34)	
Number of pathologic types			0.253
Fracture	25 (23)	9 (12)	
Infectious spondylitis	31 (28)	24 (32)	
Spinal malignancy	49 (44)	36 (47)	
Disc herniation or degeneration	6 (5)	7 (9)	
Perioperative data			
Operating time [#] (mins)	224.5 ± 68.6	183.5 ± 33.2	<0.001*
Estimated blood loss [#] (ml)	916.0 ± 660.3	933.8 ± 847.6	0.879
Conversion to standard thoracotomy	8 (7)	0	0.022*
Need for postoperative ICU care	9 (8)	4 (5)	0.565

Data are expressed as mean ± standard deviation or number (%). * $p < 0.05$.

[#]Patients undergoing conversion thoracotomy were not included.

MIS: minimally invasive surgery; VATS: video-assisted thoracoscopic surgery; MASS: minimal access spinal surgery; T: thoracic; TLJ: thoracolumbar junction; ICU: intensive care unit.

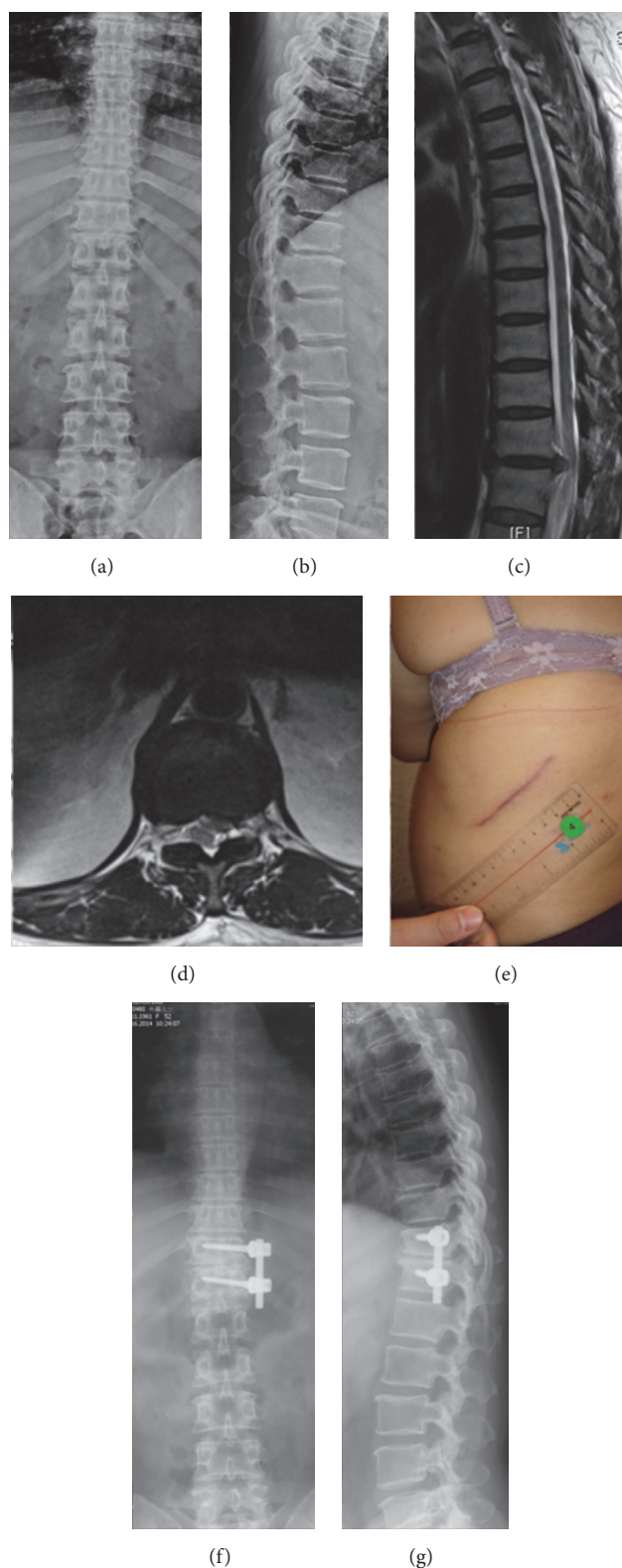


FIGURE 3: Anterior minimal access spinal surgery for treating thoracic disc herniation of T11-12 in a 41-year-old woman. (a) and (b) Narrowing disc space with endplate sclerosis on T11-12 level was noticed. (c) and (d) Magnetic resonance imaging (MRI) shows left paracentral disc herniation on T11-12 level. (e) A 7 cm skin incision in the patient's left lateral thoracic cage. (f) and (g) Anterior retropleural and retroperitoneal approach for thoracic discectomy and fusion was performed using a double-barreled rib strut graft and anterior vertebral instrumentation. No intraoperative one-lung ventilation, a postoperative chest tube, or ICU care was given. Solid bone fusion on T11-12 was noticed at the 2-year follow-up.

TABLE 2: A literature review of MIS for anterior T and TLJ spinal reconstruction.

