MIS TLIF VERSUS OPEN TLIF

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MIS TLIF VS. OPEN TLIF

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List of abbreviations and acronyms

TLIF – transforaminal lumbar interbody fusion

MIS (TLIF) – minimally invasive (transforaminal lumbar interbody fusion)

ALIF – anterior lumbar interbody fusion

OLIF – oblique lumbar interbody fusion

XLIF – extreme lateral interbody fusion

PLIF – posterior lumbar interbody fusion

BL – blood bloss

OT – operation time

CO -- complications

LOS – length of stay

1 Introduction

Transforaminal Lumbar Interbody Fusion (TLIF) surgery has become a widely utilized technique for the treatment of various lumbar spine conditions. As one of the most common procedures in spine surgery, TLIF offers several advantages, including effective fusion, neural decompression, and restoration of spinal stability. Over the years, TLIF has undergone significant advancements, with the introduction of minimally invasive techniques aiming to reduce surgical morbidity and improve patient outcomes.

This literature review aims to explore the nuances of TLIF surgery, particularly focusing on the comparison between traditional open TLIF and minimally invasive TLIF (MIS TLIF). By examining clinical parameters such as blood loss, risk of complications, cost efficacy, and duration of hospitalization, this review intends to provide a comprehensive understanding of the relative advantages of each approach and investigate whether one method is superior to the other.

The review begins with a general description of TLIF, encompassing its indications, contraindications, and procedural details. This section will explain the rationale behind TLIF surgery, its primary objectives, and the patient populations most likely to benefit from this procedure. Furthermore, an overview of the advantages of TLIF over other lumbar fusion techniques will be provided, highlighting the unique features that distinguish TLIF as a preferred surgical option.

Thereafter, the review delves into the comparative analysis between open TLIF and MIS TLIF, focusing on the abovementioned clinical outcomes. The following discussion will interpret the findings, while also exploring potential directions for future research.

2 Aims and objectives

By examining existing literature and clinical studies, this review aims to illuminate the potential advantages and limitations of each approach, providing clinicians and researchers with valuable insights for informed decision-making in clinical practice.

Overall, this literature review attempts to contribute to the ongoing discourse surrounding TLIF surgery, shedding light on the evolving landscape of spinal fusion techniques and their impact on clinical outcomes. Through a comprehensive examination of the comparative clinical parameters between open TLIF and MIS TLIF, this review aims to inform clinical practice and optimize surgical outcomes.

3 TLIF

Lumbar spinal fusion is a widely accepted treatment for instability linked with neurological compression or spinal deformity, and notable progress has been made in the methods, techniques, and implants utilized. Spine surgeons perform various approaches for lumbar interbody fusion, "including posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF), oblique lumbar interbody fusion (OLIF), anterior lumbar interbody fusion (ALIF), and extreme lateral interbody fusion (XLIF)." (1) (Figure 1)

