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Review Article

Outcome of minimal invasive surgery approach for spine infection: a systematic review

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ABSTRACT

The concept of minimally invasive surgery has gained increasing popularity in the last several decades, are being introduced as an alternative to limit the surgical complications while achieving best possible outcome. While minimally invasive spine surgery holds promise for lower blood loss, faster patient recovery, shorter hospital stays, and the potential to transition procedures to the ambulatory setting, safety in spinal surgery remains paramount and has (appropriately) tempered some of the enthusiasm for the results of aggressive early adapters. Until now, there has been no literature summarizing the evidence of MIS outcome in treating spondylitis TB of the bone. The purpose of this systematic review was to investigate the outcome of minimal invasive surgery approach for spine infection. authors comprehensively searched PubMed, EMBASE, and Cochrane Library to search for studies about minimally invasive surgery as management of tuberculous spondylitis up to June 7th, 2019. The selection of appropriate studies was performed by independent investigators based on PRISMA guideline. Given the limited number of studies, there was no restriction in terms of patient's demographics, the specific minimal invasive surgical method, and publication status. Authors identified the method for minimally invasive approach and open approach, the functional outcome, intraoperative outcome, radiological outcome, length of stay, follow up period, and complication. Authors found 81 articles from database. After evaluating full text, 8 articles (346 patients) were found to be eligible. More than 110 patients were treated with open spine surgery, while more than 270 patients were treated using minimally invasive spine surgery the minimal invasive methods were posterior pedicle screws fixation, plate fixation, lateral nail bar fixation, and bilateral pedicle screw fixation. The visualization methods include C-arm fluoroscopy, X-ray fluoroscopy. The follow-up period ranges from 1 to 40 months. The functional outcome were found to be satisfying with minimal complications. MIS yielded satisfactory result in comparison to conventional open surgery for spine infection. More long term future studies should be conducted to in order to search for more solid evidence regarding this claim.

Keywords: Approach, Infection, Minimal invasive surgery, Spondylitis tuberculosis

INTRODUCTION

In developing countries, spine infection is relatively common and might result in severe reduction of quality of life. The infection might directly damage structures of the spine or compress the spinal cord, resulting in neurological deficits. Recently, the surgical method to treat these conditions has been evolving from open approach to Minimal Invasive Surgery (MIS) approach. The objective is to minimize trauma to the surrounding tissues, minimize intraoperative blood loss, and reduce hospital stay. However,

there has been no literature summarizing the current MIS technique used and their outcome.

Spine infection might be caused by M. tuberculosis or other pyogenic bacteria. Spinal tuberculosis is among the most common forms of extrapulmonary tuberculosis. Approximately 10% of patients with tuberculosis have bone involvement, with the spine being the most commonly affected, followed by the hip and the knee.[1] Spinal TB (Pott' disease) is the most common and most dangerous form of musculoskeletal TB; it accounts for 1% of all TB cases and 50% of osseous TB.[2] As for pyogenic spine infection, the incidence was known to increase in the recent years. It also associates with a mortality rate of up to 5% and a morbidity rate of more than 7%.[3,4]

The typical presentation of spinal TB involves systemic TB symptoms and imaging presentations, including damaged contiguous vertebral bodies and their intervertebral discs without the involvement of the posterior elements, which could be easily recognized and diagnosed.[2] The goals of the management of spinal TB are to eradicate infection, prevent or treat neurologic deficits, and correct and avoid spinal deformity progression. Current surgical methods include anterior debridement, decompression, fusion followed by ventral or posterior decompression with fixation.[5,6]

Conventional spine surgery approaches to the ventral aspect are considered to be extensive and have associated morbidities. Therefore, MIS approaches are increasingly used in managing various spinal disorders, such as degenerative disorders, trauma, and tumors, with advantages including minimal trauma, less blood loss, and a shorter recovery time. In order to be widely accepted as the common treatment for spine infection, MIS should be comparable to gold standard treatment, that is the open surgery.

This study will discuss previous studies investigating the use of MIS for spine infection treatment in terms of outcomes and complications.

