Adv Ther (2021) 38:1404–1414
https://doi.org/10.1007/s12325-020-01604-7

REVIEW

Comparison Between Fusion and Non-Fusion Surgery for Lumbar Spinal Stenosis: A Meta-analysis

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Received: October 29, 2020 / Accepted: December 9, 2020 / Published online: January 24, 2021

ABSTRACT

Introduction: A large number of studies have shown that, for severe lumbar spinal stenosis, decompression surgery can often obtain better results than non-surgical treatment. However, whether the lumbar spine is fixed after decompression is still controversial. The results of biomechanical studies indicate that there is a correlation between the range of decompression and postoperative spinal instability.
Methods: The multiple databases like Pubmed, Embase, Cochrane databases and China National Knowledge database were used to search for the relevant studies, and full-text articles involved in the evaluation of fusion and nonfusion surgery for lumbar spinal stenosis. Review Manager 5.2 was adopted to estimate the effects of the results among selected articles. Forest plots, sensitivity analysis and bias analysis for the articles included were also conducted.
Results: A total of nine relevant studies were eventually satisfied the included criteria. There were significant differences in length of stay [mean difference (MD) = 3.04, 95% CI (2.00, 4.08), $P < 0.000$]1), but there were no differences in Oswestry Disability Index (ODI score) [MD = − 1.14, 95% CI (− 2.92, 0.63), $P = 0.21$; $I^2 = 87\%$] and complications [RR = 1 with 95% CI (0.69, 1.46), P value of overall effect was 0.98]. The study was robust and limited publication bias was observed in this study.
Conclusion: Our research supported that fusion and nonfusion surgeries had no differences in clinical effects and complications for lumbar spinal stenosis, while fusion surgery involved a longer length of stay than nonfusion surgery.

Keywords: Fusion; Lumbar spinal stenosis; Meta; Nonfusion

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Key Summary Points

Regarding clinical effects, there were no significant differences in success between the fusion and nonfusion groups considering ODI score even in different races.

In the comparison of safety, there was no difference between the fusion and nonfusion groups.

The results of our research showed that fusion surgery involved a longer length of stay than for the nonfusion group.

DIGITAL FEATURES

This article is published with digital features, including summary slide, to facilitate understanding of the article. To view digital features for this article go to https://doi.org/10.6084/m9.figshare.13341893.

INTRODUCTION

Lumbar spinal stenosis is caused by a reduction in the volume of the lumbar spinal canal due to various reasons, resulting in compression of adjacent nerve roots and the spinal cord. The cause of the disease is complex and can be by congenital lumbar spinal dysplasia, degenerative spinal disease, traumatic spinal fractures and lumbar surgery [1–3]. The main clinical manifestations are intermittent claudication and low back pain. Symptomatic analgesia is the main treatment for mild lumbar spinal stenosis. Severe lumbar spinal stenosis requires surgical spinal decompression with or without fusion [4–6].

A large number of studies have shown that, for severe lumbar spinal stenosis, decompression surgery can often obtain better results than non-surgical treatment [7–9]. However, whether the lumbar spine is fixed after decompression is still controversial. The results of biomechanical studies indicate that there is a correlation between the range of decompression and postoperative spinal instability. Decompression and infusion have the risk of secondary spondylolisthesis. Increasing fusion after decompression can maintain mechanical stability, but fusion will be accompanied by complications. However, some studies have pointed out that, for patients with single-segment or two-segment lesions, there is no significant statistical difference between simple decompression treatment and fixed surgery after decompression in the short term [10, 11].

In recent years, a non-fusion dynamic stabilization system that protects sports has been partially used to treat degenerative spinal diseases. As an alternative to fusion, non-fusion dynamic stabilization has many advantages [12, 13]. This procedure increases spinal mobility by removing the disc and facet joints, and stabilizes the spinal cord segment without fusion. Studies have shown that, compared to simple conservative treatment, the dynamic stabilization system has better effects, can effectively retain certain lumbar spine activity, and provide a certain stability [14, 15]. However, to confirm whether the non-fusion technology can effectively prevent the occurrence and development of adjacent segmental degeneration requires long-term and careful observation and research.