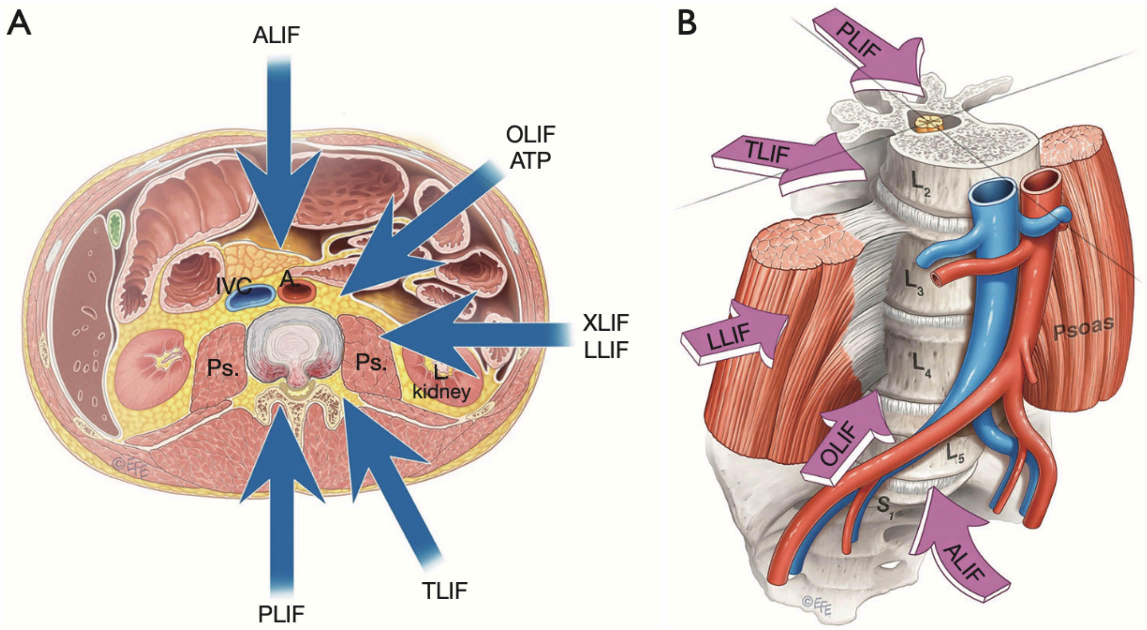

Figure 1: Overview of different approaches in lumbar spine surgery (2)

TLIF is a method of lumbar fusion performed through a posterior transforaminal approach to the disc, primarily recommended for conditions such as degenerative disc disease, mild spondylolisthesis, non-traumatic instability and repeat surgeries for disc herniation. (3) Since its inception by Harms in the 1980s, it is a commonly performed operation to fuse the anterior and posterior sections of the spine following failed conservative treatment. (1)

3.1 Indications and Contraindications

The indications for a TLIF approach include degenerative disc diseases and prolapses, pseudoarthrosis, and symptomatic spondylosis (2). Specific indications for TLIF further encompass grade 1 and 2 spondylolisthesis (degenerative or lytic) with mechanical lumbar pain or radicular syndromes, as well as reduced high-grade spondylolisthesis, central canal stenosis, lateral recess syndrome, facet joint disease, severe discogenic back pain, lumbar segmental instability, postlaminectomy instability and failed lumbar fusion with other techniques. (1) (2)

Conversely, contraindications for TLIF mirror those of other lumbar fusion techniques and include conditions such as broad epidural scarring, current infection, malignancies, traumatic instability, merged nerve roots hindering access to the intervertebral space, and osteoporosis (2). Additionally, TLIF is only indicated in low grade spondylolisthesis. For high-grade spondylolisthesis, other techniques like ALIF are preferred as it is associated with better biomechanical stability, restoration of lumbar lordosis and and a lower risk of nerve damage during surgery (4).

Patients with lumbar spine disease often complain about a variety of symptoms, including pain, radicular symptoms, and weakness (4). When assessing patients suspected of having lumbar spine disease, it is crucial to rule out other potential causes of pain, such as abdominal pathologies like aortic aneurysms, pancreatic disease or kidney stones. (1)

3.2 Procedure

TLIF can be conducted through either the conventional open method or a minimally invasive approach. Both methodologies can be applied for single-level fusion, involving the fusion of vertebrae at a singular site, or for multi-level fusion, which involves merging multiple segments together. (5)

3.2.1 Open TLIF procedure

The procedure is performed under general anesthesia with the patient placed prone.

After positioning the patient, the process of identifying and locating the target segments is conducted under radiological guidance in lateral and anteroposterior views. Additionally, the lateral iliac crest serves as a clinical landmark, frequently associated with the L4/5 level. Subsequently, the surgical site undergoes sterilization and covering. The conventional method for dorsal instrumentation and interbody fusion involves the posteromedial approach. Following an incision over the spinous processes and dissection of the subcutaneous tissue, the fascia is opened, and the intrinsic back muscles are detached subperiosteally. Upon exposure of the facet joints and corresponding laminae, pedicle screws can be initially placed or alternatively, decompression of the target segment may commence. (2) (6)

Following this, facetectomy is conducted, resulting in the bony decompression of the neuroforamen. After flavectomy, central decompression of the spinal canal becomes feasible, and during undercutting, this decompression can be extended to the contralateral side. The exiting nerve root is visualized and relieved from its origin at the axilla to beyond the neuroforamen. By means of transforaminal or slightly medial modification, access to the disc space is achieved by sectioning the posterior longitudinal ligament, facilitating clearance of the disc space and meticulous preparation of the endplates with suitably adapted instruments. There are two available variations of cages for insertion into the disc space and the industry is always working on innovations. (6)

