ORIGINAL ARTICLE

Comparative study of open Transforaminal Lumbar Interbody Fusion (TLIF) and Minimally Invasive Transforaminal Lumbar Interbody Fusion (MISTLIF) based on clinical outcome, radiological outcome, tissue injury markers and radiation exposure

Srikanth T[1], Silpa Thota[2], Venkat K[1], Ramesh Chandra V V[1], BCM Prasad[1]*

[1]Department of Neurosurgery, [2]Department of Biochemistry

Sri Venkateswara Institute of Medical Sciences, Tirupati-517501(Andhra Pradesh) India

Abstract

Background: Spondylolisthesis refers to forward slippage of one vertebral body with respect to the one beneath it. Spondylolisthesis is treated with spinal fusion which can be open spinal fusion or minimally invasive fusion. Minimal Invasive Transforaminal Lumbar Interbody Fusion (MISTLIF), is the most popular type of minimally invasive fusion. No consensus is available regarding best type of fusion surgery till date. *Aim and Objectives:* To evaluate the clinico-radiological outcome, changes in tissue injury markers and radiation exposure between open TLIF and MIS TLIF. *Materials and Methods:* A clinical series of 70 patients with symptomatic lumbar spondylolisthesis who underwent surgery (Open TLIF-35, MISTLIF-35) were included in the study. Clinical outcome and the function were assessed using the Visual Analogue Scale (VAS) score for pain and the Oswestry Disability Index (ODI). Serum levels of creatine phosphokinase and C-reactive protein were measured on pre-operative day and post-operatively on days 1 and 3. Radiation exposure levels were quantified with a dosimeter which was worn by operating surgeon over the lead apron. *Results:* A total of seventy patients (Open TLIF-35, MISTLIF-35) were included in the study. The preoperative demographic, clinical, biochemical, and radiological parameters were comparable in both the groups. The patients in both the groups had significant improvement in VAS and ODI scores postoperatively. The fusion rates in the follow up were same in both the groups. The patients in MISTLIF group scored better over the open TLIF group in terms of intraoperative blood loss, requirement for blood transfusions, requirement of postoperative analgesia and muscle injury markers. The rate of complications was more in the open TLIF group; however, the radiation exposure was less in the open group. *Conclusion:* The postoperative VAS, ODI scores and fusion rates were similar in both groups. MISTLIF results in less tissue damage which accounts for lesser blood loss, shorter hospital stay and lesser postoperative analgesia requirements with increased radiation exposure being a shortcoming.

Keywords: Lumbar Fusion, Lumbar Spondylolisthesis, Minimally Invasive, Tissue Injury Markers

Introduction

Spondylolisthesis refers to the forward slippage of one vertebral body with respect to the one beneath it. It is classified based on aetiology into congenital or dysplastic, isthmic, degenerative, traumatic and pathologic [1]. Spondylolisthesis is treated with spinal fusion, which can be open spinal fusion or minimally invasive fusion. Open spinal fusions include posterolateral fusion, Posterior Lumbar Interbody Fusion (PLIF), Anterior Lumbar Interbody Fusion (ALIF) and Transforaminal Lumbar Interbody Fusion (TLIF). Minimal invasive fusions include Minimal Invasive TLIF (MISTLIF), Direct Lateral Interbody Fusion (DLIF), Extreme Lateral Interbody Fusion (XLIF) and Oblique Lateral Interbody Fusion (OLIF) [2]. Open spinal fusions are associated with extensive soft tissue dissection, increased operative blood loss, the necessity for blood transfusions and increased postoperative pain [3]. Minimal invasive fusion preserves attachment of paraspinal muscles, minimizes soft tissue trauma, decreases operative blood loss, diminishes postoperative pain, has quicker postoperative recovery [4] but has disadvantages such as increased radiation exposure, steep learning curve, and lower fusion rates [5]. Consensus regarding the best type of fusion surgery has yet to be made available.

Material and Methods

The Institutional Ethics Committee of Sri Venkateswara Institute of Medical Sciences (SVIMS) in Tirupati, Andhra Pradesh, India, sanctioned the study protocol (IEC No.; Roc. No. A&E/08/IEC/SVIMS/09/484). All patients participating in the study provided their informed consent.The study implemented a consecutive sampling method for participant selection. All suitable patients who underwent surgical intervention for symptomatic lumbar spondylolisthesis at SVIMS within the study period were included. This technique ensured representativeness of the surgical population during that time and minimized selection bias. Patients were divided into two groups for the study: one that underwent conventional open surgery and another that underwent minimally invasive surgery. The allocation of patients to these groups was primarily influenced by surgeon recommendation, patient preference, and their suitability for minimally invasive procedures. Strict adherence to age and gender matching was maintained between the two groups to eliminate potential bias. For each patient in the open surgery group, we aimed to find a counterpart in the minimally invasive surgery group with similar age (±3 years) and the same gender. This strategy allowed us to ascribe any observed differences in outcomes to the surgical method rather than age or gender-related factors. To confirm that the two groups were statistically comparable in terms of age and gender, we conducted independent-samples t-tests for age and chi-square tests for gender. In both tests, the p-values exceeded 0.05, indicating no statistically significant difference between the two groups in terms of age and gender. This reaffirmed that the groups were well-matched, allowing for reliable comparison of surgical outcomes.

