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Evidence-Based Systematic Reviews

Rate of Reoperation Following Decompression-Only Procedure for Lumbar Degenerative Spondylolisthesis

A Systematic Review of Literature

Sathish Muthu, MS, DNB, MNAMS, Stipe Ćorluka, MD, Zorica Buser, MBA, PhD, James G. Malcolm, MD, PhD, Zhuojing Luo, MD, PhD, Prajwal Gollahalli Shivashankar, MS, Luca Ambrosio, MD, Cristiana Griffoni, PhD, Andreas K. Demetriades, MPhil, FRCSEd(NeuroSurg), FEBNS, Stjepan Ivandić, MD, Yabin Wu, PhD, Jeffrey Wang, MD, Hans-Jorg Meisel, MD, and Tim Sangwook Yoon, MD, PhD, FAOA

Investigation performed at AO Spine Knowledge Forum Degenerative, AO Spine, AO Network Clinical Research, AO Foundation, Davos, Switzerland

Background: Management of lumbar degenerative spondylolisthesis with decompression-only procedure has been performed for its added benefit of a shorter duration of surgery, lower blood loss, and shorter hospital stay. However, reported failure rates for decompression-only procedures vary depending on the methods utilized for decompression. Hence, we aim to identify the failure rates of individual methods of decompression-only procedures performed for degenerative lumbar spondylolisthesis.

Methods: An independent systematic review of 4 scientific databases (PubMed, Scopus, clinicaltrials.gov, Web of Science) was performed to identify relevant articles as per the preferred reporting in systematic reviews and meta-analysis guidelines. Studies reporting on failure rates defined by reoperation at the index level following decompression-only procedure for degenerative lumbar spondylolisthesis were included for analysis. Studies were appraised using ROBINS tool of Cochrane, and analysis was performed using the Open Meta[Analyst] software.

Results: The overall failure rate of decompression-only procedure was 9.1% (95% confidence interval [CI] [6.5-11.7]). Furthermore, open decompression had failure rate of 10.9% (95% CI [6.0-15.8]), while microendoscopic decompression had failure rate of 6.7% (95% CI [2.9-10.6]). The failure rate gradually increased from 6.9% (95% CI [2.0-11.7]) at 1 year to 7% (95% CI [3.6-10.3]), 11.7% (95% CI [4.5-18.9]), and 11.7% (95% CI [6.6-16.7]) at 2, 3, and 5 years, respectively. Single level decompression had a failure rate of 9.6% (95% CI [6.3-12.9]), while multilevel decompression recorded a failure rate of 8.7% (95% CI [5.6-11.7]).

Conclusion: High-quality evidence on the decompression-only procedure for degenerative spondylolisthesis is limited. The decompression-only procedure had an overall failure rate of 9.1% without significant differences between the decompression techniques.

Level of Evidence: Level IV. See Instructions for Authors for a complete description of levels of evidence.

Introduction

Degenerative spondylolisthesis is one of the most common degenerative spine diseases and a significant cause of disability. Nonoperative management including physical therapy, activity modification, and pain alleviation has traditionally been recommended as the first-line treatment for low-grade spondylolisthesis. Operative management is recommended in a limited group of patients not responding to nonoperative

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treatment methods and leads to better patient outcomes concerning pain and function[1]. While operative management leads to better patient-reported outcomes in this subset of patients, the selection of appropriate treatment modality (fusion vs. decompression) and the extent of operative intervention is still a controversial topic.

The decompression-only procedure intends to achieve pain relief by resecting the cause of neural compression for example, partial lamina removal (laminotomy). The aim was to provide neural decompression through direct means by removing an offending anatomic structure. However, pain due to instability may not be addressed by this procedure. The procedure is associated with lower blood loss and operative time, as well as the length of hospital stay[2]. Recent studies have demonstrated similar pain and functional outcomes for decompression-only procedures compared with fusion[2-4]. The added benefit of a shorter duration of surgery, lower blood loss, and shorter hospital stay, decompression-only procedure presents an acceptable, less invasive treatment option associated with lower morbidity and reduced surgical trauma. Laminectomy alone is accompanied by lower rates of complication and mortality in elderly patients[5,6]. Furthermore, decompression alone may be a viable surgical option in patients with risk factors for failure of fusion such as frailty, smoking, or severe osteoporosis[6].

Reported failure rates for decompression-only procedures vary from 0% to 37.5% among studies[2,5]. One of the issues in comparing failure rates may be the lack of a standard definition of failure. Failure may be defined as the need for reoperation at the index level of previous surgery. However, one should consider that reoperation is performed at the discretion of the treating surgeon and that the threshold for performing a reoperation in an unsatisfied patient could be lower if there is another treatment option, such as fusion[4]. This may partially explain higher reoperation rates for decompression-only procedures compared with fusion[7]. Interpreting the different rates of reoperation among studies is difficult because it often reflects the subjective preferences of surgeons and patients involved in the treatment decision[8].

It has also been argued that different failure rates may be due to variations in surgical technique and amount of resection such as laminotomy compared with laminectomy[2]. In a recent meta-analysis comparing decompression with fusion in low-grade spondylolisthesis, an 8.5% reoperation rate was noted for decompression-only procedures with the most common reasons for reoperation being recurrent stenosis, increased listhesis, and disc herniation[8,9]. However, there exists a wide variety of surgical options to perform decompression-only procedures such as single or multilevel open laminotomy or laminectomy, interlaminar decompression, laminotomy with tubular retractors, and microendoscopic decompression. While laminectomy involves complete removal of the lamina to aid in the indirect decompression to address the secondary stenosis due to spondylolisthesis, laminotomy involves making a rent in the region of interest in the lamina where the compression is much pronounced to prevent inadvertent destabilization of the posterior elements. Interlaminar decompression involves the utilization of the interlaminar window to decompress the degenerative elements causing canal stenosis. Furthermore, the approach utilized to perform these decompression methods dictates the extent of destabilization incurred. The minimally invasive methods utilizing microscopes, tubular retractors, and endoscopes limit the injury to the posterior musculoligamentous complex. Compared with open complete laminectomy, unilateral laminectomy with bilateral decompression through tubular retractors can result in lower instability rates with similar clinical outcomes[10]. The success of the decompression technique relies on a delicate balance between inadequate resection that fails to provide satisfactory pain relief and too much resection that may lead to iatrogenic instability and mechanical pain. Current evidence suggests that less invasive surgical techniques with preservation of posterior elements may provide superior results.

The purpose of this study was to identify the need for reoperation with the individual methods of decompression-only procedures performed for degenerative lumbar spondylolisthesis.

Methods

The present systematic review was conducted according to the Preferred Reporting in Systematic Reviews and Meta-analysis (PRISMA) guidelines[11]. The protocol of the study was registered in the prospective registry for systematic reviews before the start of the study (CRD42022353300)

Literature Search

Two individual researchers (S.M., S.C.) independently reviewed 4 scientific databases (PubMed, Scopus, clinicaltrials.gov, Web of Science) to identify relevant articles. The algorithms used for the literature search included the following keywords: "decompression," "spondylolisthesis," "degenerative," "laminectomy," "laminotomy," and "surgical management." Appropriate adjustments to the algorithms were made for each of the databases using Boolean operators such as "AND," "OR," and "NOT." The algorithms used in the included databases are presented in Appendix 1, http://links.lww.com/JBJSOA/A638. The bibliographies of the identified studies were also reviewed for the identification of additional relevant studies. Any conflicts were resolved by consulting a third researcher (Z.B.).