REVIEW OF LITERATURE

Search strategy

This systematic review was conducted based on PRISMA guideline. Literature research was primarily performed using the PubMed, EMBASE, and Cochrane Library to search for studies about minimally invasive surgery as management of tuberculous spondylitis up to June 7th, 2019 with the keywords "minimally invasive spine surgery") OR "minimally invasive") OR "percutaneous") AND "tuberculosis") OR "spine infection") OR "tuberculous spondylitis". Authors filtered the search to include only studies in human, published in the last 5 years, and ones written in English. After that, authors combed through all articles cited and citing the articles so as not to miss any relevant articles.

Inclusion criteria

The inclusion criteria were tuberculous spondylitis, with the intervention of minimally invasive surgery as compared to standard open surgery, and neurological and functional outcome as the main outcome. Case report and case series were also included. Given the limited number of studies, there was no restriction in terms of patient's demographics, though case reports and literatures not in English were excluded. Study that focus in diagnosis biopsy, consecutive therapy and tuberculous spondylitis after spine surgery is excluded from this review.

Quality evaluation

First, all authors screened eligible studies through the titles and abstracts based on inclusion criteria. Then, all authors screened the full articles of all the collected studies. The authors had a meeting and agreed on highly relevant publications to be included in this study. All authors performed appraisal of study quality independently and any disagreement was resolved through discussion.

All inherent aspects of the studies, including study quality, variables for which data were sought, and assessment of risk of bias, were appraised by all authors independently by filling up forms. The forms were collected by the first author and the contents were scanned for any disagreement. The authors then gathered again for discussing any contradicting points.

Result of systematic review

The electronic search resulted in 81 records, after elimination of duplicate results. On the basis of titles and abstracts screening, a total of 72 records and 1 article on the basis of assessment of full text article were excluded. The remaining articles were subsequently studied by two independent investigators based on the full text extracted. A list of inclusion and exclusion criteria previously agreed by the authors were utilized for screening the full text. This selection process yielded 8 final articles to be included in the systematic review and was depicted in Figure 1.

All articles were of level III-IV evidence (Table 1) and, in total, 346 patients were eventually included in the analysis. Among these patients, more than 110 patients were treated with open spine surgery, while more than 270 patients were treated using minimally invasive spine surgery. The mean age of the samples ranges from 25-83 years old, and male counts for the majority of samples (Table 2).

There are several ethnic of minimally invasive surgery that used on this study, that is mini-open anterior TL corpectomy using extreme lateral interbody fusion (XLIF), extreme lateral channel (XLIF) combined with

lateral or percutaneous posterior pedicle screw fixation, local chemotherapy combined with percutaneous pedicle

screw and computer navigation-assisted minimally invasive direct lateral interbody fusion. All of the studies mentioned that patient have regimen of anti-tuberculosis drug 2 weeks preoperatively continued post operatively for 12-18 months (Table 3).

Only 2 study have comparison group with the open surgery (Table 4). All of studies that have comparison group mention that minimally invasive surgery group have better outcome especially in VAS, estimated blood loss, duration of operation, and length of stay. In all eight literatures mentioned patient that have been treated with minimally invasive surgery have good functional, neurological, intraoperative and radiological outcome with minimal complication. (Table 5).

DISCUSSION

Minimal Invasive Surgery (MIS) has been gaining interests in recent years, including in the field of spine surgery. In order to be a routine procedure, this novel procedure should be comparable to established surgical techniques in terms of outcomes and risks.

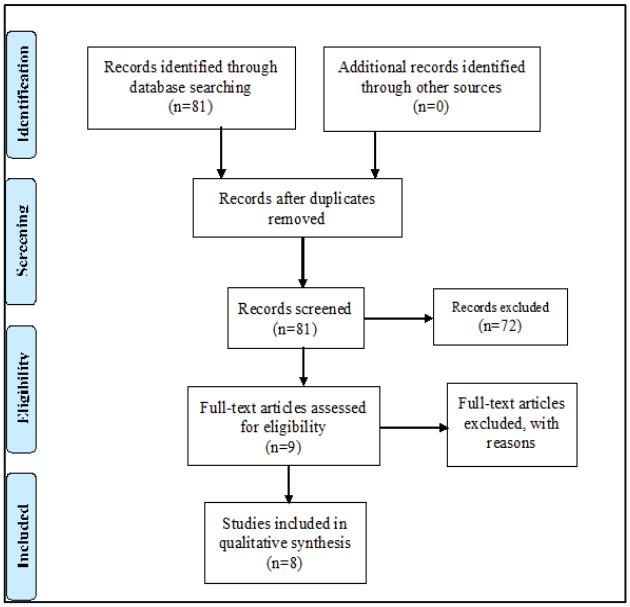

Figure 1: The strategy for conducting this study based on Prisma guideline.