The purpose of this meta-analysis was to compare the role decompression with fusion surgery and without fusion in patients undergoing lumbar spinal stenosis. To address these concerns, we performed a meta-analysis that examines the difference between fusion and nonfusion groups for patients with lumbar spinal stenosis.

METHODS

Literature Search Strategy

We searched articles published between January 2000 and March 2020 for fusion surgery and non-fusion surgery. Searchable databases included Pubmed, Embase, Cochrane databases and the China National Knowledge database, and used the following keywords: (1) lumbar spinal stenosis; (2) fusion; and (3) decompression. In the strategy, all these words were combined using the Boolean operator “and”. There were no restrictions on the publication language in the literature search.

Study Selection

After the primary selection, the text of the studies that potentially relevant were reviewed and the studies included must meet the following inclusion criteria:

1. Research comparing patients receiving decompression with fusion surgery and decompression without fusion surgery;
2. Patients with lumbar spinal stenosis;
3. Containing indicators evaluating effectiveness and safety between fusion and non-fusion surgery;
4. Available in full text.

The studies excluded were determined by the following exclusion criteria:

1. Research on other diseases;
2. Patients receiving other surgery;
3. Study lacking available data.

Data Extraction and Quality Assessment

Two reviewers independently scanned the full text of the manuscript and extracted the following data from each eligible study: first author's name, patient age and gender, country of origin, year of publication, sample size, and the size of each article's research time. The methodological quality of the study was evaluated by the Cochrane bias risk assessment tool, which is a comprehensive tool that considers multiple biases.

Statistical Analysis

The review manager (Version 5.2, Cochrane Collaboration, 2011) was used to estimate the impact of the results in the selected report. For continuous results, the mean difference was used to calculate the mean difference. Using I^2 statistics (a quantitative measure of inconsistency between studies), heterogeneity between studies was assessed. Studies with I^2 of 25–50% are considered low heterogeneity, studies with I^2 of 50–75% are considered moderate heterogeneity, and studies with $I^2 > 75\%$ are considered high heterogeneity. If $I^2 > 50\%$, the potential source of heterogeneity was tested by sensitivity analysis, which was carried out by reprinting a study each round and investigating the impact of a study on the combined estimates. In addition, when heterogeneity was observed, a random effect model was used, and, in the absence of a heterogeneity model, a fixed effect model was used. Egger and Begger's tests were used to examine potential publication bias.

Compliance with Ethics Guidelines

This article is based on previously conducted studies and does not contain any new studies with human participants or animals performed by any of the authors.

RESULTS

Search Process

At the end of the electronic search, there were 802 articles. After careful reading, 87 papers met the preliminary criteria. In further screening, 78 articles were excluded because the design of the study failed and the data and article types were insufficient. Finally, 9 papers were selected for analysis. Figure 1 is a flowchart of the identification, inclusion and exclusion, reflecting the search process and the reasons for exclusion.

Characteristics of Included Studies

Table 1 summarizes the types of studies reported and the total number of patients associated with each group. The content includes author, year of publication, country, age, gender, group, sample size and recruitment time. The analysis consisted of 915 patients. All 9 articles were published between 2000 and 2019. The sample size is between 28 and 233. The study included fusion group 431 and non-fusion group 484.

Results of Quality Assessment

The Cochrane risk of bias assessment tool was used to evaluate the risk of patient selection

