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ORIGINAL ARTICLE

# Does a high BMI affect the outcome of minimally invasive TLIF? A retrospective study of 207 patients

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## Abstract

**Purpose** We investigated whether a high Body Mass Index (BMI) affects the outcomes following Minimally Invasive TLIF (MI-TLIF) for degenerative lumbar pathologies.

**Methods** A retrospective study was undertaken to include patients operated between January 2016 and January 2020 with at least one-year follow-up. Various preoperative and demographic parameters were recorded and the patients were classified into normal, overweight and obese based on the BMI. The operative and outcome measures used for assessment were surgical time, blood loss, number of levels operated upon, skin incision length, day of independent mobilisation, total hospital stay including ICU stay, return to work and Visual Analogue Score (VAS) for back pain (VAS-BP) and leg pain (VAS-LP) and Oswestry Disability Index (ODI). Attainment of Minimal Clinically Important Difference (MCID) for the scores was calculated. Multivariate analyses were done to assess the effect of BMI on different parameters.

**Results** Blood loss and postoperative ICU stay were found to be higher in the obese patients. However, the other variables were comparable. VAS-BP, VAS-LP and ODI scores were significantly improved in all the patients with no inter-group variability. The MCID attainment was also similar. The satisfaction rating at 1-year and willingness for surgery again for similar disease was also similar. The overall complication rate was 14.9% and was comparable among the groups. Multivariate analyses revealed no significant association between BMI and various parameters.

**Conclusion** In patients treated by MI-TLIF for degenerative lumbar spine pathology, BMI is not a factor that negatively affects the functional and clinical outcomes.

**Keywords** MI-TLIF · Obesity · ODI · MCID · VAS · Outcomes

## Introduction

Obesity is an epidemic of the modern ages and has a significantly high prevalence in the developed world and along with being overweight, has spread to involve approximately a third of the world population [1]. It is predicted that if current trends are to be extrapolated, 38% of the adult population of the world will be overweight and a further 20% obese by the year 2030 [2]. Obesity is defined as a body mass index (BMI) $\geq 30$ kg/m$^2$ and overweight is defined as a BMI $\geq 25$ kg/m$^2$ [1]. This has obvious medical effects on the body including non-communicable diseases. It also has particularly negative repercussions on the health of the spine, especially the lumbar spine and has been well documented. [3, 4]. The increased incidences of low backaches, disc degenerations and other similar degenerative conditions requiring treatment provide the proof needed and also give the necessary warning as to what might present to us in the future [5].

The surgery for lumbar degenerative disc disease (LDDD) commonly involves procedures to cause interbody fusion. Several approaches and procedures have been described to attain this with Transforaminal interbody fusion (TLIF) among one of them. Although the open surgeries were relatively successful in achieving the fusion and improving the

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functional outcomes, they carried with them many disadvantages like a longer incision and surgery time and more blood loss. There was also a delayed mobilisation, longer hospital stay and delayed return to work observed. [6] Hence, such surgeries via the minimally invasive route e.g. Minimally Invasive TLIF (MI-TLIF) have attained a lot of traction due to the benefits like a lesser postoperative pain and early rehabilitation [6]. These are thus comparable to, if not better, than the traditional open approach. In addition, the complications seen in patients with obesity can have an important part to play in the process of surgical decision-making [7].

The presence of obesity in a patient requiring surgery for LDDD brings with it, its own set of challenges. Complications thus arising have been studied extensively and described in detail. Functional outcomes after surgeries in obese and overweight patients following open surgeries have shown mixed results. The additional challenges mainly relating to the extensive dissection required to achieve a proper exposure were supposed to be responsible. While a few have reported poorer results, others have observed no similar differences. [8–10] Minimally invasive surgeries have been, however, studied scarcely with respect to this category of patients [11–13]. So, the authors felt the need to evaluate and compare the results of MI-TLIF in different BMI categories and to infer if there was any significant difference in the results. Hence, this study aims to investigate whether obesity and overweight affect the functional outcomes following MI-TLIF in patients undergoing surgery for LDDD compared to those with normal BMI.

## Methodology

The retrospective study was conducted at a tertiary care hospital in Western India. The patients' data were recorded in the case record forms from the hospital data. The patients operated with MI-TLIF for LDDD from January 2016 to January 2020 were enrolled in the study as per the inclusion and exclusion criteria Table 1 All the relevant demographic data and preoperative variables were collected at the time of admission. The patients were classified into three groups based on their BMI i.e. normal (BMI $< 25$ kg/m$^2$), Overweight (25–29.9 kg/m$^2$) and Obese ($\geq 30$ kg/m$^2$). The intraoperative data were collected from the surgery records. The postoperative data were collected on postoperative day 1, 1 month, 3 months, 6 months and 1 year and then every year as a routine for all the patients.

## Surgical technique (Fig. 1 and Fig. 2)

All the surgeries were performed by the same team of surgeons. Under general anaesthesia, the patient was positioned prone and a 22 mm tubular retractor system docked on the facet joint of the symptomatic side under radiographic guidance as per the Wiltse paraspinal approach. Removal of the inferior facet followed by the superior facet was done using an osteotome or ultrasonic scalpel. Flavectomy was done and the neural structures were identified. Discectomy was

**Table 1** Inclusion and exclusion criteria for the patient selection

| Inclusion criteria | Exclusion criteria |
|---|---|
| Age $\geq 18$ years | Previous surgery of the lumbar spine |
| Degenerative lumbar pathology | Other pathologies like trauma, tumour, infection |
| Follow up $\geq 12$ months | Patients with spondyloarthropathies |
| Willingness for participation in the study | Concomitant cervical/dorsal spine pathology |