Eligibility Criteria

Following the removal of the duplicates, the titles and abstracts of the identified studies were reviewed for relevance using the online platform www.rayyan.ai, which enables the users to highlight the inclusion and exclusion terms in the title and abstracts to aid in the screening process. The full texts of the possibly relevant studies were then examined against our inclusion criteria. Studies that fulfilled the following inclusion criteria were included in the systematic review:

Patient: adult patients (aged 18 years or older) with lumbar degenerative spondylolisthesis.

Intervention: decompression-only procedure of one approach

Comparison: decompression-only procedure of another approach or no comparator

Outcome: reoperation rate

Study types: prospective and retrospective comparative or noncomparative studies with at least 10 patients per study group

To maintain uniformity in defining the failure across all studies analyzed, reoperation at the index level has been considered as the failure of the decompression-only procedure.

Exclusion Criteria

We excluded observational studies with less than 10 patients; study types such as case reports, letters to the editor, brief reports, conference abstracts, and studies including patients with tumors, infections, spinal cord injuries, trauma/fractures, degenerative scoliosis, skeletal immaturity, patients younger than 18 years; and studies involving decompression-only procedure without a clear description of the procedure.

Data Extraction

Using an Excel form, 2 independent authors (S.M., S.C.) extracted the following data from the studies, if available:

Study characteristics: name of the first author, year of publication, type of study, number of participants in each group

Patient characteristics: age, gender, body mass index (BMI), spondylolisthesis grade, American Society of Anesthesiologists grading

Procedure characteristics: approach and levels of surgery

Outcome parameter: reoperations at the index level, follow-up period

Any discrepancies between the reviewers were resolved by a third investigator (Z.B.).

Quality Assessment

Quality assessment was performed using the ROB 2 tool of Cochrane Collaboration for RCTs with 5 domains of assessment and the ROBINS tool for nonrandomized prospective and retrospective studies using 7 domains of assessment analyzing the confounding bias, selection bias, bias in classification of interventions, deviation bias, missing data bias, measurement bias, and reporting bias. The quality assessment was performed independently by 2 investigators especially looking at the impact of these biases in affecting the robustness of the results derived from them (S.M., S.C.). Any discrepancy is resolved upon discussion with the third investigator (Z.B.).

Statistical Analysis

The meta-analysis was performed using Open Meta[Analyst] software. The reported failures in the included studies were pooled and calculated with 95% confidence interval (CI). The random effects meta-analysis model was used for data synthesis when the heterogeneity of the studies was high (I^2 >50% and $p < 0.10$), otherwise the fixed effects model was implemented. We performed sensitivity and subgroup analysis if heterogeneity was noted among the reported results.

Results

Study Characteristics

Following duplicate removal, 1,560 studies were identified from the included databases and screened for inclusion. After an initial screening of titles and abstracts, we excluded 1,432 studies. The full texts of the 128 remaining studies were then examined against our inclusion criteria, leading to the inclusion of 23 studies[5,6,9,12-31] incorporating 1,865 patients. Among the included studies, reporting reoperation data for decompression-only procedures, only Bisson et al.[25] made a direct comparison of different approaches for performing decompression-only procedures. Hence, a single-arm meta-analysis was performed with the failure data reported in the included studies stratified based on the approaches used to perform decompression-only procedures. The reason for the exclusion of studies from the full-text review is presented in the PRISMA flow diagram in Figure 1. The characteristics of the included studies are presented in Table I.

Risk of Bias Assessment

None of the studies had a high risk of bias to warrant exclusion from the analysis as shown in Figure 2. Some of the included studies had some concerns related to selection bias, missing data bias, and outcome measurement bias as shown in Figure 2, especially in the retrospective studies. However, the overall risk of bias assessment of all the included studies scored low concerns.

Overall Reoperation Rate

We analyzed 23 studies[5,6,9,12-31] with 1,865 patients reporting the reoperation rate of decompression-only procedure for lumbar degenerative spondylolisthesis. We noted significant heterogeneity among the included studies ($I^2 = 79.66\%$, $p < 0.01$) and consequently a random-effects model single-arm meta-analysis was conducted. The overall failure rate of decompression-only procedure was 9.1% (95% CI [6.5-11.7]) as shown in Figure 3.

Subgroup Analysis

We stratified the analysis to explore the heterogeneity by subgroup analysis based on the type of decompression procedure, levels decompressed, and follow-up period.

Upon subgroup analysis based on the type of decompression procedure, it is noted that open decompression had a reoperation rate of 10.9% (95% CI [6.0-15.8]), while microendoscopic decompression had a reoperation rate of 6.7% (95% CI [2.9-10.6]). Decompression with tubular retractors and microscopes had reoperation rates of 9.5% (95% CI [1.7-17.2]) and 9.7% (95% CI [6.0-13.4]), respectively, as shown in Figures 4 and 5.

Upon subgroup analysis based on the levels of decompression procedure, it is noted that single-level decompression had a reoperation rate of 9.6% (95% CI [6.3-12.9]), while multilevel decompression recorded a reoperation rate of 8.7% (95% CI [5.6-11.7]) as shown in Figure 6. Furthermore, when analyzed based on the follow-up period, it is noted that a reoperation rate gradually increased from 6.9% (95% CI [2.0-11.7]) at 1 year to 7% (95% CI [3.6-10.3]) during the second

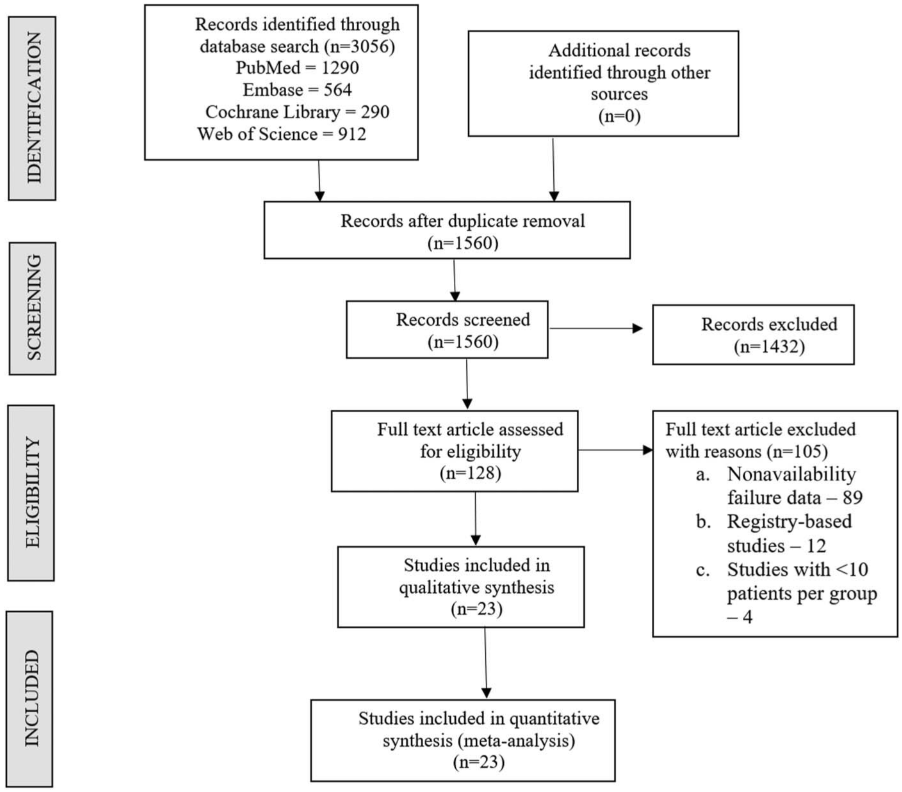

Fig. 1
PRISMA flow diagram of inclusion of studies into the analysis. PRISMA = Preferred Reporting in Systematic Reviews and Meta-analysis.

