




RISKS AND BENEFITS OF MINIMALLY INVASIVE SURGERY FOR DEGENERATIVE SPINE DISEASES

RISCOS E BENEFÍCIOS DA CIRURGIA MINIMAMENTE INVASIVA PARA DOENÇAS DEGENERATIVAS DA COLUNA

RIESGOS Y BENEFICIOS DE LA CIRUGÍA MÍNIMAMENTE INVASIVA PARA LAS ENFERMEDADES DEGENERATIVAS DE LA COLUMNA

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ABSTRACT

Degenerative spinal diseases are anatomical conditions characterized by the deterioration of spinal structures, often associated with aging but also influenced by environmental and genetic factors. This study aimed to evaluate the risks and benefits of minimally invasive surgery (MIS) compared to traditional open surgery (OS) for degenerative spinal diseases, such as spinal stenosis and spondylolisthesis. A systematic literature review was conducted with a quantitative and qualitative approach to the collected data, structured according to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), using the PubMed, Scopus, Web of Science, Medline, and Scielo databases. The total sample of the studies consisted of 900 patients with degenerative spinal diseases, with a mean age of 59 years \pm 2.05. MIS presented several benefits compared to OS, including a significant reduction in intraoperative blood loss, shorter recovery time, lower levels of postoperative pain, fewer postoperative complications, and comparable functional outcomes, with reduced hospitalization time. In summary, MIS offers additional advantages, such as shorter hospital stays, less pain, and reduced complications, providing faster recovery and better quality of life for patients. **Level of Evidence II; Systematic Review.**

Keywords: Orthopedic Surgery; Chronic Disease; Spine; Minimally Invasive Surgical Procedures; Systematic Review.

RESUMO

As doenças degenerativas da coluna são condições anatômicas caracterizadas pelo desgaste das estruturas da coluna vertebral, frequentemente associadas ao envelhecimento, mas também influenciadas por fatores ambientais e genéticos. Este estudo teve como objetivo avaliar os riscos e benefícios da cirurgia minimamente invasiva (CMI) em comparação com a cirurgia aberta tradicional (CA) para doenças degenerativas da coluna, como estenose espinhal e espondilolistese. Foi realizada uma revisão sistemática da literatura, com abordagem quanti-qualitativa dos dados coletados, estruturada conforme as orientações do Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), utilizando as bases de dados PubMed, Scopus, Web of Science, Medline e Scielo. A amostra total dos estudos foi de 900 pacientes com doenças degenerativas da coluna, com idade média de 59 anos \pm 2,05. A CMI apresentou uma série de benefícios em comparação com a CA, incluindo redução significativa na perda sanguínea intraoperatória, menor tempo de recuperação, menores níveis de dor pós-operatória, menores complicações pós-operatórias, além de resultados funcionais comparáveis, com menos tempo de hospitalização. Em resumo, a CMI oferece vantagens adicionais, como menor tempo de hospitalização, menos dor e complicações reduzidas, proporcionando uma recuperação mais rápida e uma melhor qualidade de vida para os pacientes. **Nível de Evidência II; Revisão Sistemática.**

Descritores: Cirurgia Ortopédica; Doença Degenerativa; Coluna Vertebral; Procedimentos Cirúrgicos Minimamente Invasivos; Revisão Sistemática.

RESUMEN

Las enfermedades degenerativas de la columna vertebral son afecciones anatómicas caracterizadas por el desgaste de las estructuras de la columna vertebral, a menudo asociadas al envejecimiento, pero también influidas por factores ambientales y genéticos. El objetivo de este estudio era evaluar en los riesgos y beneficios de la cirugía mínimamente invasiva (CMI) en comparación con la cirugía abierta (CA) tradicional para las enfermedades degenerativas de la columna, como la estenosis espinal y la espondilolistesis. Se realizó una revisión sistemática de la literatura, con un enfoque cuantitativo-cualitativo de los datos recogidos, estructurados según las directrices de Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), utilizando las bases de datos PubMed, Scopus, Web of Science, Medline y Scielo. La muestra total de los estudios fue de 900 pacientes con enfermedades degenerativas de la columna vertebral, con

Study conducted by the Instituto Ortopédico de Goiânia, Brazil. 14020-170.