Only patients with Grade I and II spondylolisthesis were included. Exclusion criteria included osteoporosis, high-grade listhesis (Grades III and IV), a history of surgery at the same level, and those unwilling to consent to surgery. Patients were subjected to detailed examinations, and their clinical symptoms, VAS, and ODI were evaluated both before and after the surgery. On the preoperative day and postoperatively on days 1 and 3, the serum levels of creatine phosphokinase and C-reactive protein were recorded.

Patients also underwent radiological evaluations, comprising of X-rays (SIEMENS, 500mA, India 2009), AP and lateral views, a whole spine X-ray, and MRI (SIEMENS, 1.5 TESLA, Germany 2002) to determine listhesis grade, canal stenosis, degenerative disc and the cal sac compression/root compression. Surgeries were performed under general anaesthesia with the patient positioned prone, in both open and minimally invasive procedures.

Surgery duration, intraoperative blood loss, and radiation exposure, quantified in rem or Sieverts (Sv), with 1 Sv equalling 100 rem, were measured. Radiation levels were calculated using the Instadose™ dosimeter (Mirion Technologies, Irvine, CA, USA), which uses Direct Ion Storage (DIS) technology for radiation detection and provides dosage calculations through a web-based software (Figure 1). The dosimeter, worn over the surgeon's lead apron, provided readings immediately after each surgery's conclusion. Post-operative transfusion requirements and hospital stay length were noted, along with the need for analgesics post-surgery, measured in days. Follow-up assessments of postoperative VAS and ODI scores took place six months after surgery.

Figure 1: Image showing the The Instadose™ dosimeter and the method of wearing it during surgery

Statistical analysis

All the data were tabulated in Microsoft Excel 2007 data sheet under various headings. Data were expressed as mean and frequency tables. Statistical analysis was performed using a Microsoft Excel spreadsheet and SPSS for Windows version 20.0. Statistical comparisons of the groups were made using the student t-test and Chi-square test. Comparison between the two groups was made with reference to the following parameters – functional assessment of ODI, VAS, duration of surgery, blood loss, radiation exposure, duration of hospital stay, wound complication, levels of tissue injury markers, analgesic requirement and fusion rate. Results with p - value ≤ 0.05 were considered statistically significant.

Results

The study included a total of seventy patients. Both open TLIF and MISTLIF groups had thirty five patients each. The demographic profile, clinical features and the imaging of listhesis were comparable between the groups (Table 1). The open TLIF and MISTLIF groups were compared on various factors like duration, blood loss, radiation exposure, hospital stay, analgesia and biochemical parameters (Table 2).

In the open TLIF group, 7(20%) of patients required blood transfusion, and in the MISTLIF group, blood transfusion was not needed for any patient. There was a significant improvement in VAS score in postoperative follow-up compared

Table 1: Demographic, clinical and radiological profile of subjects

Parameters	Open TLIF (N=35)	MISTLIF (N=35)	*p*
Average age	44.34	47.31	NS
Sex ratio (m : f)	1:2.5	1:2.5	NS
Symptoms			
Pain	35 (100%)	35 (100%)	NS
Parenthesis	24 (69%)	15 (43%)	NS
Weakness	14 (40%)	12 (34%)	NS
Signs			
Motor deficits	30 (86%)	30 (86%)	NS
Sensory deficits	12 (34%)	7 (20%)	NS
Listhesis			
Grade I	13 (37%)	16 (45.7%)	NS
Grade II	22 (63%)	19 (54.3%)	NS
Degenerative	19 (54.3%)	21 (60%)	NS
Isthmic	16 (45.7%)	14 (40%)	NS

NS- Not significant

to preoperative VAS score in both open TLIF and MISTLIF groups ($p<0.0001$). There was no significant difference in postoperative VAS scores between open TLIF and MISTLIF groups ($p=0.6102$). There was a substantial improvement in ODI scores in postoperative follow-up compared to preoperative ODI scores in both open TLIF and MISTLIF groups($p<0.0001$). There was a significant difference in postoperative ODI scores, with better improvement in the MISTLIF group ($p=0.0419$). In the open TLIF Group, 2(5.7%) patients had wound complications in the form of one patient developing surgical site infection, and another developing CSF leak. In MISTLIF, there were no complications.

