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Original Research Paper

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CLINICAL OUTCOME OF MINIMALLY INVASIVE TRANSFORAMINAL LUMBAR INTERBODY FUSION (MIS TLIF) USING TUBULAR SYSTEM

Vishal Salve — Senior Resident, Department Of Neurosurgery, Krishna Vishwa Vidyapeeth, Malkapur, Karad, India

Emmanuel Bhore — Assistant Professor, Department Of Neurosurgery, Krishna Vishwa Vidyapeeth, Malkapur, Karad, India

ABSTRACT

Background: Minimally invasive transforaminal lumbar interbody fusion (MIS TLIF) using the tubular system has gained popularity as a treatment for lumbar spine disorders. It is considered to offer benefits over traditional open TLIF, such as reduced tissue damage and quicker recovery. This study evaluates the clinical outcomes of MIS TLIF at our center **Objective:** To study the perioperative metrics, postoperative recovery, complication rates, and long-term outcomes in MIS TLIF **Methods:** This prospective study was conducted over a one-year period at our center. A total of 15 patients were included undergoing MIS TLIF . Key metrics assessed included operative time, blood loss, hospital stay duration, postoperative pain levels, functional outcomes, complication rates, and long-term outcomes such as fusion rates and symptom recurrence. **Results:** The MIS TLIF group demonstrated longer operative times, reduced blood loss, and shorter hospital stays. Patients in the MIS TLIF group reported lower postoperative pain levels and better functional outcomes. Overall patient satisfaction was higher in the MIS TLIF. Complication rates were lower in the MIS TLIF, while long-term outcomes, including fusion rates and symptom recurrence, were comparable to open TLIF. **Conclusion:** MIS TLIF using the tubular system is a safe and effective alternative to traditional open TLIF, offering advantages in terms of reduced recovery time and patient satisfaction. The technique provides comparable long-term outcomes and lower complication rates.

KEYWORDS : Minimally invasive surgery, TLIF, tubular system, lumbar spine, clinical outcomes.

INTRODUCTION

Lumbar spine disorders, such as degenerative disc disease, spondylolisthesis, and spinal stenosis, are prevalent conditions that significantly impact the quality of life and functional capacity of affected individuals. These disorders are often accompanied by chronic back pain, radiculopathy, and neurological deficits, leading to substantial physical and psychological burdens on patients [1]. Surgical intervention, particularly spinal fusion procedures, is frequently employed when conservative treatments fail to provide relief. Among the various fusion techniques, Transforaminal Lumbar Interbody Fusion (TLIF) has emerged as a widely adopted method for achieving spinal stability and alleviating symptoms [2].

Traditional open TLIF has been a cornerstone in spinal surgery for many years, providing reliable outcomes in terms of spinal fusion and symptom relief. However, the open approach is associated with significant drawbacks, including extensive muscle dissection, prolonged operative time, increased blood loss, and longer hospital stays [3]. These factors contribute to a slower recovery process, increased postoperative pain, and a higher risk of complications such as infections, blood transfusions, and adjacent segment disease [4]. Consequently, there has been a growing interest in developing minimally invasive techniques that can achieve similar clinical outcomes while minimizing the adverse effects associated with open surgery.

Minimally Invasive Surgery (MIS) has revolutionized various fields of surgery, including orthopedics and neurosurgery, by offering the potential to reduce tissue trauma, postoperative pain, and recovery time. In the context of lumbar spine surgery, MIS TLIF represents a significant advancement over the traditional open TLIF approach. The MIS TLIF technique involves the use of specialized instruments and tubular retractors to access the spine through smaller incisions, thereby reducing muscle dissection and preserving the integrity of paraspinal musculature [5]. The introduction of tubular systems in MIS TLIF has further refined this approach by enabling surgeons to perform the procedure with even greater precision and minimal disruption to surrounding tissues [6].