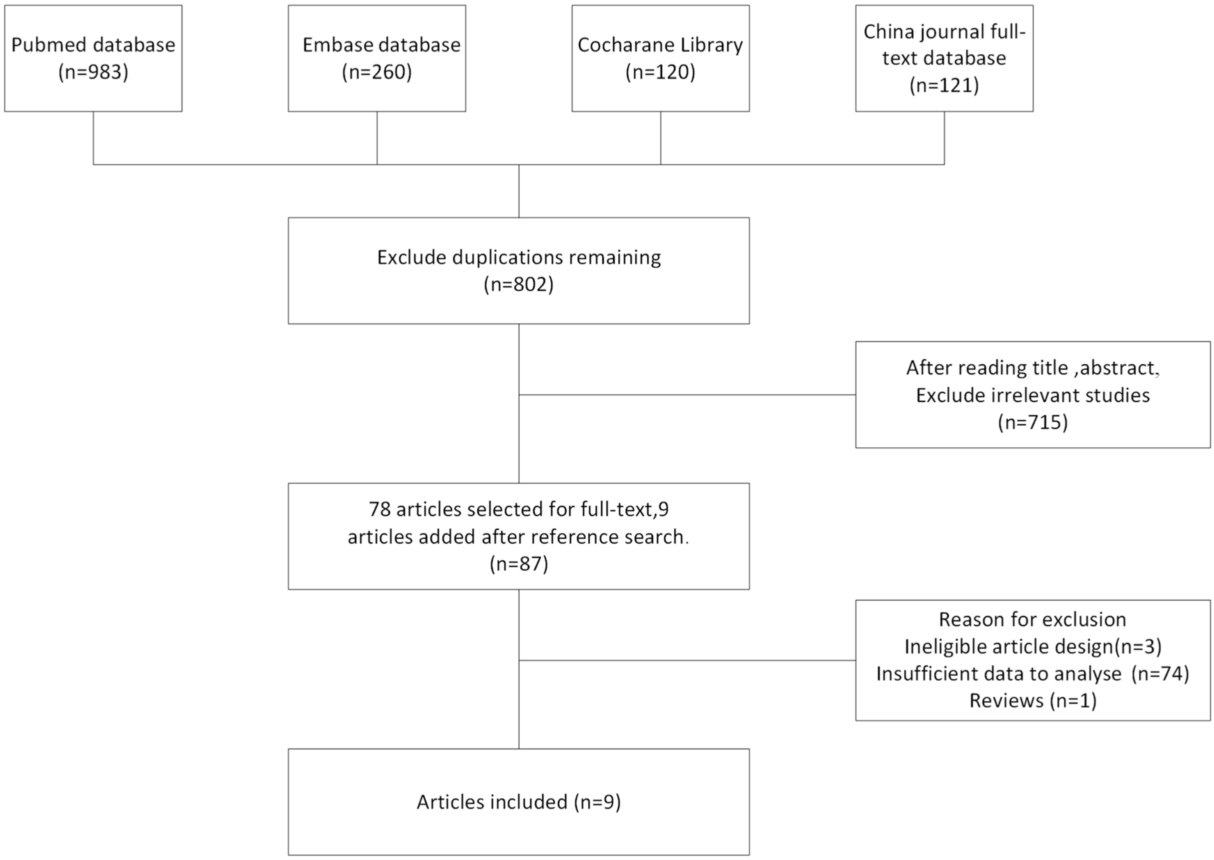

Fig. 1 Flow diagram of the study selection

problems in 9 trials. Only one study showed a problem of attrition bias, and 1 showed reporting bias. In view of the bias summary, there were no problems in selection bias, detection bias and other biases. In general, there were 2 trials with bias risk, and 7 trials had low risk (Figs. 2, 3).

Results of Heterogeneity Test

The Oswestry disability index (ODI) was used to assess subjects with low back pain to determine its impact on the activities of daily living. To analyze the clinical effects difference between decompression with fusion surgery and without fusion surgery, we performed a meta-analysis to calculate the overall mean difference using the fixed effect model in patients with lumbar spinal stenosis based on heterogeneity analysis. The mean difference was – 1.14 with 95% CI (– 2.92, 0.63), $I^2 = 87\%$, which demonstrated that the ODI score between the fusion group and the nonfusion group showed no difference (Fig. 4).

Similarly, a meta-analysis for the evaluation of length of stay (LOS) between vfusion and nonfusion groups was conducted. LOS was analyzed bs a random effectz model. The mean difference of LOS was 3.04 with 95% CI (2.00, 4.08) (Fig. 4). The mean value of LOS in the fusion group was higher than that in the nonfusion group, which supported that fusion surgery might mean a longer time in hospital than for the nonfusion group (Fig. 5).

The heterogeneity of complications was evaluated based onthe a fixed effects model. Insignificant heterogeneity was observed between these studies. The results showed that there was no difference between the fusion and nonfusion groups in evaluation of complications [RR = 1 with 95% CI (0.69, 1.46)] (Fig. 6).