Table 2: Comparative study of open TLIF and MISTLIF

Parameters	Open TLIF (N=35) (Mean ± SD)	MISTLIF (N=35) (Mean ± SD)	*p*
Average duration (hr)	3.06 ± 0.38	3.14 ± 0.41	NS
Intraoperative blood loss (ml)	206.86 ± 41.66	90.21 ± 23.39	**p < 0.0001**S
Intraoperative radiation exposure to the surgeon (mSv)	0.11 ± 0.02	0.34 ± 0.04	**p < 0.0001**S
Average length of hospital stay (days)	7.66 ± 1.04	7.43 ± 1.10	p = 0.3854 NS
Post-operative analgesia (days)	23.71 ± 4.27	6.18 ± 1.35	**p < 0.0001**S
Creatine phosphokinase on postoperative day 3 (IU/L)	278.44 ± 46.33	147.28 ± 22.13	**p < 0.0001**S
C-reactive protein on postoperative day 3 (mg/L)	17.27 ± 3.22	6.76 ± 1.22	**p < 0.0001**S

NS- Not significant, S- Significant

Discussion

The ideal minimally invasive spine surgery should result in less collateral tissue damage leading to decreased morbidity with rapid functional recovery than open procedures without compromising the intended surgical goal [6]. Therefore, this study compared the clinical, radiological, and intra-operative parameters, postoperative outcomes and tissue injury markers in patients with lumbar spondylolisthesis between open TLIF and MISTLIF.

The mean duration of surgery in the MISTLIF and TLIF groups were 3.14 hrs and 3.06 hrs, respectively. However, the difference in operative time was variable in the literature; few studies reported shorter operative times for MISTLIF [7], some did not find much difference [8-9] and then there were studies which found MISTLIF having longer operative times [10-11]. This variability may be attributed to the inclusion of cases from an earlier phase of their learning curve and different modalities of imaging systems used during surgery [12].

Average intraoperative blood loss was 90.21 ml in the MISTLIF group, which was significantly low compared to 206.86 ml of the open TLIF group, as found in other studies [13-14]. In our study, 20% of patients in the open TLIF group required blood transfusion similar to other findings [15-16].

The average radiation exposure to the surgeon during the MISTLIF procedure was 0.34mSv, significantly higher than the average of 0.11 mSv during the open TLIF procedure. Our study is the first in which instant read-out dosimeter was used. It helped the surgeon in giving immediate feedback regarding radiation exposure. The literature review revealed a higher exposure to radiation with MISTLIF than with open TLIF [17-19]. The amount of radiation exposure can be minimized by using shielding devices (lead aprons, gloves, thyroid shields), keeping a distance from the radiation sources, using navigation, and using low-dose pulsed fluoroscopy and collimation [20]. The average postoperative analgesia requirement was significantly higher in open TLIF patients (23.71 days) compared to MISTLIF patients (6.18 days). This allowed early mobilization in this group, similar to other studies [21-22]. Though the MISTLIF group ambulated early, there was no significant difference in length of hospital stay between open TLIF and MISTLIF groups. The hospital stay varied in literature with some studies finding no difference in hospital stay [23], whereas few studies found shorter hospital stay in the MISTLIF group [24]. There was no significant difference in VAS scores at six months follow-ups between open TLIF and MISTLIF groups. These findings were in line with that of the literature [16-17]. Postoperative ODI score at six months follow-up in the MIS TLIF group was significantly lower when compared with the open TLIF group. Similar results were seen in a few studies [14], but no significant difference between ODI scores in the long term [25-26]. The overall complication rate in the open TLIF group was 5.7%, while it was 0% in the MISTLIF group. Studies analysing complications enumerated multiple complications like the postoperative neurological deficit, surgical site infection, CSF leak, screw malposition, cage migration, etc. Still, they found no significant difference between MISTLIF and open TLIF groups [14-28].

The levels of tissue injury markers, such as C-reactive protein and creatine kinase, were significantly lower in MISTLIF patients compared to open TLIF patients. This suggests that MISTLIF causes less surgical trauma and tissue damage, resulting in a less inflammatory response and faster recovery [11]. As with any study, there are limitations to our findings. Our study follow-up period was six months in contrast to other studies where the mean follow-up was 24 months. Our study looked at only the short-term outcomes.

Though efforts were made to minimize bias throughout the study, it's crucial to acknowledge potential sources that may affect the study's findings. One such potential bias could stem from the non-randomized assignment of patients to the open surgery and minimally invasive surgery groups. Another potential source of bias was the single-center nature of the study. Since all patients were drawn from one institution (SVIMS), the results may not be fully generalizable to all patients with lumbar spondylolisthesis. Lastly, there might be a potential for observer bias since the surgeons who performed the operations were likely the same individuals assessing postoperative outcomes. Even with objective measurements, knowing the type of procedure a patient underwent could subtly influence their evaluations. Despite these potential biases, this study represents an essential step in understanding the comparative outcomes of traditional and minimally invasive surgery for symptomatic lumbar spondylolisthesis. Future research should focus on larger sample sizes, more extended follow-up period, long-term results (clinical, fusion rates, subsidence rates, adjacent segment disease) and cost-effectiveness analyses.

Conclusion

The short-term patient outcomes, i.e. postoperative VAS scores and ODI scores, were comparable in both groups. MISTLIF results in less tissue damage, translating into lesser blood loss, lesser postoperative analgesia requirements, and early mobilization. The drawback is increased radiation exposure.

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***Author for Correspondence:**
Dr Silpa Thota, Department of Biochemistry, SVIMS, Tirupati, A.P – 517507
Email: rcvvns@gmail.com Cell: +91 9493031608

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