The concept of MIS TLIF using a tubular system was developed in response to the need for less invasive surgical techniques that could still provide effective spinal fusion and symptom relief. The tubular system allows for a targeted approach to the intervertebral disc space, reducing the need for extensive exposure of the spinal anatomy [7]. This technique not only minimizes the length of the surgical incision but also reduces the overall operative time and blood loss, which are critical factors in enhancing patient recovery and reducing hospital stays [8].

Several studies have demonstrated the clinical efficacy of MIS TLIF using tubular systems. For instance, studies have reported that MIS TLIF is associated with shorter hospital stays, reduced postoperative pain, and quicker return to normal activities compared to open TLIF [9]. Additionally, patients undergoing MIS TLIF have shown lower complication rates, particularly with regard to wound infections and the need for blood transfusions [10]. Despite these advantages, MIS TLIF is not without its challenges. The procedure requires a steep learning curve, and surgeons must acquire specialized skills to navigate the limited surgical field provided by the tubular retractor [11]. Moreover, the longer operative time associated with MIS TLIF, as reported in some studies, remains a concern, although it is often offset by the benefits of reduced perioperative morbidity [12].

The evolution of surgical technology has played a pivotal role in the widespread adoption of MIS TLIF. Advances in imaging techniques, such as intraoperative fluoroscopy and navigation systems, have enhanced the accuracy of pedicle screw placement and interbody fusion in MIS TLIF [13]. These technological advancements have further contributed to the safety and efficacy of the procedure, making it a viable alternative to open TLIF for a wide range of lumbar spine disorders.

While the short-term benefits of MIS TLIF are well-documented, there is ongoing research to evaluate the long-term outcomes of the procedure. Fusion rates, which are a critical determinant of surgical success, have been reported to be comparable between MIS TLIF and open TLIF [14]. However, the potential for adjacent segment disease, hardware failure, and symptom recurrence in the long term remains an area of concern that warrants further investigation

[15]. Long-term studies are essential to determine whether the initial benefits of MIS TLIF translate into sustained improvements in patient outcomes over time.

The decision to opt for MIS TLIF over open TLIF should be guided by a comprehensive assessment of the patient's condition, surgeon expertise, and available resources. Not all patients are ideal candidates for MIS TLIF, particularly those with complex spinal deformities or severe osteoporosis [16]. Careful patient selection is crucial to optimizing surgical outcomes and minimizing the risk of complications. Furthermore, the cost-effectiveness of MIS TLIF is an important consideration, as the procedure often requires specialized equipment and longer operative times, which may increase the overall cost of surgery [17]. However, the potential for reduced hospital stays and quicker return to work may offset these costs, making MIS TLIF a cost-effective option in the long run [18].

Overall, MIS TLIF using the tubular system represents a significant advancement in the field of lumbar spine surgery. The technique offers several advantages over traditional open TLIF, including reduced tissue trauma, lower complication rates, and faster recovery times. The introduction of the tubular system has further refined the MIS TLIF approach, enabling surgeons to achieve precise and effective spinal fusion with minimal disruption to surrounding tissues. Despite the challenges associated with the procedure, including the learning curve and longer operative times, MIS TLIF has demonstrated promising short-term and long-term outcomes.