Authors	Years	PT no.	Study design	AOT (min)	ABL (ml)	CR (%)	TCR (%)
Dickman et al.	1996	17	VATS for reconstruction in T spine	347	1117	29.4	0
Khoo et al.	2002	371	VATS in treating T or TL spinal fractures	240	650	9.7	1.1
Kapoor et al.	2005	16	VATS in treating TB spondylitis	223	497	31.2	6.2
Le Huec et al.	2010	50	VATS for treating TLJ fractures	155	620	20.0	0
Lü et al.	2012	50	VATS in treating thoracic TB spondylitis	210	550	34.0	0
Wait et al.	2012	121	VATS for discectomy and fusion in T spine	NA	310	22.3	1.7
Kossmann et al.	2001	58	MASS for reconstruction in T/TLJ(58) + L(7)	170	912	7.7%	0
El Saghir	2002	21	MASS for reconstruction in TL spine	101	724	33%	0
Scheufler	2007	38	MASS for reconstruction in T/TLJ spine	167	652	18%	0
Payer and Sottas	2008	37	MASS for reconstruction in TL spine	181	632	16.2%	0
Smith et al.	2010	52	MASS in treating TLJ fractures	128	300	13.5%	0
Uribe et al.	2010	21	MASS in treating T spinal tumor	117	291	4.8%	0
Khan et al.	2012	20	MASS for reconstruction in T/TLJ(20) + L(4)	188	423	0	0
Deviren et al.	2011	12	MASS for reconstruction in T spine	210	400	16.7%	0
Baaj et al.	2012	80	MASS for reconstruction in TL spine	NA	NA	12.5%	0
Uribe et al.	2012	60	MASS for discectomy and fusion in T spine	182	290	25%	0

MIS: minimally invasive surgery; T: thoracic; TLJ: thoracolumbar junction; PT no.: patient number; AOT: average operating time; ABL: average estimated blood loss; CR: complication rate; TCR: thoracotomy conversion rate; VATS: video-assisted thoracoscopic surgery; MASS: minimal access spinal surgery.

publications (Table 3). The assessment score agreement between the reviewers was good (kappa statistic: 0.62, $p < 0.001$). There were 126 (17%) perioperative complications in VATS patients and 71 (15%) in MASS patients ($p = 0.317$): there was not significantly different distribution of no, minor, and major complication ($p = 0.567$). Revision surgery was the most common major complication in both groups: 11 VATS patients and 8 MASS patients. There were 6 mortalities in this study, 3 in each cohort of VATS and MASS: 1 with pneumonia, 1 with acute thromboembolism, and 1 with intraoperative arrhythmia and acute cardiac infarction in VATS patients; 1 with pneumonia and 2 with acute thromboembolism in MASS patients. The incidence of approach-related complications was significantly higher in VATS patients than MASS patients ($p = 0.011$). There was no significant difference in the prevalence of pulmonary infection or iatrogenic cardiovascular injury between both surgical procedures.

The overall conversion rate from MIS to standard thoracotomy in VATS patients was 2% ($n = 15$) and 0% in MASS patients ($p = 0.001$) (Table 4). The most common cause for unplanned conversion to standard open thoracotomy was severe intrathoracic adhesion (40%), followed by iatrogenic cardiovascular injury (20%) and excessive uncontrollable bleeding from cancellous bone or soft tissue (20%).

6. Discussion

VATS and MASS are well-known MIS methods for anterior spinal surgeries [1]. It is generally believed that using VATS for spinal surgery entails a learning curve more difficult to negotiate than does using MASS [19]; however, few studies focus on analyzing the advantages and disadvantages of using VATS and MASS to treat anterior spinal disorders. In this study, VATS required longer operating time and a higher

incidence of conversion to standard open thoracotomy than did MASS at our hospital. Similarly, our review of the VATS and MASS literature for anterior T and TLJ spinal reconstruction showed that VATS was more likely to need operating time and to increase blood loss. In addition, Molina et al. [32], in a systematic review of MIS in the management of metastatic spine disease, reported that VATS was associated with longer operating time, a longer length of stay in the hospital, and more blood loss than was MASS. We found that since MASS seems more familiar to most surgeons it yields faster and safer decompression, stabilization, and reconstruction than does VATS.

We found that the overall MIS complication rate for anterior T and TLJ spinal reconstruction in the 1211 patients analyzed in the selected articles and in our hospital was 16.2%: 126 perioperative complications in VATS patients (17%) and 71 complications in MASS patients (15%). VATS and MASS patients had similar minor and major complication rates; however, VATS is more associated with approach-related complications. Consistent with the results of previous case series [3, 16, 19, 33], approach-related complications are most common in patients undergoing VATS. This might be true because trocar placement sometimes injures an intercostal nerve or pleural membrane, which leads to intercostal neuralgia, pleural effusion, pneumothorax, or subcutaneous emphysema [15]. Hence, the first thoracoscopic portal, which is not made using endoscopic visualization, is created using a minithoracotomy to make a 1.5 cm skin incision that precludes blind trocar insertion [16, 34, 35].

