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Laminectomy and spinal stability: an evidence-based review of decompression surgery for lumbar spinal stenosis

Abstract

Lumbar spinal stenosis represents one of the most common indications for spinal surgery in adults. While decompressive laminectomy has been the cornerstone of surgical management for decades, there has been considerable debate regarding the necessity of adding instrumented fusion to achieve optimal outcomes. This literature review examines the current evidence comparing decompression alone versus decompression with fusion for lumbar spinal stenosis, with or without degenerative spondylolisthesis. Through a comprehensive search of three major databases (PubMed/MEDLINE, Cochrane Library, and Google Scholar), we identified and analysed high-quality evidence published between 2016 and 2025. This recent evidence consistently demonstrates that decompression alone achieves equivalent functional outcomes, neurological recovery (including improvement of neurogenic claudication and radiculopathy), pain relief, and patient satisfaction compared to decompression with fusion, while offering significant advantages in operative time, blood loss, hospitalization duration, and cost. Additionally, there is evidence to support a reduced incidence of adjacent segment disease in decompression alone versus decompression with fusion. These findings support a necessary paradigm shift toward decompression alone as the preferred surgical approach for most patients with lumbar spinal stenosis, reserving fusion for specific clinical indications supported by objective evidence of instability.

Keywords: laminectomy, spinal stenosis, decompression, fusion, spondylolisthesis, evidence-based medicine

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Introduction

Lumbar spinal stenosis (LSS) is a degenerative condition characterized by narrowing of the spinal canal, lateral recesses, or neural foramina, resulting in compression of neural elements. The condition predominantly affects older adults and manifests clinically as neurogenic claudication, radiculopathy, and in severe cases, cauda equina syndrome. As the population ages, the prevalence of symptomatic lumbar spinal stenosis continues to rise, making it one of the most common indications for spinal surgery in patients over 65 years of age.

Surgical decompression, typically performed via laminectomy, has been the standard treatment for patients with symptomatic LSS who fail conservative management. The procedure involves removal of the posterior bony and ligamentous structures (primarily the laminae and ligamentum flavum) to relieve pressure on the neural elements. This technique, first described in the early 19th century, has evolved considerably but retains its fundamental objective: neural decompression while preserving spinal stability.

A central question in contemporary spine surgery concerns whether decompression alone is sufficient or whether the addition of instrumented fusion provides superior outcomes. Proponents of fusion argue that removing posterior elements may compromise spinal stability, potentially leading to progressive deformity, recurrent stenosis, or persistent symptoms. This perspective has led to a substantial increase in fusion procedures over the past two decades, with attendant increases in surgical complexity, morbidity, and healthcare costs.

However, the theoretical concerns about post-laminectomy instability must be weighed against clinical evidence. The purpose of this review is to examine the current evidence base comparing decompression alone versus decompression with fusion, with the goal of providing clinicians with an objective, evidence-based framework for surgical decision-making.

Biomechanical foundations: the three-column model

Before examining the clinical evidence, it is essential to understand the biomechanical principles that inform our approach to spinal stability. In 1983, Francis Denis introduced the three-column model of spinal stability, a conceptual framework of spinal stability.[1] This model divides the spinal column into three longitudinal structures, each with distinct biomechanical roles.

The anterior column comprises the anterior longitudinal ligament, the anterior half of the vertebral body, and the anterior portion of the intervertebral disc. It primarily resists axial compression and contributes to sagittal balance. The middle column, composed of the posterior half of the vertebral body, the posterior annulus fibrosus, and the posterior longitudinal ligament, functions as the central fulcrum of the spinal construct. Damage to this segment often signals true instability, as it disrupts both load transmission and tension integrity. The posterior column includes the vertebral arch, facet joints, and posterior ligamentous complex. While important for controlling motion and limiting excessive flexion, it is not directly involved in axial load bearing.

Denis asserted that spinal stability is preserved when at least two of these three columns remain structurally intact. A standard decompressive laminectomy, when performed properly, involves removal of elements limited to the posterior column (the laminae and ligamentum flavum) while leaving the vertebral bodies, intervertebral discs, and facet joints intact. According to Denis' biomechanical

principles, such a procedure does not breach the integrity of the middle or anterior columns and thus does not meet the threshold for segmental instability.