The traditional TLIF cage typically takes on a banana-like shape and is positioned at the anterior edge of the vertebral body, adjacent to the anterior longitudinal ligament. Following insertion of the cage into the disc space, it is maneuvered to its correct placement along a curved path using application aids and guidance from the anterior longitudinal ligament, which must remain intact during preparation. Radiological checks in both planes aid in ensuring optimal positioning. In addition to the choice of filling the cage with bone or bone substitute material, bone material can be compacted posterior to the cage into the disc space. The placement far ventrally enables the surgeon to achieve favorable lordosis through compression during tethering. (6)

Another variation of the cage is the oblique design, positioned at an angle of approximately 30° to the sagittal plane, ensuring support across the biapophyseal region. A notable advantage is the extensive contact surface area with stable vertebral body structures. However, this necessitates vigorous preparation of the contralateral ventral side, requiring specialized instruments for accurate preparation. Attention to detail is crucial for aligning the cage correctly to achieve the desired restoration of lordosis. Additionally, ventrally distractable implants are available to aid in lordosis reconstruction within the segment. This approach also entails filling the cage with bone material and compacting additional bone material into the remaining disc space, either before or after cage placement. Radiological assessment in two planes is employed to confirm the accurate positioning of the inserted cage. (6)

3.2.2 MIS TLIF procedure

In recent years, the TLIF approach, particularly the development of less traumatic and minimally invasive access routes, has become more widespread. The minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) utilizes a surgical pathway through the lumbar paraspinal muscles, specifically the intervertebral multifidus and longissimus muscles, without the need for extensive dissection. This intermuscular approach is distinguished by reduced tissue damage and minimized bleeding. Additionally, it eliminates the necessity for excessive traction on nerve roots and dural sacs typically associated with other approaches. (7)

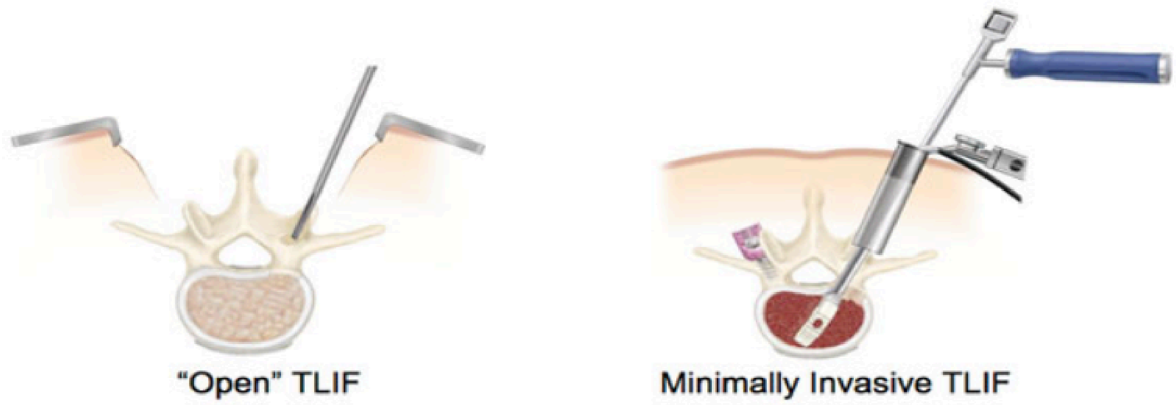

Figure 2: Open TLIF vs. MIS TLIF (Source: https://www.pauljeffordsmd.com/minimally-invasive-surgical-mis-tlif)

Defining minimally invasive transforaminal lumbar interbody fusion (TLIF) presents a challenge due to variations in surgical approaches. The absence of a precise definition leads to discrepancies among surgeons' interpretations. While some practitioners classify TLIF procedures as minimally invasive, others may consider them as mini-open, blurring the distinction between truly minimally invasive TLIF and more invasive open procedures. As such, the term "minimally invasive" does not consistently reflect the degree of invasiveness across all TLIF techniques. (8)