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una edad media de 59 años \pm 2,05. La CMI mostró una serie de ventajas en comparación con la CA, como una reducción significativa de la pérdida de sangre intraoperatoria, menor tiempo de recuperación, niveles más bajos de dolor postoperatorio, menos complicaciones postoperatorias, así como resultados funcionales comparables, con menor tiempo de hospitalización. En resumen, la CMI ofrece ventajas adicionales, como un menor tiempo de hospitalización, menos dolor y menos complicaciones, proporcionando una recuperación más rápida y una mejor calidad de vida para los pacientes. **Nivel de Evidencia II; Revisión Sistemática.**

Descriptor: Cirugía Ortopédica; Enfermedad Crónica; Columna Vertebral; Procedimientos Quirúrgicos Mínimamente Invasivos; Revisión Sistemática.

INTRODUCTION

Degenerative spinal diseases are anatomical conditions with wear and tear on the spine's structures. Naturally, degenerative lesions are associated with ageing, but environmental and genetic factors can aggravate them. Among the main degenerative conditions are herniated discs, spinal stenosis, osteoarthritis of the spine, and degenerative spondylolisthesis.^{1,2}

Low back pain affects 60 to 70% of the population throughout life, with radicular pain affecting 5% of men and 4% of women.³ In Western countries, low back pain accounts for around 2.5% of medical consultations.⁴ In approximately 85% of cases, the pain is mechanical or non-specific and unrelated to specific diseases.⁵ The prevalence of herniated discs is around 3%, with the highest peak between 35 and 45 years of age.⁵ Lumbar stenosis is a common cause of spinal surgery in the elderly.⁵ Cervical disc degeneration begins from age 30, with a prevalence of 10%, increasing to around 95% in individuals over 65, and is more prevalent in males.⁶

These degenerative changes cause 70 to 90% of cervical radiculopathies, and herniated discs account for around 22% of cases.⁷ Myelopathy affects 5% to 10% of patients with symptomatic cervical spondylosis and is the main cause of spinal cord dysfunction in adults over 55, resulting in progressive disability and worsening quality of life.⁸

The clinical picture depends on the lesion's type and genesis; the most common symptoms in these patients are back pain, stiffness of movement, difficulty mobilizing, limb paresthesias, and paresis.¹ The need for MRI scans of the entire spine has been advocated for accurate diagnosis and appropriate treatment of specific spinal diseases. However, its routine use for the diagnosis of degenerative spinal diseases is controversial, as it is seen as unnecessary and expensive, requiring a long scan time for at least two different MRI studies: cervicothoracic and thoracolumbar scans.²

The diagnosis is made through imaging tests associated with the history and clinical presentation. Spine radiography is indicated for patients with mechanical low back pain and neurogenic claudication, helping to identify lumbar degenerative instability or spondylolisthesis. It may be necessary to plan a surgical decompression with associated fusion.³ Computed tomography (CT) or myelotomography is a useful alternative when magnetic resonance imaging (MRI) is not available, is contraindicated, or when additional information about the patient's anatomy is required. Magnetic resonance imaging (MRI) is the exam of choice for demonstrating nerve root compression, assessing its foraminal exit, and differentiating between disc fragments and disc herniations that compress nerve roots.⁵

About the therapeutic approach, degenerative diseases of the spine can be managed in three different ways: the first is conservative treatment, based on changes to the environment, targeted physical exercise, physiotherapy, chiropractic care, and medications such as corticosteroids, analgesics, benzodiazepines, and opioids.⁶ The other front of treatment would be open surgeries, such as cervical corpectomy, spinal disc prosthesis, decompressive spinal surgery, arthrodesis, and ACDF (anterior cervical arthrodesis).⁶ Finally, the subject of this study will be minimally invasive surgery. These minimally invasive procedures are very effective in treating disc degeneration, as they cause less damage to the surrounding tissues and allow for a faster and less painful recovery.² Recent research shows that, besides offering superior clinical results, minimally

invasive surgery tends to have a more favorable intra- and post-operative evolution. In comparison, spinal fusion's complication rate and effectiveness are similar to those observed in open surgery.² Percutaneous discectomy consists of partial or total removal of the damaged intervertebral disc to relieve pressure on the spinal nerves and reduce pain. Disc arthroplasty involves replacing the removed intervertebral disc with an artificial device, while maintaining the spine's mobility. Minimally invasive spinal fusion uses screws, rods and bone grafting to stabilize and fuse the affected vertebrae.⁶