Table 1: Criteria of inclusion and exclusion based on population, intervention, comparison and outcome.

Characteristic	Inclusion	Exclusion
Population	Patient with pyogenic spine infection in thoracolumbar region	Patient with pyogenic spine infection other than thoracolumbar region and patient with spine tumour and traumatic spine lesion
Intervention	Minimally invasive surgery	Diagnostic biopsy surgery
Comparison	Open spine surgery	Conservative therapy
Outcome	Functional, intraoperative and radiological outcome after minimally invasive surgery	Tuberculous spondylitis after spine surgery

Table 2: References characteristic.

Reference	Journal	Study design	Level of evidence
Guo S. et al	Medical Science Monitor	A retrospective cohort study	Level III
Jiang et al	Medicine Journal	A retrospective study	Level III
Gan et al	BMC Musculoskeletal Disorders	A retrospective study	Level III
Viezens L, et al	World Neurosurgery	A retrospective cohort study	Level III
Wang et al	Journal of Musculoskeletal and Neuronal Interactions	A retrospective study	Level III
Wang, et al	Medicine	Case report	Level IV
Yang et al	Spine Surgery	Retrospective study	Level III
H. Yang et al	Journal of Clinical Neuroscience	Retrospective study	Level III

The purpose of our investigation is to summarize the current evidence of MIS usage for spine infection surgeries. authors collected the patient demographics, including preoperative neurological status and the spine level involved, the surgical techniques performed including the compared open surgery approach, and the outcomes and complications. The patients from the 8 studies presented herein are of similar baseline characteristics regarding age, sex, involved spinal level, and preoperative neurological status. As for the treatment, all patients receive appropriate antimicrobial regimen, that is anti-tuberculosis regimen for TB cases and antibiotic for non-TB cases.

Table 3: Summary of total sample, demographic data, site of infection and preoperative spinal status.

Reference	Total sample size	Group		Age	Gender		Spinal level	Preoperative Neurological Status
		Control	Intervention		Male	Female		
Guo S et al	42	22	20	Range 26-67	23 (54.7%)	19 (45.3%)	Thoracolumbar	N/A
Jiang et al	33	15	18	Range 26-85	17 (51.5%)	16 (48.5%)	L1-L5	N/A
Gan et al	35	N/A	35	Range 25-83	16 (45.7%)	19 (54.3%)	Thoracolumbar	FRANKEL C,D,E
Viezens L et al,	148	73	75	MIS group (mean 64.1±13.7); open surgery (mean 64.1±13.7)	85	63	Thoracolumbar	N/A
Wang et al	22	N/A	22	Range 28-79	12 (54.5%)	10 (45.5%)	L2-L5	FRANKEL C,D,E
Wang et al	1	N/A	1	68	0 (0%)	1(100%)	L1-L2	FRANKEL E
Yang et al	34	N/A	34	Averages 59	17 (50%)	17 (50%)	Thoracolumbar	ASIA B,C,D
H Yang et al	31	N/A	31	Range 33-78	19 (61.3)	12 (38.7)	Thoracolumbar	ASIA C

Table 4: Minimally invasive surgery technique.