year. Longer follow-up periods such as 3 and 5 years recorded increasing reoperation rates of 11.7% (95% CI [4.5-18.9]) and 11.7% (95% CI [6.6-16.7]), respectively, as shown in Figures 7 and 8.

Sensitivity Analysis

To further explore the heterogeneity noted in the included studies, we performed a sensitivity analysis to understand the impact of individual studies on the overall estimate. We did not find a single study to significantly modify the final estimate through a leave-one-out analysis of the outcomes presented.

Discussion

Although 4% to 6% of the population suffers from some degree of lumbosacral spondylolisthesis, most of them remain asymptomatic[32]. Nonoperative management remains the mainstay of management, while surgical management is needed only in patients presenting with intractable pain or neurological symptoms[33]. The commonly performed surgical management includes decompression with or without fusion with comparable functional outcomes in either of the procedures[2-4]. The traditional surgical technique for decompression is laminectomy, which is being replaced more and more with less invasive techniques such as unilateral laminectomy and bilateral decompression, tubular microdiscectomy, and endoscopic procedures. Less invasive procedures allow for a smaller incision and minimal tissue dissection with the added advantage of soft tissue preservation[34]. Minimally invasive techniques are associated with several potential drawbacks, including the difficulty of managing instruments through a small portal, inadequate exposure that leads to suboptimal decompression, and longer surgery time due to the learning curve involved[20].

The results of this study showed that open decompression had the highest reoperation rate of 10.9%, while microendoscopic decompression had the lowest reoperation rate of 6.7%. Decompression with tubular retractors and microscopes had reoperation rates of 9.5% and 9.7%. The results of our study are consistent with published reports in the literature and current surgical trends. Based on the reoperation rates estimated from this study, one could consider minimally invasive techniques such as microendoscopic discectomy as a decompression-only procedure of choice whenever possible in the management of lumbar spondylolisthesis with the least reported reoperation rates.

The importance of preservation of midline structures has been emphasized by several studies[2,18,23,30,34,35]. Minamide et al.[18] suggested that the preservation of midline structures enables degenerative spondylolisthesis to continue its natural path to restabilization. Nyström performed interspinous microdecompression, a bilateral laminotomy without preservation of the posterior ligaments, in 200 patients. The authors report a 14.5% reoperation rate with a mean follow-up

TABLE I Characteristics of the Included Studies for Analysis*

Sl. No	Author	Year	Study Design	Decompression Method	Total Patients	Age	Sex	Spondylolisthesis Grade	No. of Levels	Failure Patients	Follow-up	Risk Factors
1	Müslüman[12]	2011	Prospective Cohort Study	Open decompression	84	62.1	52/32	Grade I	1	1	4.4	NI
2	Park[13]	2012	Retrospective Study	Open decompression	20	67.6	5/15	Grade I	1	3	4.4	NI
3	Blumenthal[5]	2013	Prospective Cohort Study	Open decompression	40	68	10/30	Grade I	1	15	3.6	Motion at index level
4	Sato[6]	2015	Retrospective Study	Open decompression	74	65.8	NR	Grade I	1	25	5.9	BMI, disc height
5	Minamide[14]	2015	Prospective Cohort Study	Microendoscopic decompression	61	67.5	NR	Grade I	1	7	5	NI
6	Ahmad[15]	2017	Prospective Cohort Study	Open decompression	83	66	36/47	Grade I–86% Grade II–14%	1/2 level–71% 3/more level–9%	9	1.5	More levels
7	Ikuta[9]	2016	Retrospective Study	Tubular decompression	40	73	19/21	Grade I	1	11	1	NI
8	Jang[16]	2016	Retrospective Study	Microscopic decompression	21	67	6/15	Grade I	1 level–7 2 level–7 3/more level–1	1	4	Motion at index level
9	Staartjes[17]	2018	Prospective Cohort Study	Open decompression	51	52.7	22/29	Grade I	1	4	2	NI
10	Minamide[28]	2018	Prospective Cohort Study	Microendoscopic decompression	156	68.3	NR	Grade I	1	13	4.6	NI
11	Yagi[19]	2018	Retrospective Study	Microscopic decompression	59	68.5	37/22	Grade I	1	7	3	NA
12	Montano[20]	2018	Retrospective Study	Open decompression	28	67.3	13/15	Grade I	1	0	1.4	NA
13	Minamide[21]	2019	Retrospective Study	Microendoscopic decompression	218	69.7	96/122	Early–5 Advanced–145 End stage–13	1	17	2	Advanced disease
14	Nystrom[22]	2020	Retrospective Study	Microscopic decompression	200	65	92/108	Grade I–90% Grade II–10%	1 level–72 2 level–86 3/more level–42	29	3	NI
15	Ravinsky[23]	2020	Retrospective Study	tubular decompression	56	65.6	23/33	Grade I–47 Grade II–9	1 level–41 2 level–15	2	1.7	NI
16	Kuo[24]	2019	Retrospective Study	Open decompression	164	68.5	59/105	NR	1 level–60 2 level–59 3/more levels–45	17	5	NI
17	Bisson[25]	2020	Retrospective Study	Open decompression	69	66.9	42/27	Grade I	NR	3	2	NI
17	Bisson[25]	2020	Retrospective Study	Tubular decompression	71	72.2	32/39	Grade I	NR	10	2	NI
18	Ha[26]	2020	Retrospective Study	Microscopic decompression	36	63.2	14/22	Grade I–29 Grade II–7	1 level–30 2 level–10	2	5	NA
19	Cheng[27]	2020	Retrospective Study	Microendoscopic decompression	53	70.2	13/40	Grade I	1	1	1	NA
20	Zhong[28]	2021	Retrospective Study	Open decompression	37	64.2	19/18	NR	1	4	1.4	NI
21	Sugiura[29]	2021	Retrospective Study	Open decompression	51	70.4	21/30	Grade I	1	4	2.8	NI
22	Liang[30]	2022	Retrospective Study	Tubular decompression	53	62	27/26	Grade I	1	1	2	NA
23	Moayeri[31]	2022	Retrospective Study	Microscopic decompression	140	68	76/64	Grade I	1 level–98 2 level–31 3/more level–11	12	8.2	NI

*BMI = body mass index, NA = not assessed, NI = none identified, and NR = not reported.