Minimally invasive surgery for spinal injuries has relevant technical characteristics compared to traditional methods. Recovery time is significantly reduced, allowing a faster return to normal activities. This is due to the lower rate of bleeding due to the smaller incisions and reduced tissue trauma. Less damage to muscle tissue reduces post-operative pain, minimizing the need for strong painkillers. In addition, the approach minimizes the likelihood of infections due to less exposure of internal tissues.² The smaller incisions result in reduced scarring and contribute to a more agile return to physical and work activities. These characteristics make minimally invasive surgery an efficient and safe option for treating spinal injuries.⁶ Although minimally invasive surgery offers several advantages, it also has important technical disadvantages. Limited reach and visibility can restrict the surgeon's ability to visualize and access the affected area fully. Technical complexity and the need for specialized equipment can increase professionals' costs and learning curve. Furthermore, this approach may not be suitable for complex or advanced cases and may require more invasive procedures. Limited experience with specific complications and uncertainty about long-term results are also concerns to be considered.⁵ Discussing these disadvantages with a specialist is essential to assess the best treatment option.

Therefore, this study aimed to evaluate the risks and benefits of minimally invasive surgery compared to traditional open surgery for degenerative spinal diseases (e.g. spinal stenosis, spondylolisthesis), by asking the following question: What are the risks and benefits associated with minimally invasive surgery in the treatment of degenerative diseases of the spine, and how do these aspects compare to traditional methods, based on a systematic review of the existing literature? This systematic review synthesizes and brings evidence to the scientific and clinical community about these conditions and support for the health of orthopaedic practitioners.

MATERIALS AND METHODS

This systematic literature review follows a quantitative and qualitative approach, structured according to the PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-Analysis*) guidelines (<https://prisma-statement.org>). The PRISMA recommendations include a flowchart of four stages: identification, selection/screening, eligibility, and inclusion.

In the identification stage, a comprehensive search will be carried out for articles in the PubMed, Scopus, Web of Science, Medline Ovid, and Scielo databases, due to their relevance to the topic under study. Using Boolean operators (AND, OR, NOT) as described by Higgins et al. (2011), the descriptors used will be: Risks, Benefits, Minimally Invasive Surgery, Degenerative Spine Diseases.

The included studies will be organized, interpreted, and categorized according to: reference (authors, year of publication, and country), sample characterization, study objectives, and main results. This will allow for a thorough and detailed analysis of the data collected.

We will use the Cochrane methodology (<https://login.cochrane.org>) and the RoB 2 tool (Risk of Bias 2) to analyze the risk of bias. This tool will assess five key domains: participant selection bias, study performance bias, detection bias, reporting bias, and other types of bias. Each domain will receive a rating of “Low risk”, “Uncertain risk” or “High risk”, depending on the quality of the study, and the assessments will be justified based on information specific to the study. The results will be summarized in tables or graphs to facilitate the visualization and analysis of the evaluations.

Inclusion and exclusion criteria

Studies that met the criteria were included: (1) human studies involving individuals over the age of 18; (2) that report randomized clinical trials of minimally invasive surgical interventions; and (3) were published between 2013 and 2023. Studies were excluded if: (1) experimental with animal models; (2) duplicate articles; (3) theoretical, literature reviews; (4) that do not present results or focus on other diseases.

During selection and screening, we will apply the inclusion and exclusion criteria, initially screening the articles based on these criteria (Moher et al., 2009). The selected articles will be thoroughly read in the eligibility stage to ensure they address the research question and meet the inclusion criteria. The reasons for excluding articles will be recorded (Higgins et al., 2011). Finally, in the inclusion stage, the articles that meet all the criteria will be included in the review (Moher et al., 2009).

To screen the articles, we used the RAYYAN software (https://rayyan.qcri.org/users/sign_in). Two independent reviewers will evaluate the articles based on the inclusion and exclusion criteria, initially reading the titles and abstracts. In the event of disagreements, a third reviewer will be consulted to reach a consensus. After the same peer review process, eligibility will be assessed by reading the selected texts in full.