This biomechanical framework provides a theoretical foundation for decompression alone. However, theory must be validated by clinical outcomes. The question is not whether laminectomy can theoretically preserve stability, but whether it does so in practice, as measured by patient function, pain relief, and long-term outcomes.

Methods

Ethical considerations

This study is a review of previously published clinical data and did not involve the collection of new patient information or any direct patient contact. As such, Institutional Review Board (IRB) or Ethics Committee approval was not required.

Search strategy

We conducted a systematic search of the literature to identify high-quality evidence comparing decompression alone versus decompression with fusion for lumbar spinal stenosis. The search was performed across three major databases: PubMed/MEDLINE, the Cochrane Library, and Google Scholar.

Database 1: PubMed/MEDLINE

Search String:

(laminectomy OR decompression) AND (fusion OR instrumented) AND

(lumbar spinal stenosis OR spondylolisthesis) AND

(randomized controlled trial OR systematic review OR meta-analysis)

Filters Applied

i. Publication dates: January 1, 2016 to October 13, 2025

ii. Article types: Randomized Controlled Trials, Systematic Reviews, Meta-Analyses

iii. Language: English

iv. Availability: Full text or abstract available

Results: 287 citations identified

Database 2: Cochrane library

Search Terms:

i. "lumbar spinal stenosis surgery"

ii. "decompression fusion"

iii. "laminectomy"

Database Searched: Cochrane Database of Systematic Reviews (CDSR)

Date Range: 2016–2025

Results: 15 systematic reviews identified

Database 3: Google scholar

Search Queries:

1. "laminectomy fusion randomized controlled trial 2016-2025"
2. "decompression alone fusion lumbar stenosis RCT"
3. "spinal stenosis surgical outcomes systematic review"

Filters

Publication years: 2016–2025

Sorted by relevance and citation count

Results: Approximately 850 citations screened

Inclusion criteria

Studies were included if they met the following criteria:

i. **Study design:** Randomized controlled trials (RCTs), systematic reviews, or meta-analyses

ii. **Population:** Adult patients (≥18 years) with symptomatic lumbar spinal stenosis, with or without degenerative spondylolisthesis (grade I or II)

iii. **Intervention:** Surgical decompression (laminectomy, laminotomy, or equivalent) with or without instrumented fusion

iv. **Comparator:** Direct comparison between decompression alone and decompression with fusion

v. **Outcomes:** At least one of the following: functional outcomes (e.g., Oswestry Disability Index), pain scores (visual analogue scale or numeric rating scale), quality of life measures, reoperation rates, complications, or neurological outcomes (e.g., leg pain, neurogenic claudication, radiculopathy)

vi. **Publication quality:** Published in peer-reviewed journals

vii. **Language:** English

viii. **Time Frame:** Published between January 1, 2016 and October 13, 2025

Exclusion criteria

Studies were excluded if they met any of the following criteria:

i. **Study design:** Case reports, case series, editorials, commentaries, or non-systematic narrative reviews

ii. **Population:** Patients with high-grade spondylolisthesis (grade III or higher), traumatic injuries, tumours, infections, or inflammatory spondyloarthropathies

iii. **Intervention:** Non-surgical treatments, decompression techniques not comparable to standard laminectomy, or fusion without decompression

iv. **Outcomes:** Studies reporting only radiographic outcomes without clinical correlation

v. **Quality:** Studies with high risk of bias or inadequate methodological reporting

vi. **Duplicates:** Duplicate publications or overlapping patient cohorts

Data extraction and quality assessment

Two independent reviewers screened titles and abstracts for eligibility. Full-text articles of potentially relevant studies were retrieved and assessed against inclusion criteria. For randomized controlled trials, methodological quality was assessed using the Cochrane Risk of Bias tool. For systematic reviews, quality was

evaluated using the AMSTAR 2 (A Measurement Tool to Assess Systematic Reviews) criteria. Data extracted included study characteristics, patient demographics, surgical techniques, outcome measures (including neurological symptoms such as leg pain and claudication), follow-up duration, and adverse events.

In addition, during full-text evaluation we prioritised studies with direct head-to-head comparison of decompression alone versus decompression with fusion, adequate reporting of neurological and **functional** outcomes, and robust methodological design. Studies that were observational, heterogeneous in their intervention definitions, or that lacked clear reporting of clinical (as opposed to purely radiographic) endpoints were excluded at this stage, to ensure that only the highest-quality comparative evidence was synthesized.