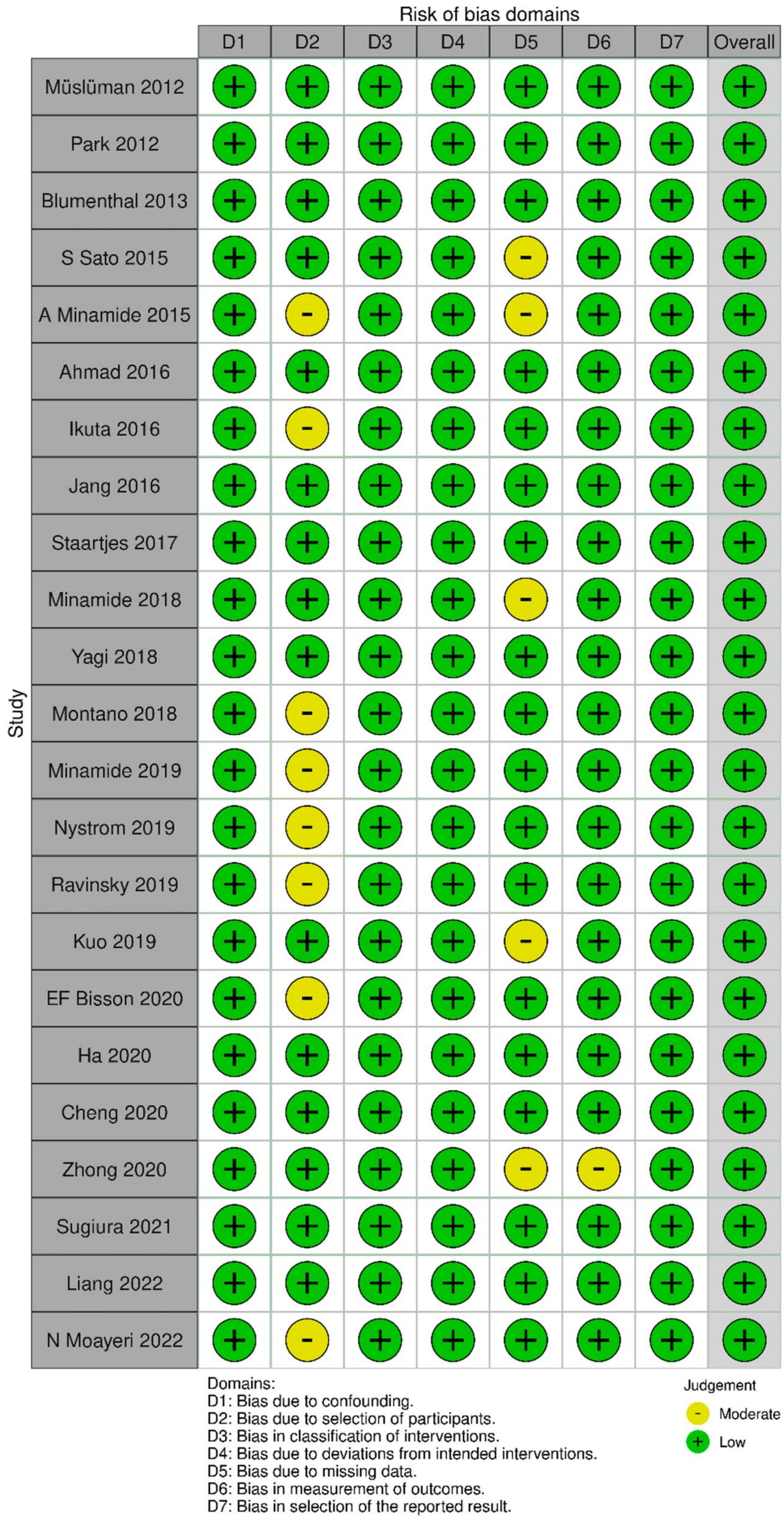
Risk of bias domains
D1
D2
D3
D4
D5
D6
D7
Overall
Study
Müslüman 2012
Park 2012
Blumenthal 2013
S Sato 2015
A Minamide 2015
Ahmad 2016
Ikuta 2016
Jang 2016
Staartjes 2017
Minamide 2018
Yagi 2018
Montano 2018
Minamide 2019
Nystrom 2019
Ravinsky 2019
Kuo 2019
EF Bisson 2020
Ha 2020
Cheng 2020
Zhong 2020
Sugiura 2021
Liang 2022
N Moayeri 2022
Domains:
D1: Bias due to confounding.
D2: Bias due to selection of participants.
D3: Bias in classification of interventions.
D4: Bias due to deviations from intended interventions.
D5: Bias due to missing data.
D6: Bias in measurement of outcomes.
D7: Bias in selection of the reported result.
Judgement
Moderate
Low

Fig. 2-A

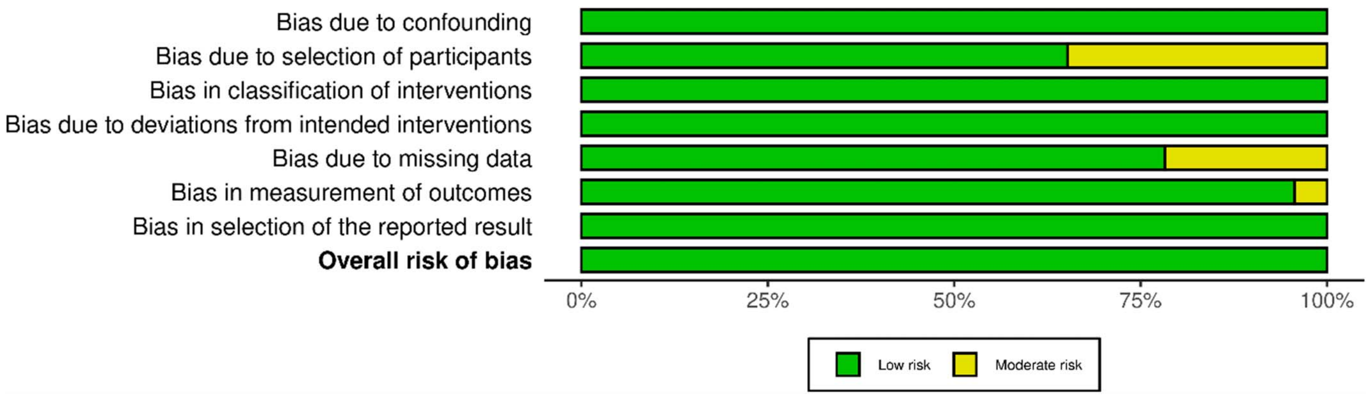

Fig. 2-B

Fig. 2 Risk of bias assessment in the included studies using Cochrane Collaboration's ROBINS tool for nonrandomized studies.

of 6.8 years[22]. This explains the higher reoperation rates noted in open decompression compared with midline-preserving minimally invasive procedures using microscopic or microendoscopic techniques.