Lener et. al investigated the different techniques and technologies used by surgeons performing MIS TLIF and elaborated criteria for defining a TLIF as being minimally invasive. In assessing the degree of invasiveness in TLIF procedures, several key factors come into play. Firstly, the type of retractor used significantly influences the categorization of TLIF as minimally invasive. TLIF conducted with non-tubular expandable retractors or expandable tubular retractors achieving "pedicle-to-pedicle" exposure should not be classified as minimally invasive. Additionally, the way the incision is made plays a pivotal role. Employing a midline incision, especially for subperiosteal dissection and lateral exposure to establish bilateral pedicle screw trajectory, disqualifies a TLIF from being labeled as minimally invasive. Furthermore, the use of visualization aids is essential in ensuring optimal outcomes. Utilizing visualization aids such as surgical loupes, a surgical microscope, or an endoscope is crucial for MIS-TLIF to ensure sufficient visualization in the narrow access pathways provided by tubular retractors. (8)

The extent to which the minimally invasive technique may be superior to the open technique is discussed in the following chapters.

3.3 TLIF Advantages over other approaches

There are many discussions whether one lumbar fusion technique is superior to one other. Despite the justification for existence of various approaches, the TLIF procedure offers several distinct advantages. Firstly, it provides direct, unilateral access to the neural foramen, thereby minimizing surgical trauma and reducing the need for extensive dissection (5) (2). This approach allows for the complete removal of the intervertebral disc through the vertebral foramen, facilitating decompression of the spinal canal and vertebral foramen with minimal risk to neural structures. (3) . By preserving spinal muscle and ligamentous integrity, structural and biochemical stability can be restored more easily, leading to improved surgical outcomes. (2)

One drawback associated with TLIF is the potential for paraspinal iatrogenic injury due to prolonged muscle retraction. This can pose challenges in correcting coronal imbalance and restoring lordosis, thereby affecting overall spinal alignment. Additionally, compared to anterior approaches, TLIF may present difficulties in endplate preparation, which is essential for achieving optimal fusion and long-term stability of the spine. (2)

In summary, despite its limitations, the TLIF procedure presents numerous advantages, including reduced surgical trauma, preservation of anatomical structures, easier access to posterior spinal structures, and favorable long-term outcomes, making it a preferred choice for treating various lumbar degenerative conditions.

4 Literature review

4.1 Methods

Electronic databases such as PubMed, Elsevier and Cochrane were used to identify and search for studies comparing MIS TLIF to open TLIF. Furthermore, references of screened publications related to the topic were manually searched to identify associated studies.

For inclusion in the literature review, studies had to meet specific criteria. These included being published between 2017 and 2024, conducting a comparison between MIS TLIF and TLIF, presenting data on surgery-related outcomes and postoperative specimens for both groups. Studies needed to report data on at least one of the following parameters: blood loss, length of hospital stay, operation time, complications, and cost efficiency.

4.2 Study selection and limitations

In total, 10 publications are included in this review. Table 1 provides detailed information about the selected publications. In the process of selecting publications for inclusion in this review, it is necessary to recognize some limitations. Notably, few single-center studies included into our analysis are also encompassed within the examined meta-analyses. While this overlap may have minimal effect on larger meta-analyses with large study cohorts, smaller meta-analyses could be more significantly affected. It is important to recognize this potential influence when interpreting the findings and conclusions drawn from the reviewed literature.

Table 1: Study selection with description of study design, year of publication and investigated parameters; blood loss (BL), operation time (OT), complications (CO), length of stay (LOS). Parameters in brackets indicate indirect investigation not specifically included in this review.

	Study design (N of studies)	**Year of Publication**	**Investigated Parameters**
Chen et al.	Meta-Analysis (10)	2019	BL, OT, CO, LOS
Hammad et al.	Meta-Analysis (32)	2019	BL, OT, CO, LOS
Li et al.	Meta-Analysis (6)	2018	BL, OT, LOS
Liu et al.	Retrospective single-center study	2022	BL, OT, CO, LOS
Miller et al.	Meta-Analysis (7)	2020	BL, OT, CO, LOS
Qin et al.	Meta-Analysis (6)	2020	BL, OT, CO, LOS
Serban et al.	Prospective study	2017	BL, OT, LOS
Lewis et al.	Retrospective single-center study	2023	CO, LOS
Bassani et al.	Scenario analysis	2024	CE (BL, OT, CO, LOS)
Djurasovic et al.	Retrospective single-center study	2019	CE (BL, OT)

4.3 Blood Loss

The comparison of blood loss between MIS TLIF and open TLIF, as described by the studies reviewed, consistently indicates a reduction in blood loss associated with MIS TLIF when compared to open TLIF.

