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Review Article

Outcome Of Minimal Invasive Surgery Approach For Spine Infection: A Systematic Review

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Abstract

Introduction: Minimally invasive surgery (MIS) has gained popularity as an alternative to conventional surgery, with potential benefits including reduced blood loss, faster recovery, and shorter hospital stays. However, evidence regarding its use in tuberculous spondylitis remains limited. This systematic review evaluated the outcomes of MIS for spinal tuberculosis.

Methods: PubMed, EMBASE, and the Cochrane Library were searched for studies evaluating MIS for tuberculous spondylitis published up to June 7, 2019. Study selection was performed independently according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. No restrictions were applied regarding patient demographics, MIS technique, or publication status. Data extracted included surgical approach, functional and radiological outcomes, intraoperative outcomes, length of hospital stay, follow-up duration, and complications.

Results: Of 81 articles identified, 10 studies involving 431 patients met the eligibility criteria. More than 110 patients underwent conventional open surgery, while more than 321 underwent MIS. MIS techniques included posterior pedicle screw fixation, plate fixation, lateral nail-bar fixation, and bilateral pedicle screw fixation, with C-arm or X-ray fluoroscopy used for intraoperative visualization. Follow-up ranged from 1 to 40 months. Overall, MIS was associated with satisfactory functional outcomes and few reported complications.

Conclusion: MIS appears to provide satisfactory outcomes with a low complication rate in patients with tuberculous spondylitis. However, the available evidence is limited, and further long-term, well-designed comparative studies are needed to establish its safety and effectiveness.

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]

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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.[5] Sequestrum and abscesses can cause vertebral collapse, spinal instability, kyphosis deformity, and alterations in normal physiological curvature and load biomechanics as the condition progresses, or they can penetrate the spinal canal and compress the nerves, resulting in nerve damage or even paralysis.[6] 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.[7,8]

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.

Methods

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". We filtered the search to include only studies in human, published in the last 5 years, and ones written in English. After that, we combed through all articles cited and citing the articles so as not to miss any relevant articles.

Inclusion criteria

The inclusion criterias 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.

Results

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 10 final articles to be included in the systematic review and was depicted in Figure 1.[6,9–16]

All articles were of level III-IV evidence (Table 1) and, in total, 431 patients were eventually included in the analysis. Among these patients, more than 110 patients were treated with open spine surgery, while more than 321 patients were treated using minimally invasive spine surgery. The mean age of the samples ranges from 17-85 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, one-stage posterior debridement and single-segment interbody fusion, minimally invasive far lateral debridement and posterior instrumentation (MI-FLDPI), 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).

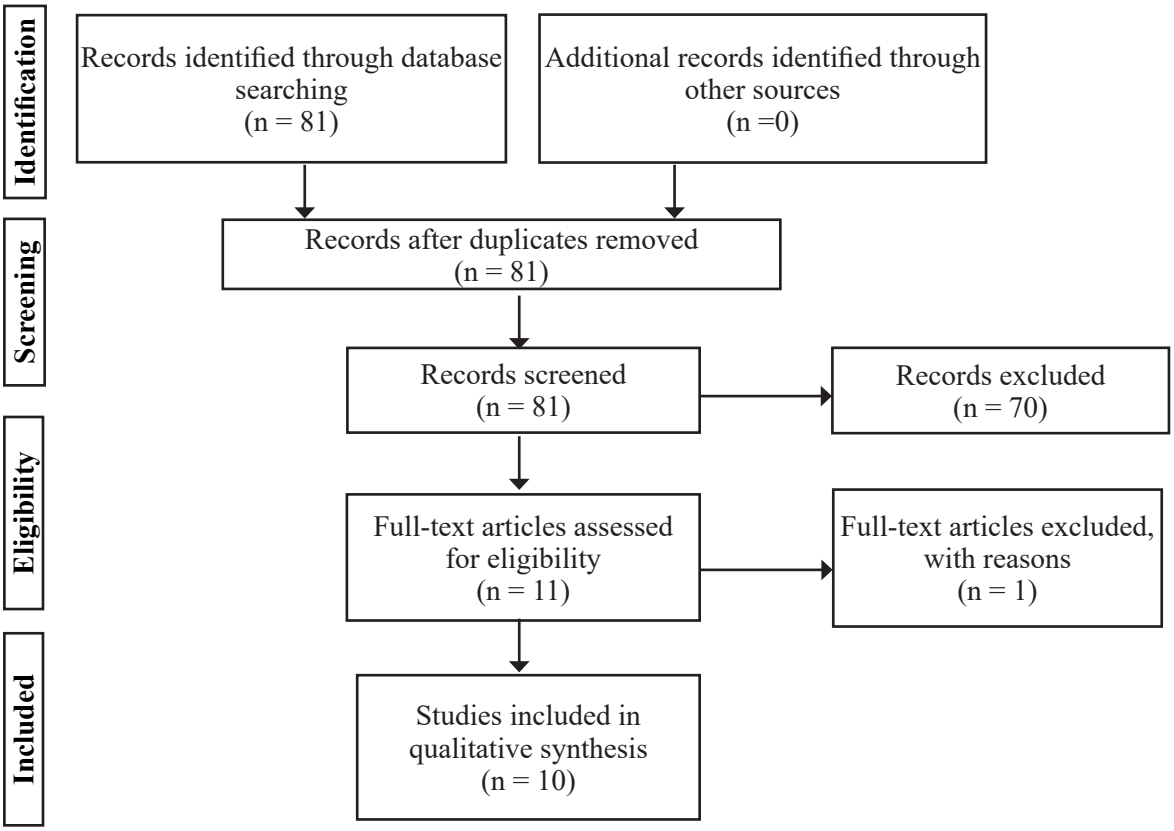

Figure 1. Flow diagram describing the strategy for conducting this study based on PRISMA guideline.