The causes of reoperation in the decompression-only procedure for degenerative lumbar spondylolisthesis indirectly relate to the amount of resection performed. It can be either too much resection which may cause iatrogenic instability and slip progression or insufficient decompression which leads to recurrent disease. Furthermore, the reasons for reoperation in minimally invasive decompression procedures mentioned in the literature were adjacent segment disease due to restenosis, stenosis, or disc herniation, followed by instability, scoliosis, and infection[20]. Furthermore, the presence of foraminal stenosis

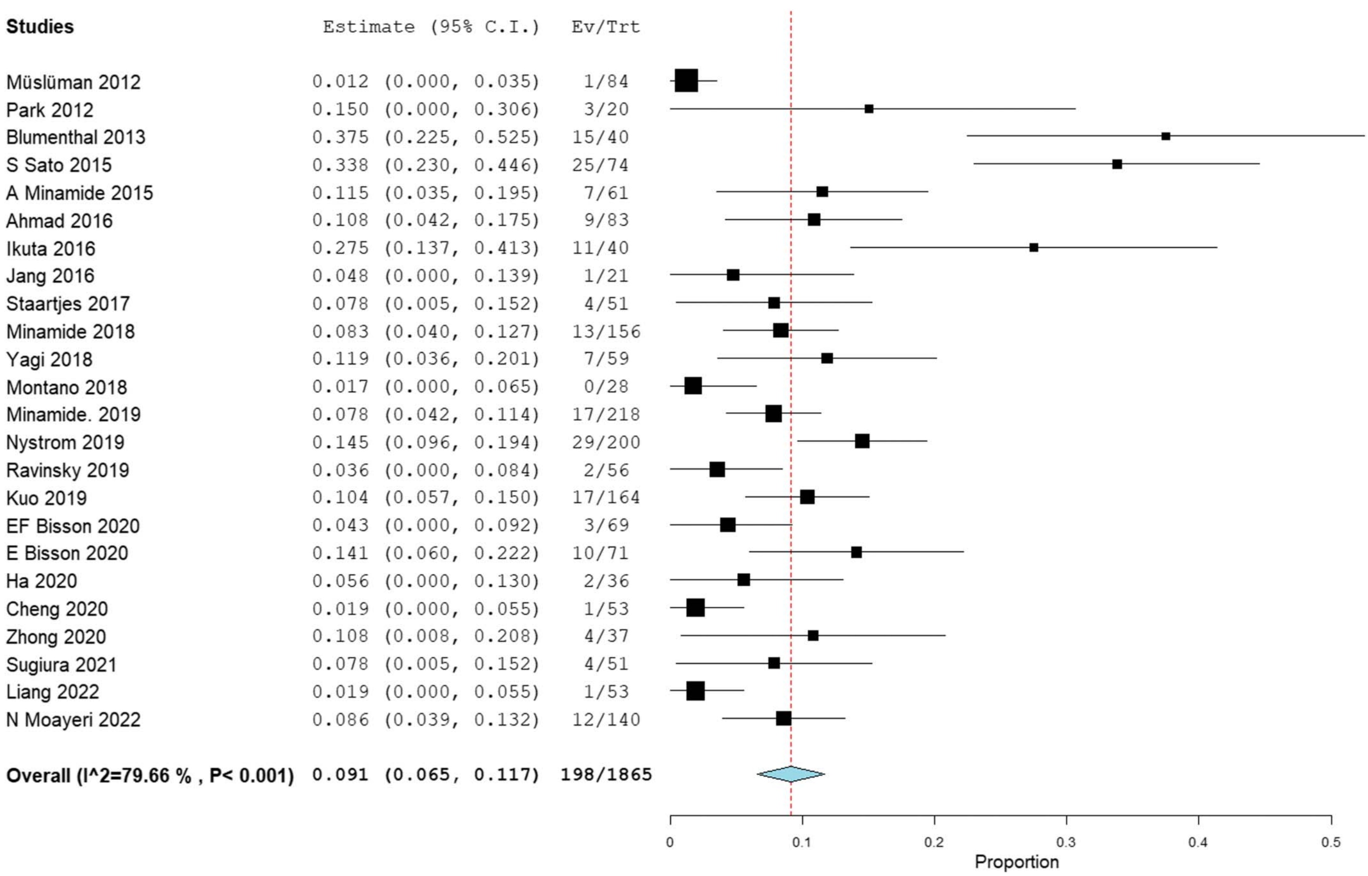

Fig. 3

Forest plot of overall failure rate among the included studies. Evt/Trt denotes the number of failure events for all the patients included in the treatment arm.