Hammad et al.'s comprehensive meta-analysis provided strong evidence favoring MIS TLIF over TLIF in terms of blood loss reduction. Among the twenty-eight studies directly comparing blood loss, twenty-six studies demonstrated significantly lower blood loss in the MIS TLIF group. Specifically, the mean blood loss volume was distinctly reduced in the MIS TLIF cohort, measuring 247.82 ml compared to 568.18 ml in the open TLIF group. (9)

Similarly, Chen et al.'s meta-analysis, which incorporates data from eight trials, revealed a strong association between MIS TLIF and decreased blood loss (10). This finding was further supported by Liu et al.'s retrospective investigation, which highlighted a notable decrease in both intraoperative blood loss and postoperative drainage volume in the MIS TLIF group compared to the open TLIF group. Moreover, none of the patients in the MIS TLIF group required blood transfusion, whereas four patients in the open TLIF group did. (11)

Further affirming these findings, Li et al.'s meta-analysis of seven studies, comprising 532 patients, confirms the superiority of MIS TLIF in reducing total blood loss compared to open TLIF (12). Despite high heterogeneity among the studies, a random-effects model supported this conclusion. Qin et al.'s systematic review and meta-analysis, encompassing four studies, similarly reinforced these results by showing lower intraoperative blood loss in the MIS TLIF group compared to the open TLIF group (13). Additionally, Miller et al.'s investigation across six studies found less perioperative blood loss in the MIS TLIF group (14).

In contrast, Serban's prospective research indicated comparable estimated blood loss between the open TLIF and MIS TLIF groups, with a slightly lower blood loss in the latter. However, the estimated blood loss in the MIS TLIF group exceeded most findings documented in existing literature, suggesting potential variability in outcomes across studies. (15)

In summary, the results from these studies consistently highlight the association of MIS TLIF with reduced blood loss compared to open TLIF.

4.4 Operation time

In examining operation time, a crucial aspect of surgical interventions, data from seven publications were investigated. Among them, five studies found no significant difference in operation time between MIS TLIF and TLIF procedures (14) (16) (15) (10) (11) (12).

However, Qin et al.'s results indicated a longer operation time for MIS TLIF compared to open TLIF, particularly evident in treating lumbar spondylolisthesis (13). This extended duration was attributed to the complex maneuvers required within the confined surgical space and limited visibility (13).

Hammad et al.'s extensive review of twenty-seven studies revealed that a majority reported longer operative times for MIS TLIF. They explained this trend by emphasizing the learning curve associated with MIS TLIF, suggesting that with increasing experience, operative times tend to decrease. (9)

Although Serban et al.'s investigation showed no significant difference with mean operative times of 296 ± 101 minutes for open TLIF and 321 ± 85 minutes for MIS TLIF the researchers also pointed to the learning curve and the novelty of the MIS approach as potential factors contributing to the prolonged operative times associated with MIS TLIF procedures. (15)

In summary, while some studies found no significant difference in operation time between MIS TLIF and TLIF, others reported longer operative times for MIS TLIF. This variability may be attributed to the learning curve associated with the MIS TLIF technique, suggesting that operative times may decrease as surgeons gain experience and expertise in performing MIS TLIF procedures.

4.5 Complications

The comparison of complications between MIS TLIF and open TLIF procedures is a crucial aspect of assessing the safety and efficacy of these surgical techniques. Complications encompass a broad spectrum of adverse events that can occur during or after surgery, ranging from minor wound issues to more severe neurological deficits or infections. It's important to note that there is no homogeneous definition for "complications," and each study included in this analysis may have employed different parameters to define and measure these events. Throughout this chapter, various complication parameters will be discussed, including intraoperative complications such as dural tears, as well as postoperative complications like infection rates, hardware malpositioning, and the need for revision surgery. By examining these diverse parameters across multiple studies, we can gain an understanding of the comparative safety profiles of MIS TLIF and TLIF techniques.

In the meta-analysis by Chen et al., a significant reduction in the overall complications rate associated with MIS TLIF compared to TLIF could be found (10). They mentioned several potential contributing factors to this finding, including the development of spine surgeons' skills in minimally invasive techniques and advancements in surgical instrumentation, which might lead to decreased infection rates.