Results

Study selection

The systematic search yielded a total of 1,152 citations across the three databases. After removing duplicates (n = 318), 834 unique citations were screened by title and abstract. Of these, 782 were excluded as they did not meet inclusion criteria. The remaining 52 full-text articles were retrieved and assessed for eligibility. After detailed review, 8 studies met all inclusion criteria and were included in this review: 5 randomized controlled trials and 3 systematic reviews/meta-analyses.

From the 52 full-text articles, 44 were excluded for the following principal reasons (some studies met more than one exclusion criterion):

i. absence of a direct comparison between decompression alone and decompression with fusion,

ii. inclusion of mixed or non-degenerative pathologies (e.g., tumors, infection, high-grade spondylolisthesis),

iii. use of non-standard or outdated surgical techniques not comparable to contemporary laminectomy and instrumented fusion,

iv. reporting of radiographic outcomes only, without robust clinical or neurological endpoints, or

v. insufficient methodological quality, including unclear randomisation, incomplete follow-up, or high risk of bias.

The final 8 studies therefore represent a deliberately restricted, high-quality evidence base, focusing on modern surgical techniques and clinically meaningful functional and neurological outcomes.

Key randomized controlled trials

1. **The Swedish Spinal Stenosis Study**[2]

This landmark multicenter randomized controlled trial, published in the New England Journal of Medicine, compared decompression with fusion versus decompression alone in 247 patients aged 50 to 80 years with lumbar spinal stenosis at one or two adjacent levels.[2] Patients were randomized to undergo either decompression surgery plus instrumented fusion or decompression surgery alone. The primary outcome was the Oswestry Disability Index (ODI) at 2 years.

Key findings

i. At 2 years, there was no significant difference in ODI scores between groups (mean 27 in fusion group vs. 24 in decompression-alone group, p = 0.24)

ii. No difference in the 6-minute walk test (397 m vs. 405 m, p = 0.72)

iii. Results were similar in patients with and without spondylolisthesis

iv. Mean hospitalization was significantly longer in the fusion group (7.4 days vs. 4.1 days, p < 0.001)

v. Operating time, blood loss, and surgical costs were all significantly higher in the fusion group

vi. At 5-year follow-up, there remained no significant differences in clinical outcomes

vii. Reoperation rates were similar (22% fusion vs. 21% decompression alone) at mean 6.5-year follow-up

Conclusion: "Decompression surgery plus fusion surgery did not result in better clinical outcomes at 2 years and 5 years than did decompression surgery alone."

This study has been cited 949 times and represents Level I evidence against routine fusion.

2. **The NORDSTEN-DS Trial**[3]

Published in the New England Journal of Medicine, this multicenter, open-label, noninferiority trial enrolled 267 patients with lumbar spinal stenosis and degenerative spondylolisthesis of 3 mm or more.[3] Patients were randomly assigned to undergo decompression surgery alone or decompression with instrumented fusion. The primary outcome was the proportion of patients achieving at least a 30% reduction in ODI score at 2 years.

Key findings

i. Mean change in ODI: −20.6 (decompression alone) vs. −21.3 (fusion), mean difference 0.7 (95% CI −2.8 to 4.3)

ii. Success rate (≥30% ODI reduction): 71.4% (decompression alone) vs. 72.9% (fusion), difference −1.4 percentage points (95% CI −12.2 to 9.4)

iii. Decompression alone was noninferior to fusion

iv. Reoperation rates: 12.5% (decompression alone) vs. 9.1% (fusion)

Conclusion: "In patients with lumbar spinal stenosis and degenerative spondylolisthesis, decompression surgery alone was noninferior to decompression with instrumented fusion."

This study has been cited 256 times and provides robust Level I evidence supporting decompression alone, even in the presence of spondylolisthesis.

3. **Five-year follow-up of NORDSTEN-DS**[4]

This recent publication in the BMJ reported the 5-year outcomes of the NORDSTEN-DS trial, with 90% patient retention (241 of 267 patients).[4] The extended follow-up was designed to assess whether any late differences emerged between treatment groups.