Conversion to standard open thoracotomy occurred more frequently in VATS patients than in MASS patients in our hospital and in the selected literature. Consistent with our findings, other studies [35, 36] have reported that VATS is restricted because of severe pleural adhesion, poor tolerance of one-lung ventilation, and difficulty with

TABLE 3: A summary of perioperative complications in MIS for anterior T and TLJ spinal surgery.

	VATS (<i>n</i> = 736)	MASS (<i>n</i> = 475)	<i>p</i>
Number of patients			
Complications in authors' institute	27	11	0.263
Complications in review articles	99	60	
A total number of complications	126 (17)	71 (15)	0.317
No complication	610	404	0.567
Minor complication	102	59	
Major complication	24	12	
Minor complication	102 (80)	59 (83)	0.708
Pleural effusion, pneumothorax, and intercostal neuralgia	52	18	
Superficial wound infection	12	3	
Incidental durotomy	8	15	
Pulmonary infection s/p medical treatment	8	3	
Lung atelectasis or poor pulmonary function	7	4	
Hypesthesia or transient motor dysfunction	3	5	
Paralytic ileus	0	5	
Laceration of lung parenchyma s/p repair	4	0	
Deep vein thrombosis	0	4	
Pharyngeal pain	3	0	
Subcutaneous emphysema	2	0	
Implant malposition	1	1	
Splenic contusion	1	0	
Iatrogenic rib fracture	1	0	
Urinary tract Infection	0	1	
Major complication	24 (20)	12 (17)	
Revision	11	8	
Graft dislodgment or implant failure or pseudoarthrosis	7	5	
Incomplete decompression (residual disc herniation)	3	2	
Wrong level	1	0	
Dehiscent muscular layers in the flank	0	1	
Pneumonia with requiring intubation	4	0	
Iatrogenic cardiovascular injury	3	0	
Deep wound infection	1	1	
Permanent neurogenic deterioration	1	0	
Postoperative acute myocardial infarction	1	0	
Death	3	3	
Pneumonia	1	1	
Intraoperative arrhythmia	1	0	
Acute thromboembolism	1	2	
Specific complications in MIS for anterior T and TLJ spinal Surgery			
Approach-associated complications	54	18	0.011*
Pulmonary infections	13	4	0.218
Iatrogenic cardiovascular injury	3	0	0.284

Data are expressed as mean \pm standard deviation or number (%). * $p < 0.05$.

MIS: minimally invasive surgery; VATS: video-assisted thoracoscopic surgery; MASS: minimal access spinal surgery; T: thoracic; TLJ: thoracolumbar junction.

endoscopic control of bleeding. In addition, the conversion rate from VATS to standard open thoracotomy was 7.2% in our hospital and 1.1% in the selected articles. Metastatic vertebral tumors and infectious spondylitis occurred in most of our VATS patients whereas vertebral fracture and herniation of intervertebral disc were the majority of spinal

disorders in VATS patients from the selected articles. Chronic inflammation, infection, and metastatic tumor are well-known causes of intrathoracic adhesion [37], which might explain the relatively higher incidence of conversion to open thoracotomy in our VATS patients than in the patients in the reviewed literature. Severe pleural adhesion encountered in

TABLE 4: Causes of conversion thoracotomy in MIS for anterior spinal surgery.

	VATS (<i>n</i> = 736)	MASS (<i>n</i> = 475)	<i>p</i>
Conversion to standard open procedure	15 (2)	0	0.001*
Severe intrathoracic adhesion	6	0	
Iatrogenic cardiovascular injury	3	0	
Excessive uncontrollable bleeding	3	0	
Poor tolerance of one-lung ventilation	2	0	
Extremely narrow intercostal space	1	0	

Data are expressed as mean \pm standard deviation or number (%). * $p < 0.05$.

MIS: minimally invasive surgery; VATS: video-assisted thoracoscopic surgery; MASS: minimal access spinal surgery.

metastatic chronically infected diseases of the thoracic spine, but thoracoscopic adhesiolysis is a technically demanding procedure that must be done by an expert thoracic surgeon. Besides, intraoperative bleeding was more directly and easily controlled using cauterization, hemoclips, or suture ligation in MASS. Therefore, MASS is a reasonable MIS method for treating anterior T and TLJ spinal reconstruction and fusion, especially for metastatic and infectious spinal diseases.

This study has some limitations. First, this is a retrospective study. To minimize the statistical bias, we included patients who had undergone MIS spinal surgery done by the same surgeon (T. J. Huang) at our hospital. Second, the evidence level of the systemic review in this study is low. This is because there is still a paucity of reports that a meta-analysis needs, those that show comparative data of VATS and MASS for treating anterior spinal diseases. Additional comparative VATS and MASS studies that focus on treating anterior spinal diseases are required.

In conclusion, VATS and MASS are effective MIS methods for treating anterior T and TLJ spinal reconstruction, and they have equivalent complication rates. MASS requires less operating time and has fewer approach-related complications. VATS is more likely to have a higher conversion rate from MIS to standard open thoracotomy when severe pleural adhesion and difficulty in endoscopically controlling bleeding are encountered.

Competing Interests

All authors declare that they have no conflict of interests regarding the publication of this paper.

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