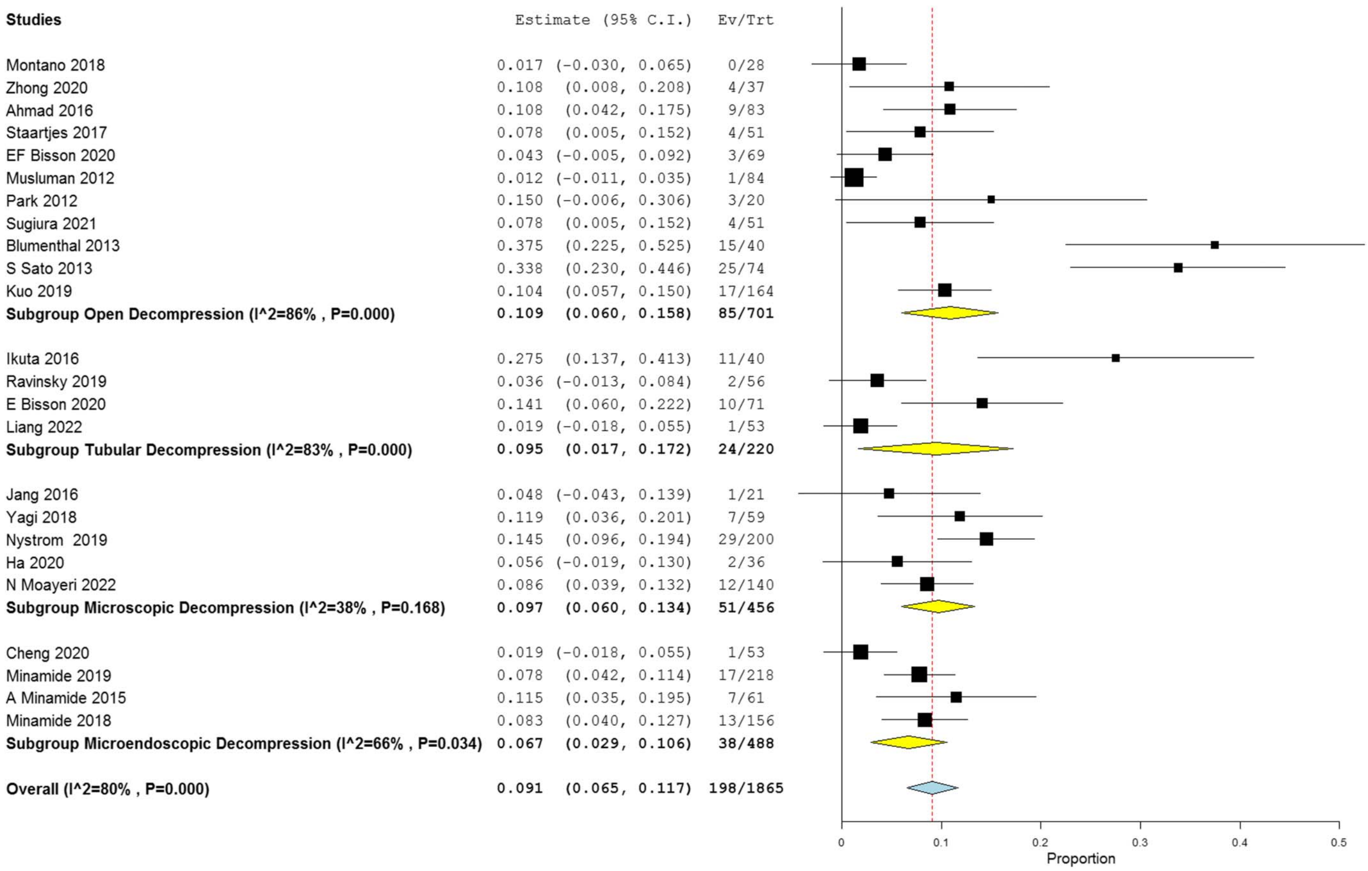

Fig. 4

Forest plot of the subgroup analysis of the included studies for failure rate based on the approach of decompression. Evt/Trt denotes the number of failure events for all the patients included in the treatment arm.

has been identified as a possible reason for revision surgery. However, the results of a study by Park et al.[13] suggest that foraminal stenosis cannot be resolved with decompression alone.

In the study by Ahmad et al.[36], the total failure rate is defined as the number of patients requiring subsequent fusion. The authors report a failure rate of 10% while excluding a patient who had a fracture caused by a fall, with an additional 6% of patients who needed revision decompression not included in the total failure rate. They suggest that 1 in 10 patients treated with decompression only will require fusion in 3 years[36]. Whereas Ravinsky et al.[23] argue that the reoperation rate is a poor metric for surgical failure as it is dependent on the interplay of 3 factors: patient willingness to undergo another operation, surgeon willingness to do a revision procedure involving increased complexity and complications, and the healthcare system itself and availability of resources[23]. Although reoperation at the index level may not reflect the actual failure following the index surgery, it is considered an outcome measure of failure in this study since it is a quantifiable proxy that is uniformly reported in the literature to arrive at an estimate.

The results of our study showed that single-level decompression had a reoperation rate of 9.6%, while multilevel decompression recorded a reoperation rate of 8.7% without any significant difference between them. Ahmad et al. in their study noted that patients undergoing multilevel decompression were unlikely to need fusion as a revision procedure. Furthermore, they argue that only a high risk of complications was noted while opting for a fusion procedure in multilevel disease[36]. In patients with multilevel disease due to the advanced disease process that adds to the inherent stiffness of the spine, further slippage is uncommon, thereby obviating the need for a fusion procedure which only adds to the stiffness resulting in complications. On the contrary, it has also been argued that after multilevel decompressions due to the removal of more structural components, iatrogenic instability may develop, which might lead to the development of postoperative slip progression, but it may not necessarily aggravate symptoms[37].

In the study by Jang et al. an increase in postoperative slippage occurred in 10 of 22 patients (45%), with only one patient requiring the fusion procedure[38]. Similarly, Nyström et al. reported no difference in the outcomes and reoperation rate in patients with postoperative slip progression compared with patients without slippage. In addition, no differences in the occurrence of postoperative slippage were observed between patients operated at one, 2, or several levels[22]. Ravinsky et al.[23] found no correlation between postoperative slip progression and worsening of symptoms. Hence, multilevel decompression despite leading to postoperative slip progression may not be the key

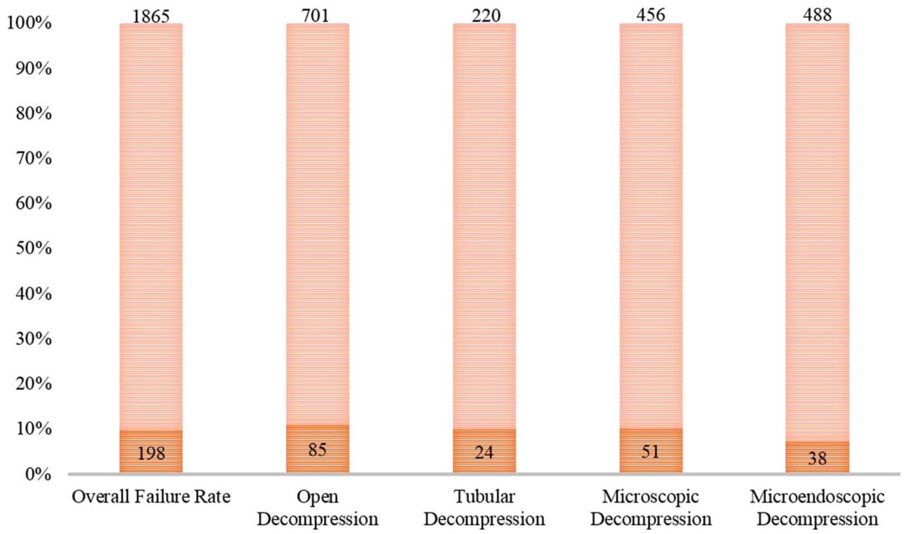

Fig. 5

Bar diagram illustrating the consolidated failure events of various decompression-only procedure approaches among the total patients included for analysis under each category.

dictating factor, resulting in symptomatic patient worsening necessitating revision surgery.

We observed a reoperation rate of 6.9% at 1 year that increased to 7% during the second year. At follow-up periods of 3 years and 5 years, recorded reoperation rate was 11.7%. The results of our study reveal that the lowest failure rate can be observed during the first follow-up year that increases thereafter. This may suggest that a significant worsening of symptoms leading to reoperation starts after the first year. This may be due to progressive mechanical disruption and the development of instability[31]. The lower reoperation rate in the first follow-up year may also reflect the reluctance of surgeons to immediately perform revision surgery, as well as the patient's reluctance. Long-term reoperation can be due to the development of stenosis and a decline in intervertebral stability, while early reoperation can be attributed to poor patient selection or factors such as technical error, wrong diagnosis, or infection[39]. Adding to that, most decompression reoperations are performed in the first 2 years[36]. Hence, one must be watchful for complications while contemplating a decompression-only procedure for lumbar spondylolisthesis for at least 2 years.