Table 1 Characteristics of studies included in the meta-analysis

Study	Year	Language	Country	Age range (mean)	Groups	*n*	Years of onset
Cabak [16]	2014	English	Poland	54.51 ± 10.65	Fusion	50	1998–2002
					Nonfusion	50	
Dave [17]	2018	English	India	49.73 ± 11.78	Fusion	27	2003–2008
					Nonfusion	37	
Donnarumma [18]	2016	English	Italy	65.29 ± 10	Fusion	92	2010–2014
					Nonfusion	82	
Forsth [19]	2016	English	Sweden	66.75 ± 7.75	Fusion	113	2006–2012
					Nonfusion	120	
Fu [20]	2019	Chinese	China	64.2 ± 6.35	Fusion	32	2014–2016
					Nonfusion	34	
Ghogawala [21]	2016	English	America	66.6 ± 7.6	Fusion	31	2002–2009
					Nonfusion	35	
Hallett [22]	2007	English	England	58 ± 9.5	Fusion	14	1998–2001
					Nonfusion	14	
Park [23]	2007	English	Korea	60.55 ± 10.9	Fusion	32	2003–2004
					Nonfusion	29	
Wu [24]	2018	Chinese	China	69 ± 7.9	Fusion	40	2013–2017
					Nonfusion	83	

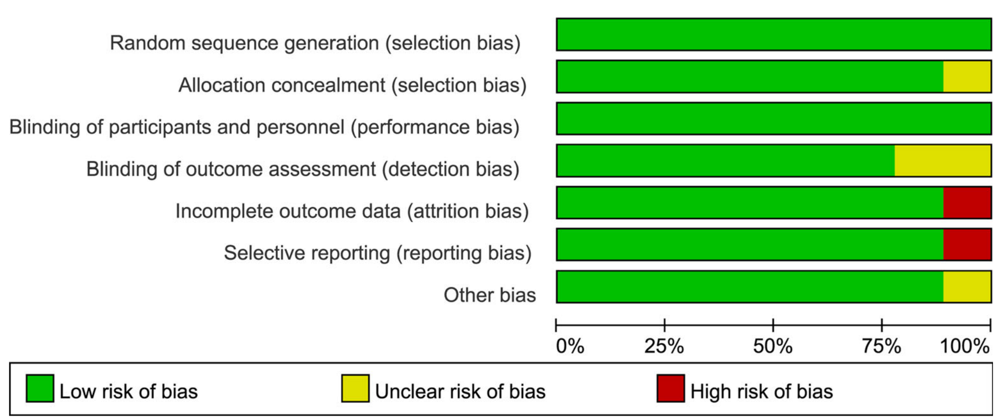

Fig. 2 Assessment of the quality of the included studies: low risk of bias (green hexagons), unclear risk of bias (yellow hexagons), and high risk of bias (red hexagons)