Similarly, in Hammad et al.'s systematic review and meta-analysis, the complication rates were numerically lower in the MIS TLIF group compared to the TLIF group (11.3% vs. 14.2%), but this difference did not reach statistical significance. (9)

Lewis et al.'s investigation revealed no notable disparities in intraoperative dural tear rates and need for revision surgery between the MIS TLIF and TLIF cohorts. Moreover, there were no significant differences in wound infection rates between the two groups. (17)

Similar results could be found by Liu et al., as no instrument-related complications were reported, and revision surgery was not indicated. However, both groups exhibited muscle atrophy and fat infiltration one year after surgery, with significantly lower multifidus muscle T2-weighted signal intensity noted in the open TLIF group. (11)

Although Qin et al.'s comparative analysis showed no statistically significant difference in overall complication rates between MIS TLIF and TLIF, the distribution of major complications varied between groups, with MIS TLIF being associated with hardware malposition, while TLIF demonstrated a higher incidence of incision infections. Nonetheless, reoperation rates were low in both groups, with similar reasons identified across studies, including pedicle screw or cage misplacement, epidural hematoma, infection, and non-fusion. (13)

Miller et al. discovered that the likelihood of perioperative complications was similar in both cohorts. When comparing MIS TLIF with TLIF, there were no significant variances between the groups in terms of the most frequently mentioned complications such as accidental dural tears, wound infections, misplacement of pedicle screws, pulmonary infections, nerve root damage, graft misplacement, epidural hematomas, and heart attacks. Additionally, there were no disparities between the groups regarding the occurrence of pseudarthrosis at either the one-year or two-year mark of minimum observation. (16) (14)

In summary, while MIS TLIF tends to be linked with a lower overall complications, both techniques exhibit relatively low rates of major complications and reoperations and most studies could not find significant differences between the two groups.

4.6 Duration of Hospitalization

Length of hospitalization was examined across various studies, with two investigations failing to identify significant differences between MIS TLIF and open TLIF cohorts in terms of hospital stay duration (12) (11). These findings suggest that, according to these studies, the choice between MIS TLIF and open TLIF may not significantly impact the length of hospitalization.

In contrast, several other studies yielded significant findings regarding length of hospital stay. Chen et al.'s meta-analysis reported a shorter duration of hospitalization associated with MIS TLIF, possibly linked to reduced intraoperative surgical trauma and complications. (10)
Qin et al.'s meta-analysis also supported this trend, with the MIS TLIF group showing a shorter hospitalization period compared to the TLIF group, indicating a potentially quicker postoperative recovery (13).
Additionally, Hammad et al.'s comprehensive review and meta-analysis, encompassing 25 studies, consistently found a significantly shorter duration of hospitalization for patients undergoing MIS TLIF (mean: 5.05 days) compared to open TLIF (6.92 days) (9).
Similarly, Serban et al.'s study corroborated these findings, reporting a significantly shorter time to discharge for patients in the MIS TLIF group (mean: 1.92) compared to the open TLIF group (mean: 4.12) (15).
Miller et al. came to similar results after investigating data from 5 studies, with shorter duration of hospitalization for MIS TLIF patients (MD -2.2 days). (16) (14)

In conclusion - although not unexceptional – MIS TLIF is associated with a significantly shorter duration of hospitalization. These results underline the potential benefits of MIS TLIF in facilitating quicker postoperative recovery and reducing hospitalization duration, with implications for healthcare resource utilization and patient satisfaction.

4.7 Cost efficiency

Bassani et al. conducted a Budget Impact Analysis comparing MIS TLIF and open TLIF. Their base case analysis was based on the findings of Miller et al., who identified longer hospital stays, increased blood loss and need for RBC blood transfusions, and higher consumption of sterile materials with the open TLIF method. (16) This analysis demonstrated cost savings of

€207,370 for 100 procedures per year with MIS TLIF, equivalent to €2,074 per patient. In the actual scenario analysis, not only the results of Miller et al.'s investigation, but also clinical data about complications and operation time from Hammad et al. were included. The incorporation of the additional data resulted in a cost saving of €166,719 for 100 procedures per year with MIS TLIF.
This adjusted outcome primarily arises from Hammad's findings that the open TLIF method results in shorter operating times. Operating time was identified as the factor with the highest impact on the cost analysis in a parameter sensitivity analysis. (5)