Reference	Antimicrobial	Surgical Technique				
		Imaging Guidance	Approach	Internal Fixation Type	Incision Length (cm)	Decompression Method
Jiang et al	Isoniazid (300mg/d), rifampicin (450mg/d), ethambutol (750mg/d), and streptomycin (750mg/d) or pyrazinamide (15-30mg/kg/d)	C-arm fluoroscopy and non C-arm fluoroscopy	Lateral	N/A	5	Navigation probes were used to identify the range of lesion debridement and decompression
Wang et al	Rifampicin (450mg/day, PO), isoniazid (300mg/ day, PO), pyrazinamide (750mg/day, PO), and Streptomycin, (75mg/day, IM) for 12-18 months	X-ray fluoroscopy	Lateral	Posterior pedicle screws fixation	3-4	Debridement of necrotic tissues, including nucleus pulposus, adjacent end plate and vertebra, and abscess
Gan et al	Isoniazide (300 mg/d), rifampicin (450 mg/d), ethambutol (750 mg/d), streptomycin (750 mg/d) or pyrazinamide (15~30 mg/kg/day) for 12-18 months	C arm fluoroscopy	Direct lateral	Plate fixation, posterior pedicle screw fixation and lateral nail bar fixation	6-8	Lesions removal of intervertebral disc and necrosis of bone by spatula, rongeur and chisel.
Wang et al	Streptomycin 75mg/day IM, rifampicin 450mg/day PO, isoniazid 300mg/day PO, and pyrazinamide 750mg/day PO) for 2 weeks continued for 12-18 months postoperatively	X-ray fluoroscopy	Lateral	Percutaneous pedicle screws	2-3	Cutting the annulus of the object intervertebral disc through this surgical channel under the direct vision.
Yang et al	HRZE (which is composed of isoniazid, rifampicin, pyrazinamide and ethambutol) for at least 2 weeks before the surgery and continued for 12-18 months	C arm fluoroscopy	Lateral	Bilateral pedicle screw fixation	1	No decompression needed
H Yang et al	INH (300mg), rifampicin (450mg), ethambutol (750mg) and pyrazinamide (1500mg)	C-arm fluoroscopy	Posterom edial	N/A	5	Opening the laminae to expose the dural sac

Table 5: Comparison of minimal invasive approach and open approach.

Reference	Antimicrobial	Group	Intervention				
			Imaging Guidance	Approach	Incision Length (cm)	Internal fixation type	Decompression method
Guo S et al	Isoniazid 300mg/day, rifampin 600mg/day, pyrazinamide 1500mg/day, ethambutol 1000mg/day	MIS Group	C-arm fluoroscopic	Transverse	1.0	Percutaneous Pedicle Screw (VIPER ® 2 MIS Spine Screws System) and pre-bent titanium rods	N/A
		Open Group	C-arm fluoroscopic	Posterior	N/A	Pedicle screws (MOSS MIAMI System)	A bilateral hemilaminectomy, or total laminectomy, according to the extent of spinal canal stenosis, and debridement of the affected intervertebral discs and the vertebral bodies
Viezens L et al	Intravenous antbiotic therapy (>14 days) and oral (10 weeks) based on microbiological findings	MIS Group	Fluoroscopic	Percutaneous	1.0-1.5 cm (additional 3-5 cm if additional decompression is needed)	Pedicle screws (XIA precision implant and MANTIS spinal system)	Insertion of tubular/ microlumbar discectomy retractor and uni-/bilateral laminotomy or laminectomy
		Open Group	Fluoroscopic	Posterior midline	At least one adjacent vertebral body cranial and caudal to the infected vertebrae	Pedicle screws (Xia implant and Universal Spinal System)	Uni-/bilateral laminotomy or laminectomy

The procedures performed ranged from debridement to internal fixation. As expected, incision in MIS is reduced, with the range of 1-5cm. This is as compared to open surgery which might need incision as long as at least one adjacent vertebral body cranial and caudal to the infected vertebrae.[7] The MIS itself can also be greatly aided with the use of visualization instrument such as computer navigation system.