Key findings

i. No benefits from adding fusion at 5 years

ii. ODI scores remained similar between groups

iii. Patient satisfaction was equivalent

iv. Reoperation rates remained similar

v. The presence of preoperative spondylolisthesis did not influence outcomes

Conclusion: "Adding fusion to decompression in lumbar spinal stenosis surgery does not improve five-year clinical outcomes. The presence of preoperative spondylolisthesis did not influence outcomes."

This study confirms the durability of outcomes with decompression alone over the long term.

4. **MRI follow-up study**[5]

This randomized clinical trial, published in The Bone & Joint Journal, included 222 patients and incorporated 2-year MRI follow-up to assess radiographic changes.[5] The study compared decompression alone to decompression with fusion.

Key findings

i. New stenosis on MRI was less common after decompression alone than after fusion

ii. Adjacent segment disease was more common in the fusion group

iii. Clinical outcomes showed no difference between groups

iv. Even with preoperative spondylolisthesis, adding fusion did not prevent new stenosis

Conclusion: "Adding fusion to a decompression increased the rate of new stenosis on two-year MRI, even when a spondylolisthesis was present preoperatively."

This finding challenges the assumption that fusion protects against progressive degeneration.

5. **The SLIP trial**[6]

Also published in the New England Journal of Medicine, this multicenter RCT enrolled 66 patients with stable degenerative spondylolisthesis (3–14 mm).[6] Patients were randomized to laminectomy with fusion or laminectomy alone. The primary outcome was the physical health composite score of the SF-36 at 2 years.

Key findings

i. Mean improvement in SF-36 physical health: 16.0 (fusion) vs. 9.5 (laminectomy alone)

ii. Difference: 6.5 points (95% CI 0.1–12.9, p = 0.046)

iii. The difference was statistically significant but of borderline clinical significance

Conclusion: "The addition of lumbar spinal fusion to laminectomy was associated with slightly greater but clinically meaningful improvement in overall physical health-related quality of life than laminectomy alone."

Critical analysis: This is the only major RCT showing a benefit for fusion. However, the study has important limitations: small sample size (66 patients), borderline statistical significance (p = 0.046), and the observed difference approaches the minimal clinically important difference threshold. The findings stand in contrast to larger, more recent trials.

Systematic reviews and meta-analyses

6. **Gadjradj et al.**[7] **– European Spine Journal**

This comprehensive systematic review and meta-analysis included multiple RCTs and prospective comparative studies.[7] The authors performed a rigorous search of MEDLINE, Embase, EmCare, Web of Science, and the Cochrane Library.

Key findings

i. High-quality evidence of no difference in functionality at 2 years: MD −0.31 (95% CI −3.81 to 3.19)

ii. High-quality evidence of no difference in leg pain: MD −1.79 (95% CI −5.08 to 1.50)

iii. High-quality evidence of no difference in back pain: MD −2.54 (95% CI −6.76 to 1.67)

Conclusion: "Based on the current literature, there is high-quality evidence of no difference in functionality after decompression alone compared to decompression with fusion in patients with degenerative lumbar spondylolisthesis at 2 years of follow-up."

This meta-analysis has been cited 66 times and represents the highest level of evidence synthesis.

7. **Guo et al.**[8] **– World Neurosurgery**

This recent systematic review and meta-analysis specifically examined patients with degenerative lumbar spondylolisthesis.[8]

Key findings

i. Decompression alone: shorter surgical time

ii. Decompression alone: shorter hospitalization time

iii. Decompression alone: less intraoperative bleeding

iv. For low-grade spondylolisthesis, decompression alone may be sufficient

v. Clinical outcomes equivalent between groups

Conclusion: The study supports decompression alone as a viable first-line surgical option for low-grade degenerative spondylolisthesis.

8. **Cochrane systematic review**[9]

The Cochrane Database of Systematic Reviews represents the gold standard for evidence synthesis. This review compared surgical versus non-surgical treatment for lumbar spinal stenosis.[9]

Key findings

i. Low-quality evidence showed no significant differences between decompression and conservative care at 6 months and 1 year

ii. At 24 months, significant differences favored decompression (MD −4.43, 95% CI −7.91 to −0.96)

iii. Among surgical options, simpler decompression procedures showed good outcomes

iv. The necessity for fusion was not clearly established in most cases

Conclusion: Surgery is more effective than non-operative treatment for symptomatic stenosis, but among surgical options, the evidence does not support routine fusion.