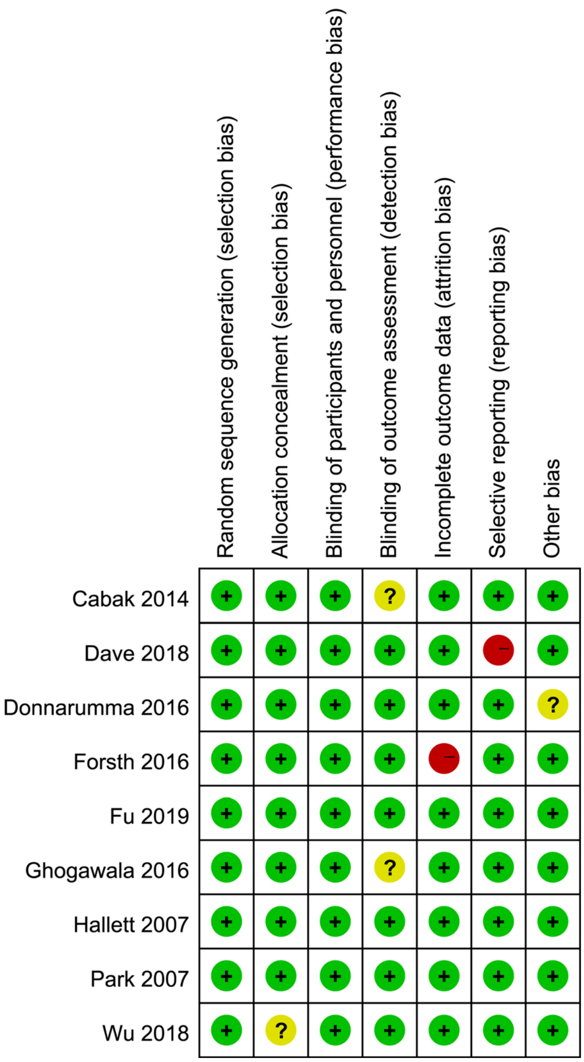

Fig. 3 Quality assessment of included studies

In the subgroup analysis of ODI scores between fusion and nonfusion groups, 6 articles were included. The results of the heterogeneity test showed that, among Caucasians, the ODI score in the nonfusion and fusion groups showed no difference, with the overall mean difference being − 1.65 with 95% CI (− 4.30, 0.9); $I^2 = 69\%$], while in a Mongolian population, the overall mean difference had no significance (Fig. 7).

Results of Sensitivity Analysis and Publication Bias

To examine the stability of the outcome, a sensitivity analysis was required. A relative outlier was excluded, and the result demonstrated that, in the heterogeneity part, the I^2 of sensitivity for the ODI score changed from 53 to 27%, indicating that the heterogeneity is mainly due to the research by Forsth in 2016. The forest plot without Forsth's article is shown in Fig. 8.

A funnel plot for failure load was performed. Six studies were included in the plot. The result indicated that there existed limited publication bias since the symmetrical characteristic of the funnel plot was good (Fig. 9).

DISCUSSION

Lumbar spinal stenosis refers to the abnormality of the bone or fibrous tissue that constitutes the spinal canal, resulting in a decrease in the effective volume in the spinal canal, so that the nerve tissue located in the spinal canal is compressed or stimulated to cause dysfunction. The common symptoms are mainly lumbosacral

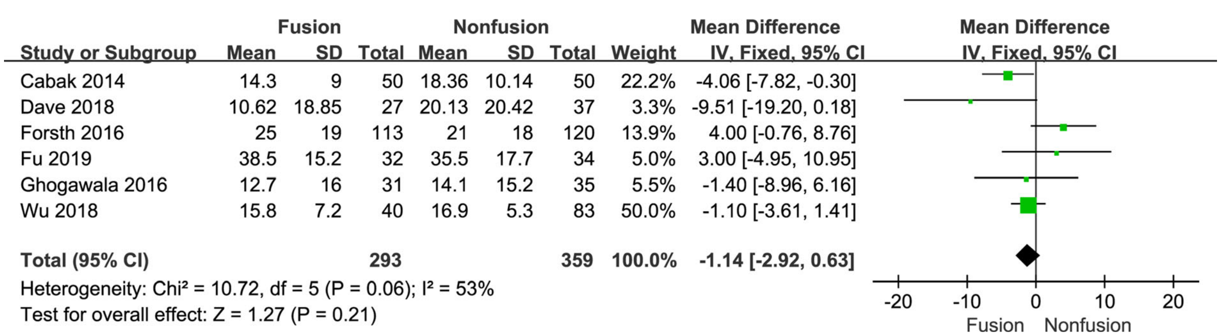

Fig. 4 Forest plots of ODI between the fusion group and the nonfusion group

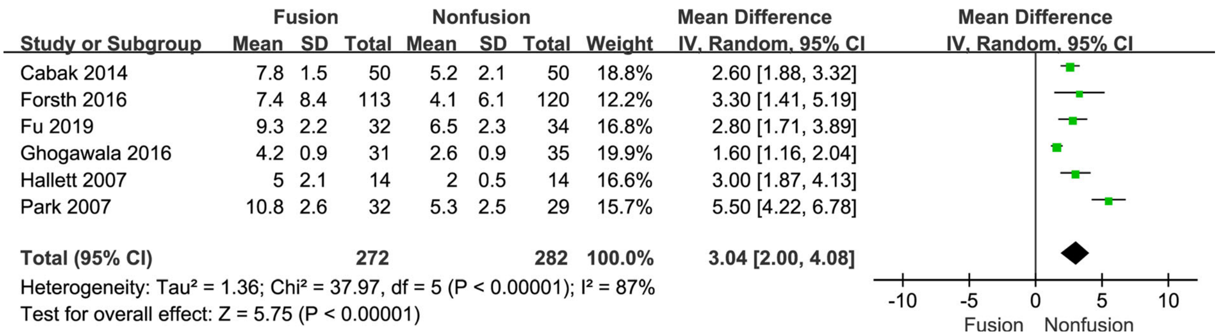

Fig. 5 Forest plots of length of stay between the fusion group and the nonfusion group