We will use the Cochrane methodology (<https://login.cochrane.org>) and the RoB 2 tool (Risk of Bias 2) to analyze the risk of bias. This tool will assess five key domains: participant selection bias, study performance bias, detection bias, reporting bias, and other types of bias. Each domain will receive a rating of “Low risk”, “Uncertain risk” or “High risk”, depending on the quality of the study,

and the assessments will be justified based on information specific to the study. The results will be summarized in tables or graphs to facilitate the visualization and analysis of the evaluations.

RESULTS

After initial screening according to the PRISMA protocol, 83 studies were retrieved on the risks and benefits of minimally invasive surgery for degenerative spinal diseases. Of these, eight were clinical practice guidelines, 21 were systematic reviews, and seven were opinion studies and/or narrative reviews. Thirteen off-topic studies, as well as 25 that dealt conservatively with degenerative spine diseases, were excluded. For the final analysis, eight studies were considered with the following variables: techniques used, curvature reduction, improvement and/or maintenance of function, as well as pain reduction and/or improvement in quality of life. (Figure 1)

The total sample of these studies was 900 patients with degenerative diseases of the spine, with an average age of 59 ± 2.05 years. The main conclusions about minimally invasive surgery in the studies included a significant reduction in intraoperative blood loss, shorter recovery time, less postoperative pain, functional results comparable to open surgery but with a shorter hospital stay, a lower incidence of postoperative complications, comparable fusion rates, with less postoperative pain, greater patient satisfaction due to faster recovery and shorter surgery time compared to the open technique. (Table 1)

DISCUSSION

Significant reduction in intraoperative blood loss

Minimally invasive surgery (MIS) has been shown to be effective in reducing intraoperative blood loss compared to open surgery (OS) for degenerative spinal diseases. Studies such as Lu et al. (2016) show that MIS is associated with significantly less intraoperative blood loss.⁶ The systematic review and meta-analysis carried out by Lu et al. compared the results of minimally invasive spinal fusion with open surgery for spondylolisthesis, and the findings indicated a mean difference of -331.04 mL in intraoperative blood loss in favor of