Djurasovic et al. arrived at similar results: In a prospective study, they compared the one-year costs of MIS TLIF and TLIF procedures, considering the costs for the index hospital stay as well as the costs associated with readmission. At the one-year mark, the MIS TLIF group revealed variable direct costs that were $2493 less than those in the open TLIF group ($15,867 versus $17,612). There were no cost differences observed for implant or biologics. However, blood usage, provisions in the operating room, charges for hospital accommodation and meals, pharmacy fees, laboratory costs, and expenses associated with physical therapy were all notably lower in the MIS TLIF cohort. (18)

5 Discussion

The comparison between MIS TLIF and open TLIF encompasses various parameters critical to surgical outcomes. The analysis of blood loss in the context of MIS TLIF versus open TLIF, as drawn from the literature reviewed, consistently reveals a reduction in blood loss associated with MIS TLIF. This discrepancy can be attributed to various advantages of MIS techniques. Specifically, MIS TLIF procedures involve smaller incisions and promise less tissue damage, by avoiding extensive muscle dissection from the spinous processes. A study conducted by Hong et al. underlines these implications of reduced blood loss and further revealed that the preservation of musculoskeletal integrity not only accelerates postoperative mobility but also patient recovery, which ultimately results in shorter hospital stays. (19)

The clinical significance of blood loss is of particular interest, as heightened blood loss correlates with increased risks of postoperative complications such as hematoma formation or the requirement for blood transfusions, emphasizing its crucial role in clinical decision-making.

The analysis of operation time in the context of MIS TLIF versus open TLIF shows a consistent trend towards longer operation times associated with MIS TLIF procedures. This observation is widely attributed to the learning curve in acquiring minimal invasive surgical expertise. Notably, Zhu et al. observed a negative correlation between operation time and the number of surgeries, highlighting the steep learning curve associated with MIS TLIF. Their findings indicate that operation times balance after a substantial number of cases, with the learning curve reaching a point of stabilization around the 43rd operation. (20)
This learning curve not only impacts operation time but also appears to influence the occurrence of complications. Silva et al., in their investigation of MIS TLIF learning curves, highlighted a significant correlation between surgical experience and complication rates. Their study showed that the complication rate diminished with increased experience of the surgeon, as they could observe a 50% learning curve by the 12th case and a 90% learning curve by the 39th case. This correlation underlines the dynamic interplay between surgical experience, operation time, and complication rates in MIS TLIF procedures. (21)
The comparison of complications between MIS TLIF and open TLIF in the literature presents with no significant superiority of one method over the other. Few publications identified notable differences between the two groups, and the lack of a standardized definition of complications entangles comparative analyses. The heterogeneity of reported complications spans a wide spectrum, ranging from dural tears and wound infections to screw misplacement and post-operative pain. Furthermore, some studies provide only limited classification of complications while others offer extensive categorizations. This variability emphasizes the necessity for future investigations to adopt standardized criteria for complication assessment, thereby enabling the comparability of findings across studies.

The examination of hospitalization durations in MIS TLIF versus open TLIF cohorts suggests a propensity towards shorter hospital stays for patients undergoing MIS TLIF procedures. As mentioned earlier in this chapter, this trend is commonly attributed to the faster recovery and reduced trauma associated with minimally invasive techniques, promoting early mobilization and diminished pain postoperatively. However, the determinants of hospital stay are complex, including factors beyond surgical parameters. Country-specific considerations such as healthcare regulations and cost approvals may influence hospitalization durations, alongside rehabilitation requirements, particularly in cases of multi-level spinal fusion.

In examining the cost effectiveness of MIS TLIF versus open TLIF procedures, the evaluation

not only direct procedural expenses but also various indirect costs. The presentation of these costs indicates a critical examination of the threshold at which economic considerations begin to influence surgical choices. Factors such as post-hospitalization therapy, medication expenses, follow-up visits, and potential revision surgeries lead to significant variability among costs.
A broad investigative approach may be needed, considering extended follow-up periods to capture the entirety of economic implications accurately. The literature revealed that scenario analyses play a meaningful role in exploring the nuances of cost differences, given the variability in predictive parameters and outcomes. Despite the outcome, that MIS TLIF tends to be more cost-efficient than open TLIF, the shown variations underline the need for cautious interpretation.