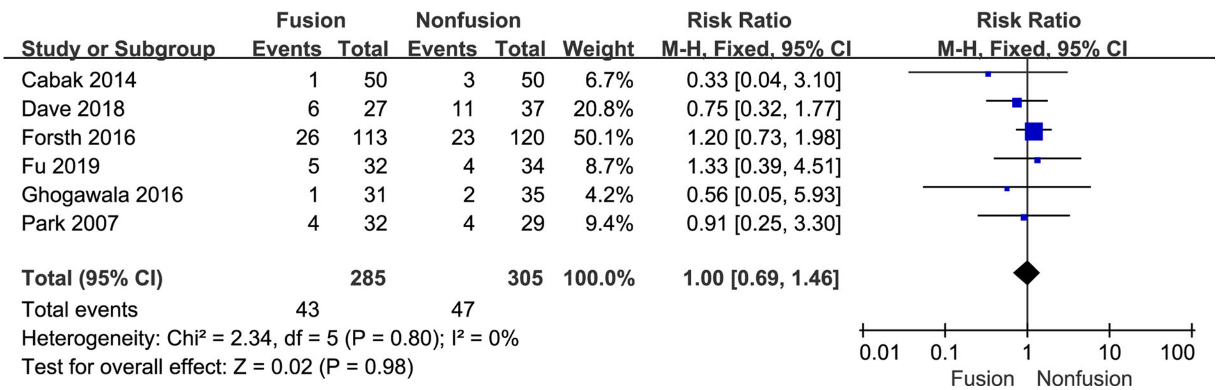

Fig. 6 Forest plots of complications between the fusion group and the nonfusion group

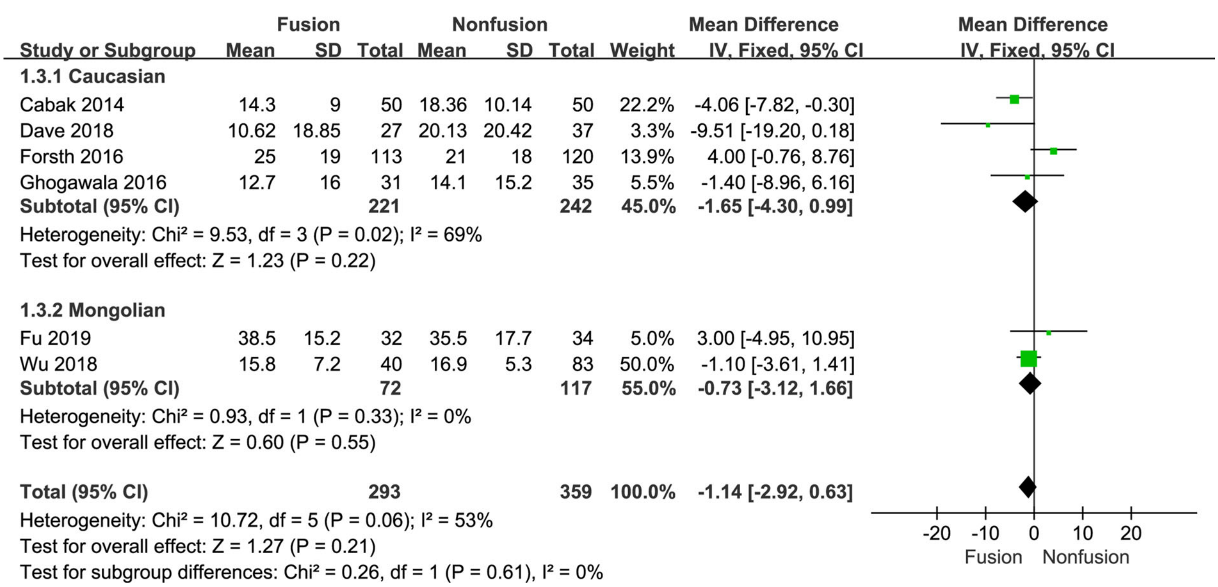

Fig. 7 Forest plots of subgroup in ODI score between the fusion group and the nonfusion group