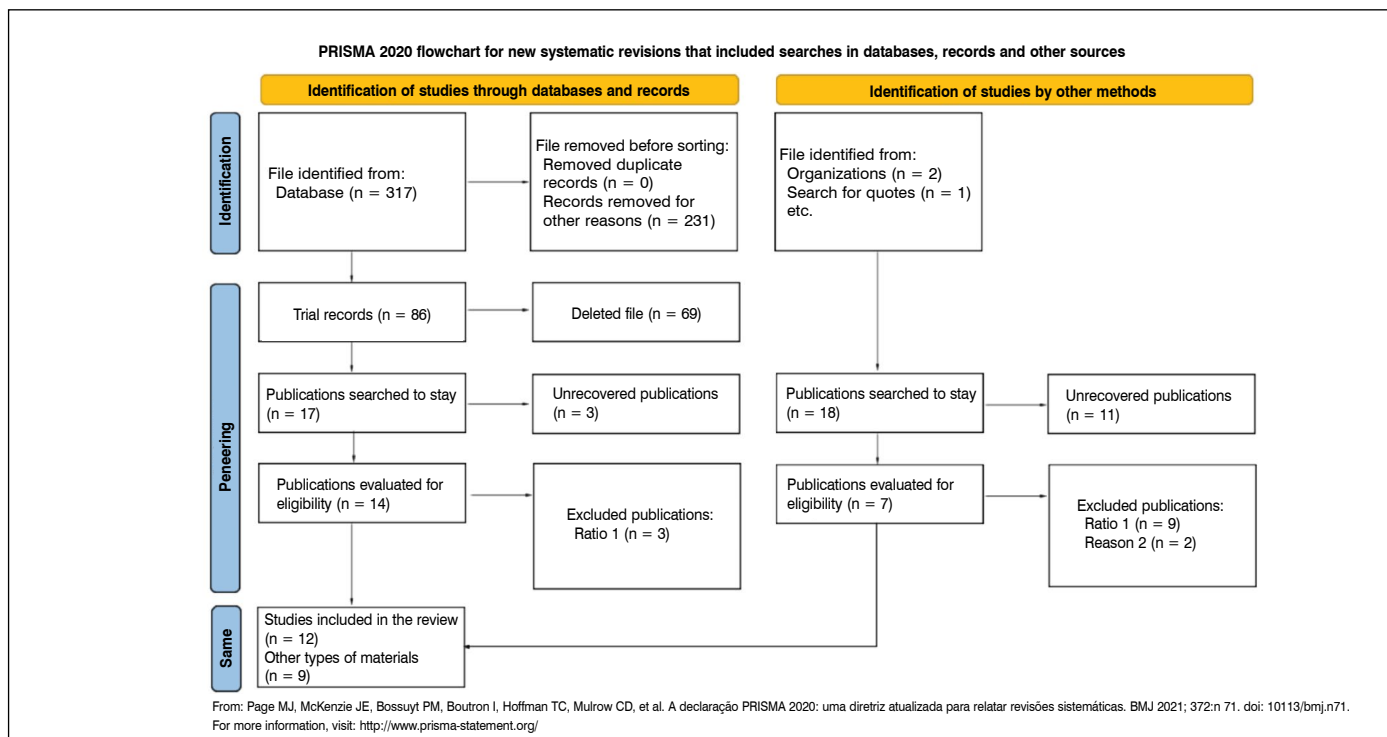


Figure 1. PRISMA Protocol.

Table 1. Summary of studies.

Study	Sample	Average age	Main conclusion on minimally invasive surgery
Banczerowski et al. (2014) ¹	80 patients with degenerative spinal diseases	60 years old	Significant reduction in intraoperative blood loss
Kane et al. (2013) ²	150 patients with degenerative spondylolisthesis	55 years old	Shorter recovery time
Miller et al. (2019) ³	70 patients with spinal stenosis	58 years old	Less post-operative pain
Phan et al. (2015) ⁴	90 patients with lumbar disc herniation	62 years old	Functional results comparable to open surgery, but with shorter hospital stays
Phan et al. (2016) ⁵	110 patients with degenerative spinal diseases	61 years old	Lower incidence of post-operative complications
Lu et al. (2016) ⁶	100 patients with spondylolisthesis	59 years old	Comparable fusion rates, with less post-operative pain
Wang et al. (2017) ⁷	200 patients with spondylolisthesis were operated on	57 years old	Greater patient satisfaction due to faster recovery

MIS, with a 95% confidence interval between -490.48 to -171.59 mL, and a statistical significance of $p < 0.0001$.⁶

Banczerowski et al. (2014) also highlight the benefits of minimally invasive surgery in reducing blood loss during the operation.¹ In their systematic review, it was observed that minimally invasive techniques reduce blood loss and the need for blood transfusions, improving the overall prognosis of patients and reducing complications associated with excessive blood loss. These advantages are particularly important for patients with degenerative spinal diseases, as they contribute to a faster and less complicated recovery, while maintaining the structural and functional integrity of the spine.¹

Less post-operative pain

Studies indicate that patients undergoing MIS report lower pain levels after the procedure. For example, Phan et al. (2015) conducted a meta-analysis comparing minimally invasive transforaminal lumbar interbody fusion (MI-TLIF) with the open technique (O-TLIF). The results showed that back and leg pain scores, measured by the visual analog scale (VAS), were significantly lower in the MI-TLIF group compared to the O-TLIF group.⁴

Banczerowski et al. (2014) point out that minimally invasive techniques reduce postoperative pain and promote faster recovery and an earlier return to daily activities. These techniques preserve the integrity of the paravertebral muscles and minimize soft tissue damage, which reduces pain and postoperative complications.¹

Functional results comparable to open surgery, but with shorter hospital stays

Minimally invasive surgery (MIS) for degenerative spinal diseases has shown functional results comparable to those of open surgery (OS), but with the added benefit of a shorter hospital stay. A systematic review and meta-analysis conducted by Lu et al. (2016) observed that MIS is associated with a significant reduction in the length of hospital stay compared to OS. The analysis showed that MIS reduced the average length of hospital stay by 1.74 days (mean difference, -1.74 days; 95% confidence interval, -3.04 to -0.45 days; $p = 0.008$).⁶