Identifying future research directions in spinal surgeries, particularly in transforaminal lumbar interbody fusion (TLIF), requires the consideration of challenges not further investigated in this review.
One issue identified is the lack of a clear definition for MIS (TLIF) and the resulting variability in surgical approaches that may blur the distinction between MIS and mini-open techniques. To overcome this, future studies must clearly define MIS procedures and exclusively include publications that explicitly describe these techniques, ensuring homogeneity across study cohorts. Similarly, the comparison between navigated and freehand TLIF procedures warrants attention, given potential differences in outcomes. In our investigations - similar to the MIS versus mini-open issue - no differentiation between navigated and freehand approaches was made.
Moreover, the implementation of endoscopic procedures in spinal surgery seems to replace MIS as the up-to-date novel method. Comparative analyses with established methods could further elaborate the efficacy and outcomes of endoscopic approaches.

Subsequently, an examination of parameters with diverse etiologies and pre-diagnosed diseases holds promise for illustrating optimal surgical approaches for specific patient groups. While our review primarily focused on degenerative etiologies as indications for surgery, future investigations could be expanded by incorporating additional influential factors. For instance, the increasing global prevalence of obesity indicates further research about the impact of adiposity on surgical outcomes and parameters. Questions regarding the association between adiposity and prolonged operation time, increased blood loss, and heightened risk of complications demand a detailed investigation.

Notably, another study emphasized the significance of body mass index (BMI) in influencing surgical outcomes, with surgery times raising significantly with increasing BMI in TLIF and MIS-TLIF procedures (22). The surgical challenges associated with obese patients, including prolonged tissue dissection and increased perioperative costs, underline the need for individualized treatment approaches tailored to patient profiles. In addition to examining the commonly discussed surgical challenges linked with obese patients, a comparative exploration of surgical methodologies could be performed to assess whether certain techniques offer superior outcomes in the context of obese patients, thereby contributing to the advancement of surgical approaches tailored to this specific patient population.

In conclusion, although MIS TLIF holds more advantages quantitatively, the qualitative determination of superiority depends on patient and surgeon factors, emphasizing the need for individualized treatment approaches based on comprehensive clinical assessments.

6 Conclusion

In conclusion, the comprehensive analysis of literature comparing MIS TLIF to open TLIF procedures reveals distinct advantages and considerations for each approach. Across various parameters, MIS TLIF demonstrates superior outcomes in terms of reduced blood loss, shorter hospitalization durations, and potentially enhanced cost efficiency. These benefits are attributed to factors such as minimized tissue damage and smaller incisions associated with MIS techniques. However, it is noteworthy that MIS TLIF may involve longer operation times, attributed to the learning curve associated with acquiring surgical skills in minimally invasive surgery. This learning curve emphasizes the importance of surgical experience in reducing operation time and potentially influencing complication rates.

Despite the advantages of MIS TLIF, the definition and classification of complications remain inconsistent across studies, complicating direct comparisons with open TLIF. While a few studies suggest slightly better outcomes for complications with MIS TLIF, the majority do not identify significant differences between the two groups. This highlights the need for standardized criteria for complication assessment in future investigations.

The review also prompts directions for further research. Clearer categorization of parameters and surgical techniques, alongside detailed comparisons with emerging methods such as endoscopic surgery, hold promise for advancing our understanding of optimal surgical approaches in spinal fusion procedures. By including these considerations future studies have the potential to advance treatment strategies and improve patient care in this specialized field.

7 Summary

This literature review compares minimally invasive transforaminal lumbar interbody fusion (MIS TLIF) with open TLIF procedures across various parameters. Analyzing ten publications, it highlights consistent findings regarding reduced blood loss and shorter hospitalization durations associated with MIS TLIF. While operation times are often longer for MIS TLIF, attributed to the learning curve, the overall complication rates do not significantly differ between the two techniques. However, the variability in complication definitions underscores the need for detailed considerations. Cost analyses suggest potential cost savings with MIS TLIF, though careful examination is essential. Overall, while MIS TLIF offers quantitative advantages, individualized treatment approaches based on comprehensive clinical assessments remain crucial for optimizing patient outcomes.

Kewywords: TLIF, minimally invasive, lumbar fixation, spine surgery

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