Study or Subgroup	Fusion Mean	Fusion SD	Fusion Total	Nonfusion Mean	Nonfusion SD	Nonfusion Total	Weight	Mean Difference IV, Fixed, 95% CI
Cabak 2014	14.3	9	50	18.36	10.14	50	25.8%	-4.06 [-7.82, -0.30]
Dave 2018	10.62	18.85	27	20.13	20.42	37	3.9%	-9.51 [-19.20, 0.18]
Fu 2019	38.5	15.2	32	35.5	17.7	34	5.8%	3.00 [-4.95, 10.95]
Ghogawala 2016	12.7	16	31	14.1	15.2	35	6.4%	-1.40 [-8.96, 6.16]
Wu 2018	15.8	7.2	40	16.9	5.3	83	58.1%	-1.10 [-3.61, 1.41]
Total (95% CI)			**180**			**239**	**100.0%**	**-1.97 [-3.88, -0.06]**

Heterogeneity: Chi² = 5.50, df = 4 (P = 0.24); I² = 27%
Test for overall effect: Z = 2.03 (P = 0.04)

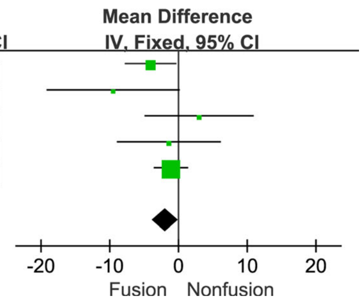

Fig. 8 Forest plots of sensitivity for ODI scores between the fusion group and the nonfusion group