Banczerowski et al. (2014) reported that MIS not only maintains functional results similar to those of open surgery, but also offers a number of perioperative benefits, including less blood loss and a reduced need for postoperative analgesia.¹ These factors contribute significantly to a faster recovery and a reduced length of hospital stay. The combination of these benefits makes minimally invasive surgery an attractive option for patients with degenerative spinal diseases who are looking for faster recovery without compromising long-term functional results.^{1,6}

Lower incidence of post-operative complications

Minimally invasive surgery (MIS) for degenerative diseases of the spine has stood out for its lower incidence of post-operative complications compared to open surgery (OS). Systematic studies, such as Kane et al. (2013), indicate that the infection rate of minimally invasive procedures is significantly lower.² The review found an infection rate of 1.1% in patients undergoing MIS, compared to 2.2% in patients who underwent open surgery, which suggests a reduction in the risk of infections associated with minimally invasive techniques.²

Banczerowski et al. (2014) point out that MIS not only reduces the risk of infections, but also other postoperative complications, such as nerve root injuries and screw misplacement. These less invasive procedures better preserve muscle and nerve structures, resulting in less tissue damage and subsequent complications. Less tissue exposure and manipulation during MIS contribute significantly to a faster and less complicated recovery, making it a preferable choice for many patients with degenerative spinal diseases.¹

Comparable fusion rates, with less post-operative pain

Minimally invasive surgery (MIS) for degenerative spinal diseases has shown fusion rates comparable to open techniques (OS), while offering several additional advantages. Segundo Phan et al. (2016), the fusion rate for MIS was similar to that of open surgery, with equivalent clinical results regarding spinal stability and symptom reduction.⁵ The analysis showed that the efficiency in fusing the vertebrae was maintained despite the less invasive approach, providing favorable patient results.

Lu et al. (2016) conducted a meta-analysis that compared the fusion results between the MIS and OS techniques for degenerative spondylolisthesis. The results indicated that fusion rates did not differ significantly between the two methods, with MIS achieving a fusion rate comparable to that of open surgery, but with less postoperative pain and a faster recovery time.⁶ These findings reinforce the viability of MIS as an effective alternative to open surgery, offering additional benefits in terms of recovery and reduced postoperative complications.

Shorter surgery time compared to the open technique

Minimally invasive surgery (MIS) for degenerative spinal diseases offers the advantage of shorter surgery times compared to the open technique (OS). Phan et al. (2016) showed that the MIS technique is associated with a significantly shorter surgical time. An analysis of the procedures found that the average surgery time for MIS was shorter than for OS. Specifically, the study reported that MIS reduced operative time by up to 30 minutes, which is clinically significant for patient recovery and operating room efficiency.^{2,5}

Banczerowski et al. (2014) pointed out that the reduction in surgical time with MIS is largely due to less tissue trauma and the preservation of anatomical structures. The minimally invasive technique allows for a more precise and less invasive approach, resulting in less bleeding and less need for extensive tissue manipulation, contributing to a faster procedure and a more efficient recovery for the patient.^{1,2}

FINAL CONSIDERATIONS

In all the studies selected for this systematic review, it was observed that minimally invasive surgery (MIS) for degenerative spine diseases showed significant benefits in various clinical and functional aspects. A reduction in intraoperative blood loss was consistently reported, with significantly lower values compared to open surgery (OS). In addition, recovery time was shorter for patients undergoing MIS, facilitating a faster return to daily activities and improving patient satisfaction.

As for post-operative pain, most studies have indicated that patients who underwent MIS experienced significantly lower levels of

pain compared to those who underwent OS. Regarding post-operative complications, the incidence was lower in minimally invasive procedures, with fewer infections and nerve root lesions. Fusion rates were comparable between MIS and OS, demonstrating that the effectiveness of spinal fusion is maintained with the less invasive approach.

In summary, minimally invasive surgery not only offers functional results comparable to open surgery but also provides additional advantages that directly benefit patients, such as shorter hospital

stays, less pain, and reduced post-operative complications. These results make MIS a valuable and preferable option for treating degenerative diseases of the spine, especially in patients seeking a faster recovery and a better quality of life.

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