Another possible explanation for the higher reoperation rate in later follow-up periods may be due to bony regrowth. Chen et al.[40] report that 94% of patients treated with decompression

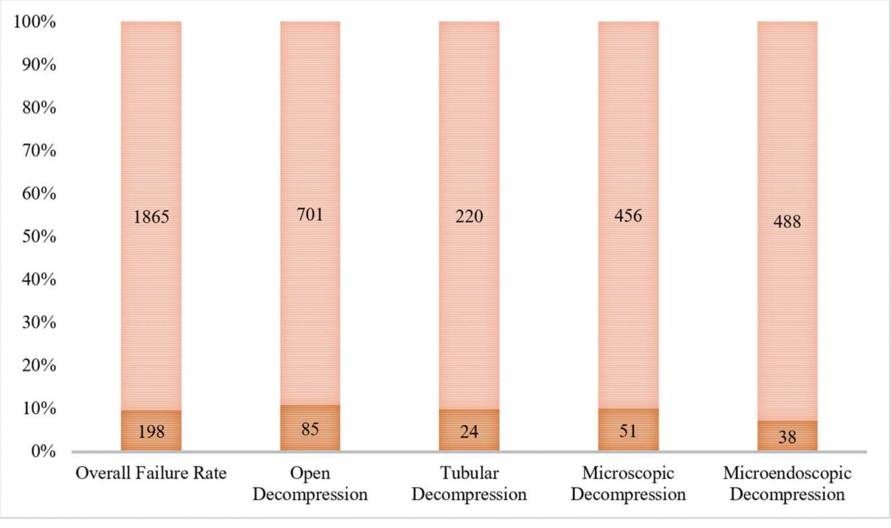

Fig. 6

Forest plot of the subgroup analysis of the included studies for failure rate based on the levels of decompression. Evt/Trt denotes the number of failure events for all the patients included in the treatment arm.

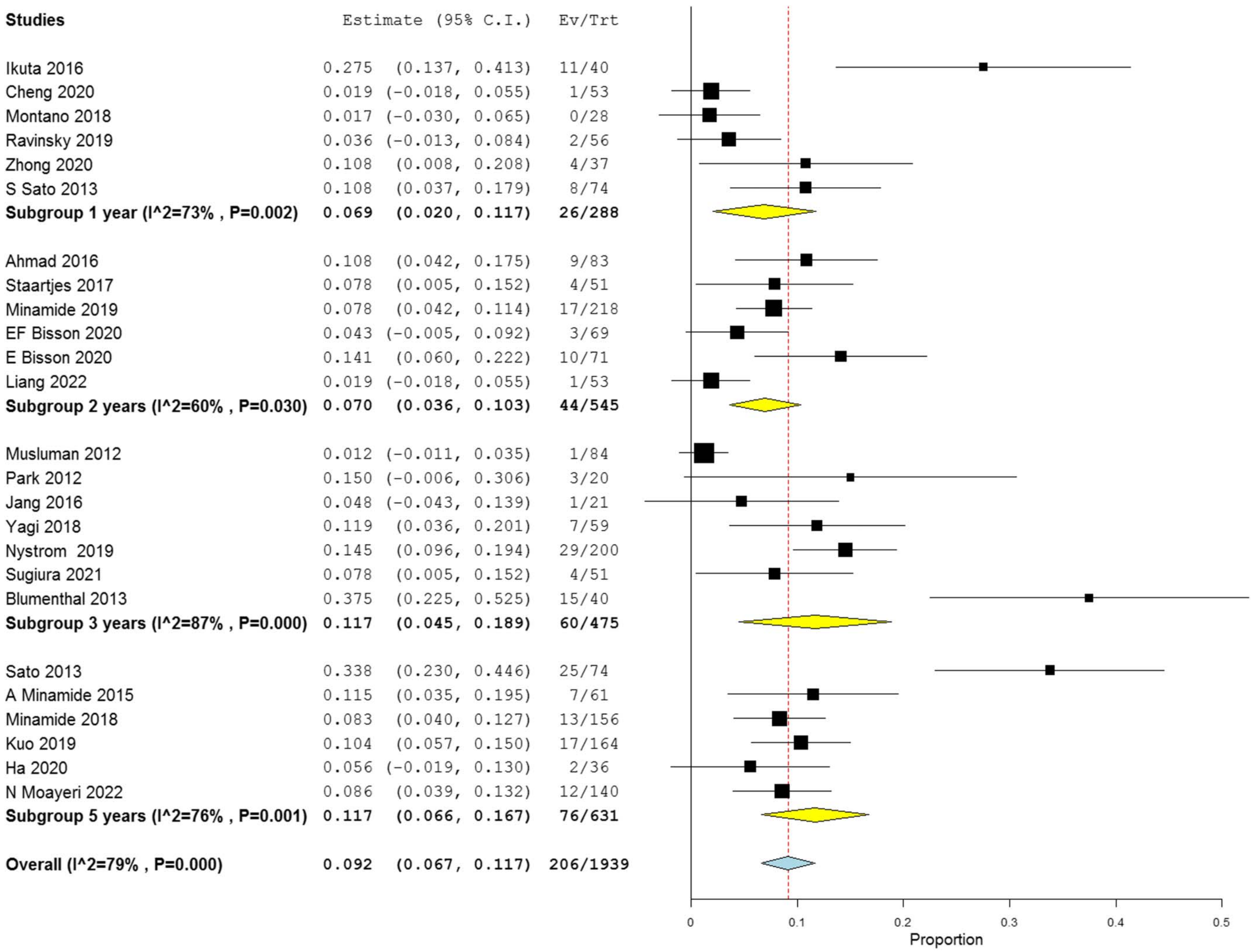

Fig. 7
Forest plot of the subgroup analysis of the included studies for failure rate based on the follow-up time points following decompression procedure. Evt/Trt denotes the number of failure events for all the patients included in the treatment arm.

for spinal stenosis had bony regrowth after 4.5 years. The time to occurrence of symptoms ranged from 3 to 5 years and was more rapid in patients with postoperative instability. Mechanical instability may provide stimulus for bony growth, and higher failure rates in later periods may be the result of the interplay between these factors. On the contrary, although present in most patients after laminectomy, other authors questioned the effect of bony regrowth on clinical results[41].

Sato et al.[6] analyzed reoperation rates of 163 surgically treated patients for degenerative spondylolisthesis with an average follow-up of 5.9 years. The reported reoperation rate for decompression alone at 1 year after surgery was 10.8%. The reoperation rate increased to 33.8% at 5 years postoperatively. A low retrieval rate of 77% may have influenced reoperation rates, as mentioned by the authors. Blumenthal et al.[5] report a reoperation rate of 10% at the 6-month follow-up, which increased to 37.5% at the final follow-up of 3.6 years after the decompression-only procedure, which consisted of facet-sparing decompressive laminectomy. The indication for reoperation was mechanical low back pain that the authors attribute to the development of instability at the index level. In the study by Moayeri et al.[31] among 140 patients with degenerative spondylolisthesis treated with minimally invasive decompression, the reported reoperation rate was 8.6% at a mean follow-up of 5 years.