Intraoperative C-arm fluoroscopy risks increased radiation exposure in both surgical staff and patients in order to ensure channel establishment and the accuracy of screw and cage implantation, while avoiding nerve damage and achieving general surgical safety. Therefore, the use of computer navigation might increase the benefit of MIS in spine surgery even more.[8] Objectively, all literature reported a functional improvement with mostly normal postoperative neurological status as assessed by frankel or asia classification. The pain level also improved significantly. These show that MIS approach give satisfactory outcome to treat spine infection conditions. There are other certain intraoperative benefits as well: considerably reduced blood loss and shorter operation duration using MIS approach. Less morbidity also showed in terms of shorter length of stay in comparison to open surgery.[4]

However, there are still possible complications associated with minimally invasive spine surgery. These include violation of the cranial (non-fused) facet joint during placement of percutaneous pedicle screws, non-union related to inadequate discectomy and bone grafting during minimally invasive transforaminal lumbar interbody fusion, and nerve injury related to inadequate visualization during decompression. Several

complications noticed were transient numbness, wound healing difficulties, and abscess.[5,9] The future of minimally invasive spine surgery continues to be bright. The coming technological and procedural advances will certainly include the minimally invasive philosophy. The future will inevitably continue to incorporate less invasive techniques.

Table 6: Outcome characteristic of minimally invasive surgery.

Reference	Functional		Intraoperative			Radio logical	Length of stay	Follow up period	Complication
	Neurological	ODI	VAS	EBL (ml)	Duration (minutes)				
Guo S et al	N/A	N/A	Preop PPS 7.64±0.95, postop 2.45±1.22	PPS 73.05±36.78	PPS 121.86±24.94	N/A	PPS 8.05±1.70	1, 6, 12, and 18 months	No complication
			Preop hybrid 7.75±1.07, post op 2.65±1.79	Hybrid 310.75±65.84	Hybrid 274.95±32.70		Hybrid 16.75±4.51	1, 6, 12, and 18 months	
Jiang et al	N/A	N/A	N/A	NAV: 316±65.3	NAV: 69.1±1.9	N/A	NAV: 9.9±1.8	1, 3, 6, and 12 months	N/A
				Non NAV 344±48.8	Non NAV: 75.5±4.4		Non NAV: 10.1±1.5	1, 3, 6, and 12 months	
Gan et al	Franke LE	N/A	Preoperative grade: 8.2±0.7 and postoperative: 2.8±0.5	200-600 (average of 320)	79-129 (average of 94)	N/a	N/a	7 to 40 months with an average of 18.5 months	5 cases occurred with transient numbness in one side of the thigh or inguinal region and 10 cases suffered from flexion hip weakness.
Viezens l,et al	Improvement preoperative frankel grade post operative	N/A	N/A	N/A	N/A	N/A	MIS 23.9±18.0	N/A	Wound-healing difficulties or screw misplacement
							Open surgery: 29.1±25.7	N/A	
Wang et al	Franke LE	Preoperative grad: 57.2±6.1 and postoperative: 23.0±3.1	Preoperative grade: 6.4.2±1.2 and postoperative: 0.6±0.7	249.82±27.8	347.5±20.7	Cobb angle (l1-l5) --> preoperative grade: 23.9±1.9 and post operative: 24.5±1.4	25.8±1.9	12.4±1.1 months (11 to 15 months)	Psoas abscess in 1 patient
Wang et al	Franke L E	Preoperative grade: 56 and postoperative: 22	Preoperative grade: 4 and postoperative: 0	500	220	Kyphosis angle -> preoperative grade: 33.5 and post operative: 14.8	8	12 months	No complication
Yang et al	Asia D E	N/A	N/A	20-150	90-160 (average of 125)	As for kyphosis deformity, there was no cobb angle loss.	3 to 5	18 (range 12-52) months	Soft tissue abscess in 1 patient
H. Yang et al	Asia E	N/A	Preoperative: median 5.8, postoperative: median 1.2	90	80	Average cobb angle increased 8.60	N/A	0.5, 1, 2, 3, 6, 12 and 18 months	No

Nevertheless, this systematic review can only describe literature level III and level IV based on strength of evidence of each literature. Authors cannot find any randomized controlled trial study regarding minimally invasive surgical approach in patient with pyogenic spine infection or systematic review that reviewing the randomized controlled trial study regarding those patient in last 5 years of published study. This can be happened because of this minimally surgical approach is a new surgical approach for management of patient with pyogenic spine infection that met indication of surgical procedure. So, it is can demonstrated why authors find only a few literatures that met our inclusion criteria of this systematic review. MIS yielded satisfactory result in comparison to conventional open surgery for spine infection. More long-term future studies should be conducted to in order to search for more solid evidence regarding this claim.

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