Table 1. Study Characteristic

No	Reference	Journal	Study Design	Level of Evidence
1	Guo S. Et al (2019)	Medical Science Monitor	Retrospective	III
2	Jiang et al (2018)	Medicine Journal	Retrospective	III
3	Gan et al. (2018)	BMC Musculoskeletal Disorders	Retrospective	III
4	Viezens L, et al (2017)	World Neurosurgery	Retrospective	III
5	Wang *et al.*, (2016)	Journal of Musculoskeletal and Neuronal Interactions	Retrospective	III
6	Wang, *et al.* (2016)	Medicine	Case report	IV
7	Yang *et al.*, (2016)	Spine Surgery	Retrospective	III
8	H. Yang et al. (2016)	Journal of Clinical Neuroscience	Retrospective	III
9	Xiong W. (2020)	Journal of Orthopaedic Surgery and Research	Prospective cohort	III
10	Xu Z. (2020)	Journal of Orthopaedic Surgery and Research	Prospective cohort	III

Table 2. Summary of total sample, demographic data, site of infection and preoperative spinal status

No	Reference	Total Sample Size	Group		Age	Gender		Spinal Level	Preoperative Neurological Status
			Control	Intervention		Male	Female		
1	Guo S. Et al (2019)	42	22	20	26-67	23 (54.7)	19 (45.3)	Thoracolumbar	N/A
2	Jiang et al (2018)	33	15	18	26–85	17 (51.5%)	16 (48.5)	L1-L5	N/A
3	*Gan et al.* (2018)	35	N/A	35	25–83	16 (45.7%)	19 (54.3%)	Thoracolumbar	Frankle C,D,E
4	Viezens L,et al (2017)	148	73	75	MIS (64.1±13.7); Open surgery (64.1±13.7)	85	63	Thoracolumbar	N/A
5	Wang *et al.*, (2016)	22	N/A	22	28–79	12 (54.5%)	10 (45.5%)	L2-L5	Frankle C,D,E
6	Wang, *et al.* (2016)	1	N/A	1	68	0 (0%)	1 (100%)	L1-L2	Frankle E
7	Yang *et al.*, (2016)	34	N/A	34	Mean 59	17 (50%)	17 (50%)	Thoracolumbar	ASIA B,C,D
8	H. Yang et al. (2016)	31	N/A	31	33–78	19 (61.3)	12 (38.7)	Thoracolumbar	ASIA C
9	Xiong W. (2020)	23	NA	23	17–71	13 (56,52%)	10 (43,48%)	Thoracolumbar	ASIA C, D, E
10	Xu Z. (2020)	62	NA	62	33.5-61.5	33 (53,23%)	29 (46,77%)	L2-S1	N/A

Table 3. Minimally invasive surgery technique

No	Reference	Antimicrobial	Surgical Technique				
			Imaging Guidance	Approach	Internal Fixation Type	Incision Length (cm)	Decompression Method
1	Jiang et al (2018)	Isoniazid (300 mg/d), rifampicin (450mg/d), ethambutol (750 mg/d), and streptomycin (750 mg/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
2	Wang et al (2016)	Rifampicin (450 mg per day, PO), isoniazid (300 mg per day, PO), pyrazinamide (750 mg per day, PO), and Streptomycin, (75 mg per 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
3	Gan et al. (2018)	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.
4	Wang et al (2016)	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.
5	Yang et al (2016)	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 cm	No decompression needed
6	H Yang et al (2016)	INH (300 mg), rifampicin (450 mg), ethambutol (750 mg) and pyrazinamide(1500 mg)	C-arm fluoroscopy	Posteromedial	N/A	5	Opening the laminae to expose the dural sac
7	Xiong W (2020)	Isoniazid (5 mg/kg, 300 mg/day), rifampicin (15 mg/kg, 600 mg/day), pyrazinamide (25 mg/kg/, 2 g/day), and ethambutol (15 mg/kg, 750 mg/day).	Fluoroscopy	Lateral	Unilateral pedicle screw fixation	3 cm	Nerve hook or a small curved curet
8	Xu Z (2020)	Isoniazid (300 mg/day), rifampicin (450 mg/day), and pyrazinamide (750 mg/day), and ethambutol (750 mg/day).	C-arm fluoroscopy	One-stage posterior	Pedicle screws fixation	N/A	Curettes of varying angles