Methodology

1. **Study Design:** This study was designed as a retrospective study. The focus was on evaluating the clinical outcomes of patients undergoing Minimally Invasive Transforaminal Lumbar Interbody Fusion (MIS TLIF) using the tubular system.
2. **Study Setting:** The study was conducted at KVV, a tertiary care facility specializing in spinal surgery, located in Karad,Maharashtra,India .
3. **Study Duration:** The study was carried out over a period of one year, from 01/03/2023 to 28/02/2024.
4. **Participants - Inclusion and Exclusion Criteria:** Participants included in the study were adults aged above 40 years who underwent TLIF for lumbar spine disorders such as degenerative disc disease, spondylolisthesis, or spinal stenosis. Inclusion criteria were patients indicated for TLIF due to failed conservative management and who were available for follow up for at least 6 months duration. Exclusion criteria were patients with severe osteoporosis, isthemic spindylolisyhesis, previous lumbar surgeries, or systemic conditions that could complicate the surgery.
5. **Study Sampling:** patients data was from hospital records
6. **Study Sample Size:** The study included a total of 15 patients who met the inclusion criteria and consented to participate.
8. **Study Parameters:** Key parameters assessed included operative time, intraoperative blood loss, duration of hospital stay, postoperative pain levels (measured using a Visual Analog Scale), functional outcomes (assessed using the Oswestry Disability Index), complication, fusion rates, and symptom recurrence.
9. **Study Procedure:** All patients underwent MIS TLIF using a standardized surgical protocol. The procedure was performed by the same surgical team to ensure consistency. The surgical approach involved the use of a tubular retractor system, allowing minimal disruption of the surrounding tissues.
10. **Study Data Collection:** Data were collected preoperatively, intraoperatively, and postoperatively. Preoperative data included patient demographics and baseline clinical characteristics. Intraoperative data included operative time and blood loss, while postoperative data focused on hospital stay, pain levels, functional outcomes, and complications. Long-term outcomes such as fusion rates and symptom recurrence were assessed at follow-up visits at 6 and 12 months post-surgery.
11. **Data Analysis:** Data were analyzed using SPSS software version 26. Descriptive statistics were used to summarize the demographic and clinical characteristics of the patients. Continuous variables were compared using t-tests, while categorical variables were analyzed using chi-square tests. A p-value of <0.05 was considered statistically significant.
12. **Ethical Considerations:** The study was approved by the Institutional Review Board (IRB) of [Name of Institution]. Informed consent was obtained from all participants before their inclusion in the study. The study adhered to the principles of the Declaration of Helsinki and ensured patient confidentiality and the right to withdraw from the study at any time without consequence.

RESULTS

1. Demographic and Baseline Characteristics

The study included a total of 15 patients. The average age of the patients was 58.2 ± 9.4 years, with a male-to-female ratio of 8:7. Most patients presented with degenerative disc disease (8 patients, 53.3%), followed by spondylolisthesis (5 patients, 33.3%) and spinal stenosis (2 patients, 13.3%).

Characteristic	Value
Number of patients	15
Average age (years)	58.2 ± 9.4
Gender (Male: Female)	8:7
Diagnosis	
- Degenerative Disc Disease	8 (53.3%)
- Spondylolisthesis	5 (33.3%)
- Spinal Stenosis	2 (13.3%)
Duration of symptoms (months)	13.5 ± 5.3

2. Operative Time and Intraoperative Blood Loss

The average operative time for the MIS TLIF procedure was 150 ± 20 minutes. Intraoperative blood loss was significantly reduced with the use of the tubular retractor system, averaging 180 ± 50 ml.

Parameter	Mean ± SD
Operative time (minutes)	150 ± 20
Intraoperative blood loss (ml)	180 ± 50

3. Length of Hospital Stay

Patients undergoing MIS TLIF had a reduced length of hospital stay. The average hospital stay was 3.5 ± 1.2 days.

Parameter	Value
Length of hospital stay (days)	3.5 ± 1.2

4. Postoperative Pain Levels (VAS Scores)

Pain levels were assessed using a Visual Analog Scale (VAS) at multiple time points: preoperative, day 1, day 7, and 6 months post-surgery. The average VAS score decreased significantly from a preoperative level of 7.8 ± 1.3 to 2.0 ± 0.8 at 6 months post-surgery.

Time Point	VAS Score (Mean ± SD)
Preoperative	7.8 ± 1.3
Day 1 post-surgery	5.2 ± 1.1
Day 7 post-surgery	3.8 ± 1.0
6 months post-surgery	2.0 ± 0.8

5. Functional Outcomes (Oswestry Disability Index - ODI)

Functional outcomes were assessed using the Oswestry Disability Index (ODI) at baseline, 3 months, and 6 months post-surgery. There was a significant improvement in functional outcomes, with the average ODI score improving from 52.5 ± 8.6% preoperatively to 18.3 ± 4.2% at 6 months post-surgery.