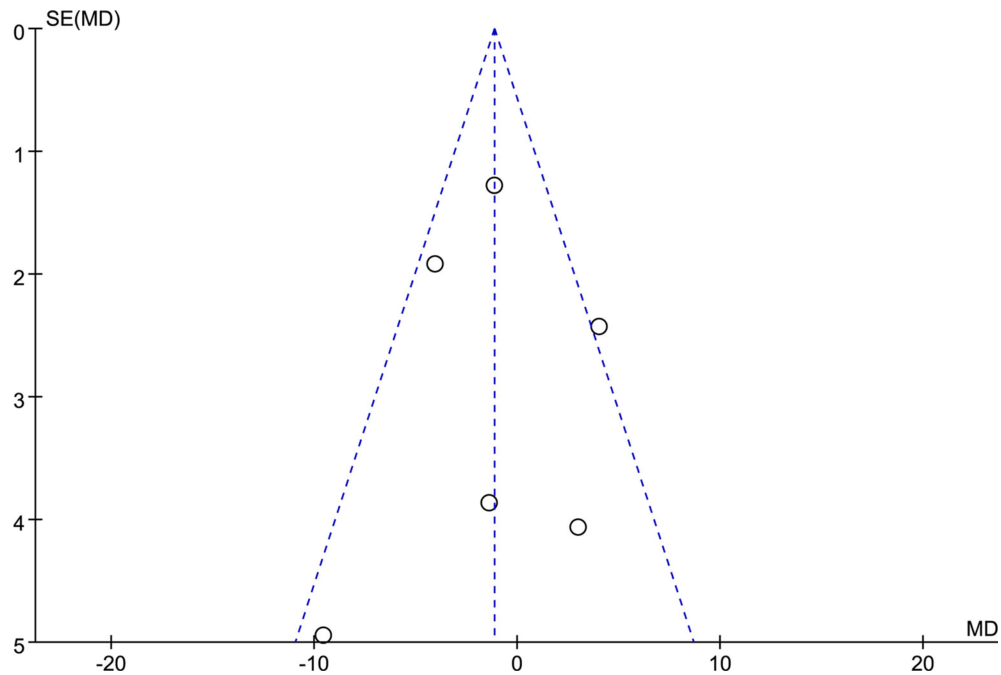

Fig. 9 Funnel plot for failure load including six studies

pain and intermittent claudication, which is one of the common degenerative spinal diseases in the elderly [25, 26]. The common surgical plan is to use traditional conventional treatment methods, including laminectomy, hemilaminectomy, total laminectomy, or minimally invasive surgery. In addition, decompression + fixed traditional conventional treatment is another choice [2, 27]. It can also be treated with minimally invasive surgery. The fusion technology includes the posterolateral interlateral process, posterior interlaminar fusion technology, and intervertebral fusion technology [4].

The process of fusion fixation is as follows: patients stay prone after general anesthesia. The median incision strips the muscles around the spinous process, removes part of the lamina and ligamentum flavum, and loosens the spinal nerve roots [6]. The level of surgery is based on the narrow area shown by the MRI of the lumbar spine. Decompression and stabilization of the narrow segment are usually fixed by posterior pedicle screws of the upper and lower vertebrae, the top vertebra, and the middle vertebra. C-arms are used during fixation to evaluate the accuracy of the fixation, and patients with scoliosis are fixed with rotary compression rods [8, 26].

Non-fusion dynamic stability is conducted as follows: after fully decompressing the nerve root, the distance between the upper and lower pedicles of both sides is measured, and the intercept of the intervertebral tubular sleeve of equal length, and polyethylene terephthalate tape is put into the tubular sleeve between the sleeve and the upper and lower pedicle screws. The small screw is tightened after tightening the multi-polyester fiber band [2].

Concerning clinical effects, there was no significant difference in success between the fusion and nonfusion groups considering the ODI score even in different races. Xu reported that, compared with the simple decompression operation, the more advanced decompression and fusion operation costs more, but has no greater clinical benefit after 2 years [5]. About two-thirds of the subjects were followed up for more than 5 years, and, in these patients, the advantage of decompression plus fusion seemed to last for 5 years. In the comparison of safety, there was no difference between fusion and nonfusion groups. Tokuhashi stated that fusion surgery is associated with an increased risk of serious complications in elderly patients [10]. A large number of analyses of the registration data showed that the inclusion of fusion in decompression doubled the risk of serious adverse events and was associated with an absolute risk difference, which corresponded to the number of injuries required for 30 treated patients, while some other reported that complications was better for patients in the fusion group compared with the nonfusion group [11–13]. Overall, there was no difference in clinical outcome between the fusion and nonfusion groups.

The result in our research showed that fusion surgery meant a longer length of stay than for the nonfusion group. Joshua reported that the addition of a fusion operation in decompression significantly increased the cost of direct hospitalization, including operation and hospitalization costs [12].

CONCLUSION

In conclusion, decompression with fusion surgery had no differences compared with nonfusion surgery in clinical effects and safety while fusion surgery would involve a longer hospital time than nonfusion surgery. In addition, some limitations exist in this article. Firstly, the comparison in different age areas was not considered, which could be evaluated in further research. Secondly, the details about complications were not included, and such details could be evaluated in the future. Thirdly, the sample size in some selected articles was limited. Fourthly, the etiology of spinal stenosis is complex and diverse, which may affect the outcome. Self-reports on symptoms cannot accurately measure the outcome.

ACKNOWLEDGEMENTS

Funding. The authors, their immediate family, and any research foundation with which they are affiliated did not receive any financial payments or other benefits from any commercial entity related to the subject of this article. The Rapid Service Fee was funded by the authors.

Authorship. All named authors meet the International Committee of Medical Journal Editors (ICMJE) criteria for authorship for this article, take responsibility for the integrity of the work as a whole, and have given their approval for this version to be published.

Disclosures. Jian Shen, Qiang Wang, Yingmin Wang, Nan Min, Lin Wang, Fei Wang, Maoyu Zhao, Tongyi Zhang and Qingyun Xue have nothing to disclose.

Compliance with Ethics Guidelines. This article is based on previously conducted studies and does not contain any new studies with human participants or animals performed by any of the authors.

Data Availability. All data generated or analyzed during this study are included in this published article/as supplementary information files.

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