Summary of evidence

The following table summarizes the comparative outcomes from the major randomized controlled trials:

Table 1 Summary of key randomized controlled trials comparing decompression alone versus decompression with fusion.

Study	Year	N	Follow-up	ODI/Functional Outcome	Hospitalization (days)	Reoperation Rate	Conclusion
Försth et al.[2]	2016	247	2–5 years	No difference (p = 0.24)	7.4 vs 4.1 (p < 0.001)	22% vs 21%	No benefit from fusion
Austevoll et al.[3]	2021	267	2 years	No difference (MD 0.7)	Not reported	12.5% vs 9.1%	Decompression noninferior
Kgomotso et al.[4]	2024	241	5 years	No difference	Not reported	Similar	No benefit from fusion
Karlsson et al.[2]	2022	222	2 years	No difference	Not reported	Not reported	Fusion increased stenosis MRI
Ghogawala et al.[6]	2016	66	2–4 years	Small benefit (p = 0.046)	Not reported	Not reported	Borderline benefit for fusion

Discussion

The weight of evidence

The cumulative evidence from multiple high-quality randomized controlled trials and systematic reviews provides a clear and consistent message: for the vast majority of patients with lumbar spinal stenosis, with or without stable degenerative spondylolisthesis, decompression alone achieves equivalent clinical outcomes compared to decompression with fusion. This conclusion is supported by Level I evidence from large, multicenter trials.

The evidence ratio stands at approximately 4:1 in favour of decompression alone among the RCTs, with only one small trial showing a modest benefit for fusion.[6] That single study, while methodologically sound, is outweighed by larger, more recent trials with longer follow-up and more robust findings. The consistency of results across different countries (Sweden, Norway, United States), healthcare systems, and patient populations strengthens the external validity of these findings.

Neurological outcomes: neurogenic claudication and radiculopathy

For a journal focused on neurology and stroke, the neurological profile of outcomes is particularly relevant. Across the key randomized trials and meta-analyses, decompression alone provides neurological benefits that are equivalent to those achieved with fusion.

In the Swedish Spinal Stenosis Study, both groups experienced substantial and comparable improvement in leg pain and walking capacity, reflecting a similar degree of relief of neurogenic claudication and radiculopathy.[2] The NORDSTEN-DS trial likewise demonstrated parallel improvements in leg-dominant symptoms and walking distance in the decompression-alone and fusion arms, with no evidence that fusion conferred superior neurological recovery, despite the presence of degenerative spondylolisthesis.[3,4]

Karlsson et al. added a radiological dimension to these findings: although fusion was associated with a higher rate of new stenosis and adjacent segment disease on MRI, this did not translate into superior neurological outcomes, as clinical results (including leg pain and functional scores) remained similar between groups.[5] In aggregate, these data indicate that key neurological endpoints—resolution of radicular pain, improvement in neurogenic claudication, and enhancement of ambulatory capacity—are not improved by routinely adding fusion.

Thus, from a neurological standpoint, the primary benefit of surgery in lumbar spinal stenosis—decompression of neural elements—is effectively achieved by laminectomy alone, provided that the procedure respects facet joint integrity and avoids iatrogenic instability.

Clinical implications

The implications for clinical practice are profound. Decompression alone offers several tangible advantages over fusion:

i. **Shorter operative time:** Fusion procedures typically require 2–3 hours longer than decompression alone.

ii. **Reduced blood loss:** Fusion involves more extensive soft tissue dissection and bone work.

iii. **Shorter hospitalization:** Patients undergoing decompression alone are discharged an average of 3.3 days earlier.[2]

iv. **Lower cost:** Instrumented fusion involves significant hardware costs and longer operating room time.

v. **Fewer perioperative complications:** Simpler procedures carry lower risk.

vi. **Reduced adjacent segment disease:** MRI studies show lower rates of new stenosis after decompression alone.[5]

vii. **Equivalent functional outcomes:** No clinically meaningful difference in ODI, pain scores, or quality of life.[2,3,4,7]

viii. **Similar reoperation rates:** Long-term follow-up shows no increased risk of revision surgery.[2–4]

ix. **Comparable neurological recovery:** Relief of radiculopathy and neurogenic claudication is similar between decompression alone and fusion.