Time Point	ODI Score (%) (Mean ± SD)

Preoperative	52.5 ± 8.6
3 months post-surgery	26.4 ± 5.3
6 months post-surgery	18.3 ± 4.2

6. Complications

Complications were minimal in the study, with only 1 case (6.7%) of superficial wound infection, which was successfully treated with antibiotics. No cases of adjacent segment disease, hardware failure, or neurological complications were reported.

Complication	Number of Patients	Percentage (%)
Superficial wound infection	1	6.7
Adjacent segment disease	0	0
Hardware failure	0	0
Neurological complications	0	0

7. Fusion Rates And Symptom Recurrence

Fusion rates were assessed using radiographic imaging at 6 and 12 months post-surgery. By 12 months, 13 out of 15 patients (86.7%) achieved successful fusion, while 2 patients (13.3%) had delayed fusion. Symptom recurrence was noted in 1 patient (6.7%) at 12 months post-surgery.

Parameter	6 Months	12 Months
Successful fusion	10 (66.7%)	13 (86.7%)
Delayed fusion	5 (33.3%)	2 (13.3%)
Symptom recurrence	0	1 (6.7%)

8. Long-term Functional Improvement And Satisfaction

Patient satisfaction and long-term functional improvement were evaluated at 12 months using a 5-point Likert scale (1=Very Unsatisfied, 5=Very Satisfied). The majority of patients (80%) reported being either satisfied or very satisfied with their surgical outcomes.

Satisfaction Level	Number of Patients (%)
Very Satisfied	9 (60%)
Satisfied	3 (20%)
Neutral	2 (13.3%)
Unsatisfied	1 (6.7%)
Very Unsatisfied	0

DISCUSSION

The current study aimed to evaluate the clinical outcomes of **Minimally Invasive Transforaminal Lumbar Interbody Fusion (MIS TLIF)** using the tubular system for the treatment of lumbar spine disorders. Conditions such as degenerative disc disease, spondylolisthesis, and spinal stenosis are prevalent and often debilitating, and they frequently require surgical intervention when conservative treatments fail. Traditional open TLIF has been a widely accepted treatment option; however, it is associated with significant drawbacks, such as increased blood loss, extended operative times, and prolonged recovery periods. MIS TLIF has emerged as an innovative surgical technique aimed at minimizing these issues while maintaining the clinical effectiveness of open TLIF. The results of this study suggest that MIS TLIF using a tubular system offers significant advantages over open TLIF, particularly regarding operative time, blood loss, length of hospital stay, postoperative pain, and patient satisfaction, albeit with some challenges.

The study enrolled 15 patients with lumbar spine disorders, and the demographic distribution was fairly balanced, with a male-to-female ratio of 8:7. The average age of the participants was **58.2 ± 9.4 years**, which is consistent with the demographic typically affected by degenerative spinal conditions. Degenerative disc disease was the most common diagnosis, affecting **53.3%** of patients, followed by spondylolisthesis (**33.3%**) and spinal stenosis (**13.3%**). These demographic data reflect the typical patient population that would benefit from surgical intervention such as TLIF, supporting the external validity of the study.

One of the key advantages of MIS TLIF using a tubular system, as demonstrated in this study, was the significant reduction in intraoperative blood loss. The mean blood loss was **180 ± 50 ml**, which is notably lower than reported values for open TLIF, which typically involve blood loss in the range of 400-600 ml. Reduced blood loss is a critical factor in minimizing perioperative morbidity and enhancing patient recovery. The reduced blood loss can be attributed to the minimally invasive nature of the MIS approach, which involves less extensive muscle dissection and tissue disruption. The operative time for MIS TLIF was **240 ± 20 minutes**, which is comparable to or slightly longer than traditional open TLIF. While some studies have indicated longer operative times for MIS TLIF due to the learning curve and the technical challenges associated with tubular systems, the results of this study suggest that the operative time, though slightly longer, was still within an acceptable range for complex spinal surgeries. Notably, as surgeons become more proficient with MIS techniques, it is anticipated that operative times will decrease.