We considered failure as any reoperation following the index surgery for the persistent symptoms for which the surgery was contemplated. However, it might not be the ideal measure of failure since it would not account for the patients who are not satisfied with the procedure who are unwilling to undergo additional operation as measured by the reported outcomes of patients. However, we considered it as a proxy for the failure of decompression-only procedures since it reflects the absolute number of patients who believed in surgery as the treatment method but were not satisfied with the results of the index surgery. It would also be of importance to examine

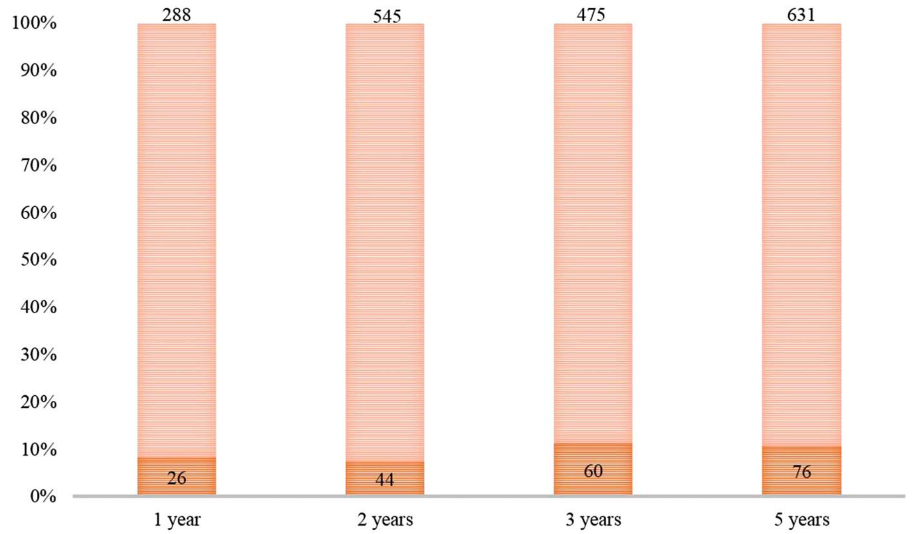

Fig. 8
Bar diagram illustrating the consolidated failures of decompression-only procedure at various time points among the total patients included for analysis at every time point.

whether symptom worsening is correlated with slip progression and whether it is time dependent.

Sato et al.[6] identified a higher BMI and a higher disc height (>10 mm) as risk factors for the development of the same-segment disease, which was the main indication of reoperation in their study. Blumenthal et al.[5] analyzed radiographic parameters in 40 patients undergoing decompression-only procedure and identified motion at spondylolisthesis >1.25 mm measured on flexion-extension radiographs, disc height >6.5 mm, and facet angle >50° as risk factors of instability. A reoperation rate of 75% was observed for patients with all the 3 identified risk factors. Jang et al.[16] report a higher percentage of postoperative slips in patients with sagittal motion in the level of spondylolisthesis identified on preoperative dynamic radiographs.

Minamide et al.[21] argued that degenerative spondylolisthesis is a dynamic and complex disease and defined 3 stages of natural history: an early stage of static slippage, an advanced stage of progressive slippage and instability with preserved disc, and an end stage with static slippage, spondylosis, and loss of disc height. The authors report that all reoperations were performed on patients in the second group. The group was defined by loss of disc height ≤2/3, >10% anterolisthesis, and/or > 3 mm of dynamic translation on flexion-extension films[21].

To further the knowledge of the decompression-only procedure for degenerative lumbar spondylolisthesis, more randomized controlled trials are warranted. The treatment group could therefore include patients with identified risk factors in the aforementioned studies compared with a control group without them. Further analysis for factors such as higher BMI, age, and gender should also be done to validate the plausibility of them being the reason for failure. If possible, the follow-up period should be longer than 5 years. In addition, further subgroup analysis may be performed for the type of intervention to avoid aggregating different types of decompression procedures.

The study has some significant limitations worth acknowledging. The number of available studies, especially exploring the decompression-only procedure for degenerative spondylolisthesis, was very few. Moreover, most of the included studies were retrospective in design, which reduced the overall strength of the evidence generated from the meta-analysis. Hence, we recommend future high-quality randomized controlled trials to be conducted to further identify the appropriate patient population who would benefit from these simple decompression-only procedures. Furthermore, the heterogeneity noted among the included studies could be due to the variability in the risk factors among the patients included, total surgical levels operated, duration of follow-up, and the invasiveness of the surgical procedure included in the analysis. To minimize the impact, we made a subgroup analysis to explore those variables while analyzing the reoperation rate of the decompression-only procedure and given the individual reoperation rates for the subgroup concerned. Furthermore, the included studies did not have uniform follow-up time points to represent a continuous cumulative failure rate as one would expect, but the presented results are from the individual studies reporting failures at particular follow-up duration. Hence, large randomized controlled trials exploring the different techniques of decompression in a more standardized fashion with sequential follow-up at various time points are needed to validate the findings of this study to enable the development of treatment guidelines and recommendations to establish the position of decompression-only procedure for lumbar spondylolisthesis with higher certainty of evidence.

Conclusion

High-quality evidence on the decompression-only procedure for degenerative spondylolisthesis is limited. The decompression-only procedure had an overall failure rate of 9.1% without significant differences between the decompression techniques.

Appendix

eA Supporting material provided by the authors is posted with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJSOA/A638). This content was not copyedited or verified by JBJS. ■

Sathish Muthu, MS, DNB, MNAMS[1,2,3]
Stipe Ćorluka, MD[4,5]
Zorica Buser, MBA, PhD[6]
James G. Malcolm, MD, PhD[7]
Zhuojing Luo, MD, PhD[8]
Prajwal Gollahalli Shivashankar, MS[9]
Luca Ambrosio, MD[10]
Cristiana Griffoni, PhD[11]
Andreas K. Demetriades, MPhil, FRCSEd(NeuroSurg), FEBNS[12]
Stjepan Ivandić, MD[4]
Yabin Wu, PhD[13]
Jeffrey Wang, MD[14]
Hans-Jorg Meisel, MD[15]
Tim Sangwook Yoon, MD, PhD, FAOA[16]

[1]Department of Spine Surgery, Orthopaedic Research Group, Coimbatore, Tamil Nadu, India

[2]Faculty of Engineering, Department of Biotechnology, Karpagam Academy of Higher Education, Coimbatore, Tamil Nadu, India

[3]Department of Orthopaedics, Government Medical College, Karur, Tamil Nadu, India

[4]Spinal Surgery Division, Traumatology Department, University Hospital Centre Sestre Milosrdnice, Zagreb, Croatia

[5]Department of Anatomy and Physiology, University of Applied Health Sciences, Zagreb, Croatia

[6]Department of Orthopedic Surgery, NYU Grossman School of Medicine, New York

[7]Department of Neurosurgery, Emory University, Atlanta, Georgia

[8]Department of Orthopeadic Surgery, Xijing Hospital, China

[9]Department of Spine Surgery, The Bangalore Hospital, Karnataka, India

[10]Department of Orthopaedic and Trauma Surgery, Campus Bio-Medico University of Rome, Italy

[11]Department of Spine Surgery, IRCCS Istituto Ortopedico Rizzoli, Bologna, Italy

[12]Department of Neurosurgery, Edinburgh Spinal Surgery Outcome Studies Group, Royal Infirmary Edinburgh, Edinburgh, UK

[13]Research Department, AO Spine, AO Foundation, Davos, Switzerland

[14]Department of Orthopaedic Surgery, Keck School of Medicine, University of Southern California, Los Angeles, California

[15]Department of Neurosurgery, Bergmannstrost Hospital, Halle, Germany

[16]Department of Orthopaedics, Emory University, Atlanta, Georgia

Email address for corresponding author: S. Muthu: drsathishmuthu@gmail.com

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