These advantages must be weighed against the theoretical concern of post-laminectomy instability. However, the clinical data do not support this concern. Reoperation rates are similar between groups, and functional and neurological outcomes remain equivalent over 5–8 years of follow-up. The biomechanical principles articulated by Denis provide a plausible explanation: a properly performed laminectomy preserves the middle and anterior columns, maintaining the structural integrity necessary for spinal stability.[1]

When might fusion be indicated?

While the evidence supports decompression alone for most patients, there remain specific clinical scenarios where fusion may be appropriate:

i. **High-grade spondylolisthesis (grade III or higher):** These patients were excluded from most trials and may benefit from stabilization.

ii. **Demonstrable instability on dynamic imaging:** Flexion-extension radiographs showing >3–4 mm translation or >10 degrees of angular motion.

iii. **Significant coronal or sagittal deformity:** Patients with scoliosis or kyphosis requiring realignment.

Citation: Martínez-Soler P, Martínez-Canca JF. Laminectomy and spinal stability: an evidence-based review of decompression surgery for lumbar spinal stenosis. *J Neurol Stroke.* 2025;15(6):162–167. DOI: 10.15406/jnsk.2025.15.00641

iv. **Iatrogenic instability:** Extensive facet resection (>50% bilateral) during decompression.

v. **Failed decompression alone:** Patients with recurrent symptoms and documented progression.

vi. **Patient preference:** After thorough informed consent regarding risks and benefits.

The key is individualized decision-making based on objective criteria rather than reflexive fusion for all patients with stenosis or low-grade spondylolisthesis.

Addressing the paradigm shift

The transition from routine fusion to selective decompression represents a paradigm shift in spine surgery. Such shifts can be challenging, as they require clinicians to reconsider long-held beliefs and practices. However, evidence-based medicine demands that we continuously update our approach based on the best available evidence.

It is important to acknowledge that this is not a condemnation of fusion as a procedure. When appropriately indicated, fusion remains an essential tool in the spine surgeon's arsenal. The issue is not whether fusion is ever appropriate, but whether it should be performed routinely in the absence of clear indications. The evidence suggests it should not.

Limitations and future directions

This review has several limitations. First, most trials excluded patients with high-grade spondylolisthesis, limiting generalizability to that population. Second, surgical techniques varied across studies, making direct comparisons challenging. Third, long-term follow-up beyond 5 years is limited, and it remains possible that late differences could emerge.

Future research should focus on:

i. Longer-term outcomes (10+ years)

ii. Health economic analyses comparing cost-effectiveness

iii. Identification of specific patient subgroups who may benefit from fusion

iv. Development and validation of objective instability criteria

v. Patient-reported outcome measures and shared decision-making tools

Conclusion

The preponderance of high-quality evidence from multiple randomized controlled trials and systematic reviews demonstrates that decompression alone is non-inferior to decompression with fusion for lumbar spinal stenosis, with or without stable degenerative spondylolisthesis. Decompression alone achieves equivalent functional outcomes, neurological recovery (including improvement of neurogenic claudication and radiculopathy), pain relief, and patient satisfaction, while offering significant advantages in operative time, blood loss, hospitalization duration, and cost. The theoretical concern about post-laminectomy instability is not supported by clinical outcomes data, which show similar reoperation rates and durable long-term results. Additionally, some studies have demonstrated that adjacent segment disease and future spinal stenosis (with radiological evidence) is more common in patients who underwent fusion.[5]

As stewards of evidence-based practice, we must align our surgical decision-making with the best available evidence. For the majority of patients with lumbar spinal stenosis, decompression alone represents the safer, more efficient, and equally effective approach. Fusion should be reserved for specific clinical indications supported by objective evidence of instability or deformity. By adopting this evidence-based paradigm, we can optimize patient outcomes while reducing surgical morbidity and healthcare costs.

The goal of spine surgery is not to achieve radiographic perfection but to restore function and relieve suffering. The evidence is clear: for most patients with lumbar spinal stenosis, we can achieve these goals through decompression alone.

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Conflicts of interest

The authors declare that there are no conflicts of interest.

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