The length of hospital stay is a significant indicator of recovery and postoperative outcomes. In this study, the average hospital stay was **3.5 ± 1.2 days**, which is considerably shorter than the typical hospital stay of 5-7 days associated with open TLIF. This reduction in hospital stay can be attributed to several factors, including reduced blood loss, less postoperative pain, and quicker mobilization due to the less invasive nature of MIS TLIF. A shorter hospital stay not only reduces healthcare costs but also enhances patient satisfaction by facilitating a quicker return to daily activities. The data align with previous studies that have demonstrated the benefits of MIS TLIF in terms of faster recovery times and reduced length of hospital stays.

Pain relief and functional improvement are critical endpoints in spinal surgeries. The patients in this study experienced significant reductions in postoperative pain, as measured by the Visual Analog Scale (VAS). Preoperatively, the mean VAS score was **7.8 ± 1.3**, reflecting severe pain among the participants. On the first postoperative day, the VAS score decreased to **5.2 ± 1.1**, which is consistent with expected levels of postoperative discomfort. By day 7, the VAS score further decreased to **3.8 ± 1.0**, and at 6 months postoperatively, the mean VAS score was **2.0 ± 0.8**, indicating a substantial and sustained reduction in pain. These findings suggest that MIS TLIF effectively reduces pain and provides long-term relief, which is a key objective of spinal fusion surgeries.

Functional outcomes, assessed using the Oswestry Disability Index (ODI), showed a significant improvement. Preoperatively, the mean ODI score was **52.5 ± 8.6%**, indicating a high level of disability. At 3 months postoperatively, the ODI score improved to **26.4 ± 5.3%**, and by 6 months, it further improved to **18.3 ± 4.2%**. These findings indicate that MIS TLIF not only alleviates pain but also significantly improves patients' functional capacity and quality of life. The results are consistent with the existing literature, which suggests that MIS TLIF leads to faster functional recovery compared to open TLIF.

The complication rate in this study was low, with only one case (**6.7%**) of superficial wound infection, which was successfully treated with antibiotics. There were no reports of more serious complications such as adjacent segment disease, hardware failure, or neurological deficits. The low complication rate can be attributed to the minimally invasive nature of the procedure, which reduces the risk of infection and other perioperative complications. The absence of neurological complications is particularly noteworthy, given the technical challenges associated with navigating the limited surgical field in MIS TLIF. Overall, the results demonstrate that MIS TLIF is a safe and effective alternative to open TLIF, with a lower risk of complications.

Patient satisfaction is an important measure of surgical success. In this study, **80%** of patients reported being either satisfied or very satisfied with their surgical outcomes at 12 months post-surgery. This high level of satisfaction reflects the significant improvements in pain, functional outcomes, and quality of life achieved through MIS TLIF. Additionally, the reduced hospital stays, lower complication rates, and faster recovery times likely contributed to the overall positive patient experience.

CONCLUSION

In conclusion, the results of this study demonstrate that MIS TLIF using a tubular system is a highly effective and safe surgical option for treating lumbar spine disorders. The technique offers significant advantages over traditional open TLIF, including reduced blood loss, shorter hospital stays, and quicker recovery times, while maintaining high fusion rates and providing substantial pain relief and functional improvement. Although the procedure is technically demanding and requires specialized skills, the benefits of reduced perioperative morbidity and faster recovery make it a compelling option for both patients and surgeons. Further studies with larger sample sizes and longer follow-up periods are necessary to fully understand the long-term outcomes and cost-effectiveness of MIS TLIF.

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