Table 4. Comparison of Minimal Invasive Approach and Open Approach

No	Reference	Antimicrobial	Group	Intervention				
				Imaging Guidance	Approach	Incision Length (cm)	Internal Fixation Type	Decompression method
1	Guo S. Et al (2019)	Isoniazid 300 mg/day, rifampin 600 mg/day, pyrazinamide 1500 mg/day, ethambutol 1000 mg/day	MIS Group	C-arm fluoroscopic	Transverse	1.0 cm	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
2	Viezens L,et al (2017)	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

Table 5. Outcome Characteristic of Minimally Invasive Surgery

No	Reference	Functional			Intraoperative		Radiological	Length of stay	Follow up period	Complication
		Neurological	ODI	VAS	EBL (ml)	Duration (minutes)				
1	Guo S. Et al (2019)	N/A	N/A	Preop PPS 7.64±0.95 , postop 2.45±1.22 Preop Hybrid 7.75±1.07 , Post op 2.65±1.79	PPS 73.05±36.78 Hybrid 310.75±65.84	PPS 121.86±24.94 Hybrid274.95±32.70	N/A	PPS 8.05±1.70 Hybrid 16.75±4.51	1, 6, 12, and 18 months 1, 6, 12, and 18 months	No complication
2	Jiang et al (2018)	N/A	N/A	N/A	NAV : 316±65.3 Non NAV 344±48.8	NAV :69.1±1.9 Non NAV :75.5±4.4	N/A	NAV :9.9±1.8 Non NAV :10.1±1.5	1, 3, 6, and 12 months 1, 3, 6, and 12 months	N/A
3	Gan et al. (2018)	FRANKEL E	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.
4	Viezens L,et al (2017)	Improvement preoperative Frankel Grade post operative	N/A	N/A	N/A	N/A	N/A	MIS 23.9±18.0 Open surgery : 29.1±25.7	N/A N/A	Wound-healing difficulties or screw misplacement
5	Wang et al., (2016)	FRANKEL E	Preoperative grade: 57.2±6.1 and postoperative: 23.0±3.1	Preoperative grade: 6.4.2±1.2 and postoperative: 0.6±0.7	249.8.2±27.8	347.5±20.7	Cobb angle (L1-L5) --> preoperative grade: 23.9±1.9 and postoperative: 24.5±1.4	25.8±1.9	12.4±1.1 months (11 to 15 months)	Psoas abscess in 1 patient
6	Wang, et al. (2016)	FRANKEL E	Preoperative grade: 56 and postoperative: 22	Preoperative grade: 4 and postoperative: 0	500	220	Kyphosis angle --> preoperative grade: 33.5 and postoperative: 14.8	8	12 months	No complication
7	Yang et al., (2016)	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
8	H. Yang et al. (2016)	ASIA E	N/A	Preoperative : median 5.8, postoperative : median 1.2	90	80	Average Cobb angle increased 8.6^0	N/A	0.5, 1, 2, 3, 6, 12 and 18 months	No
9	Xiong W. (2020)	Complete recovery at the last follow-up	Pre-operative: 4.2 ± 6.7 Post-operative: 26.5 ± 6.8 ($p<0.05$)	Pre-operative: 7.6 ± 0.9 Post-operative: 1.5 ± 0.7 ($p<0.05$)	223 ± 97	165 ± 42	Cobb's angle improved significantly from preoperative 23.2 to 13.2° and maintained at 13.5°	N/A	12 to 36 months	No complication
10	Xu Z. (2020)	JOA score from 18.3 ± 3.7 to 26.9 ± 2.2 ($p<0.05$)	Pre-operative: 42.6 ± 6.2 Post-operative:10.2 ± 1.6 ($p<0.05$)	Pre operative: 6.9 ± 1.1 Post-operative:1.0 ± 0.8 ($p<0.05$)	N/A	N/A	Correction rate of lordosis angle 37.8 ± 4.5% Correction of lumbosacral angle 34.1 ± 6.1%	N/A	75.0 ± 11.5 months	• Superficial wound infection: 2 patients • Hypostatic pneumonia: 4 patients • Local abscess recurrence: 1 patient

In all ten 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

The conventional surgical method involves prolonged exposure of the affected areas, with significant morbidity and mortality rates. Prolonged surgery, higher blood loss, significant iatrogenic paraspinal muscle damage, a lengthier hospital stay, and rehabilitation time are all potential risks.[16] 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. The purpose of our investigation is to summarize the current evidence of MIS usage for spine infection surgeries. We 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 10 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. The procedures performed ranged from debridement to internal fixation. As expected, incision in MIS is reduced, with the range of 1-5 cm. 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.[17]

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.[18]

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.[7,19]

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.

Nevertheless, this systematic review can only describing literature level III and level IV based on strength of evidence of each literature. We 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 we find only a few literature that met our inclusion criterias of this systematic review.

Conclusion

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.

CONFLICT OF INTEREST

The authors reported no potential conflict of interest.

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CONTRIBUTIONS

All authors contributed to data analysis, drafting, and revising of the article and agreed to be responsible for all aspects of this work.

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None declare.

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