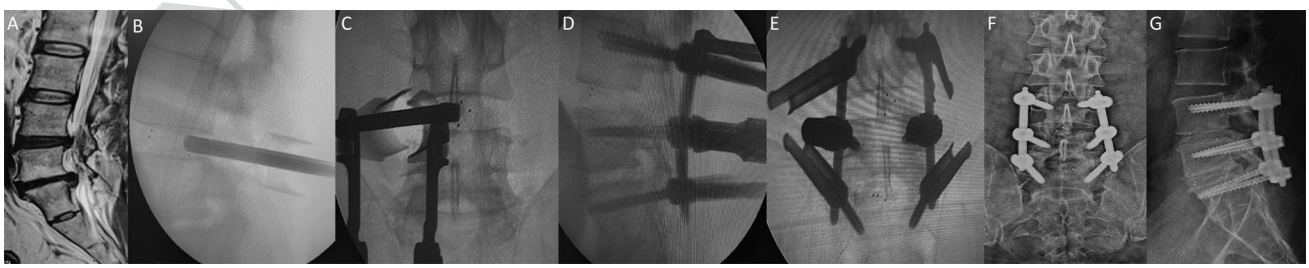


**Fig. 1** Procedure of the MI-TLIF by a case example a Preoperative MRI of the lumbosacral spine in the sagittal plane of a male patient with normal BMI having a degenerative disc disease at L4-L5 and L5-S1; b, c: Intraoperative image-intensifier images showing cage implantation at L4-L5 level as seen in the lateral b and anteroposterior c views; d, e: Completion of the procedure with cage implantation at L5-S1 and pedicle screw and rod placement as seen in the lateral d and anteroposterior e views; f and g: Radiographs of the lumbosacral spine in the anteroposterior f and lateral g views at one-year follow up of the same patient showing a good fusion at both the levels







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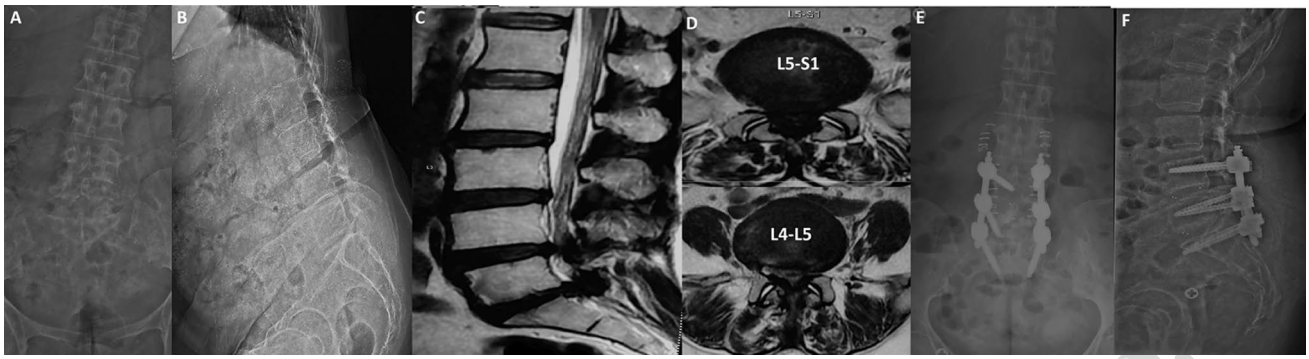


**Fig. 2** Example MI-TLIF in an obese female a, b: Preoperative radiographs of the lumbosacral spine in the anteroposterior a and lateral b views of the patient showing degenerative disease with loss of lumbar lordosis; c, d: Preoperative MRI of the lumbosacral spine showing severe lumbar canal stenosis at L4-L5 and L5-S1 in the sagittal c and axial planes d; e and f: Postoperative radiographs of the lumbosacral spine in the anteroposterior e and lateral f views showing MI-TLIF at L4-L5 and L5-S1





completed and adequate endplate preparation done was with curettes. The morselised autograft obtained was packed anteriorly under the anterior longitudinal ligament and in the PEEK cage which was then implanted. Fig. 1b, c Over-the-top decompression was done in every case and adequate decompression was ensured. Facetectomy on the opposite side was not done in any case. Percutaneous titanium pedicle screw insertion and rod placement after appropriate compression completed the procedure Fig. 1d, e.

The operative and outcome measures used for assessment were the surgical time, blood loss, number of levels operated upon, skin incision length, day of independent mobilisation, total hospital stay including ICU stay if any, return to work and Visual Analogue Score (VAS) for back pain (VAS-BP) and leg pain (VAS-LP) and Oswestry Disability Index (ODI). Whether the improvement obtained in the ODI, VAS-BP and VAS-LP scores was meaningful was ascertained by the attainment of the Minimal Clinically Important Difference (MCID) for each variable. So, the final outcome was dichotomised based on whether the patient achieved the MCID threshold or not. This was taken as 14.9 for the ODI score and 2.1 and 2.8 for VAS-BP and VAS-LP, respectively [14].

The fitness for returning to work was assessed by an independent Occupational Therapist who was blinded to the intervention. The patients were also asked to rate their satisfaction at the end of 1 year by choosing a number between 0 and 10 with 0 representing "completely unsatisfied" and 10 representing "completely satisfied". They were also asked at the end of 1 year whether they would like to have the procedure for the same pathology in the future and the responses were recorded as "yes", "no" and "not sure". The fusion rates were assessed at the end of 1 year based on the findings on the computed tomographic (CT) imaging.

The differences between study groups were tested using One-way analysis of variance (ANOVA) with equal variance assumptions for continuous variables and Chi-Squared tests with Yates' correction for continuity. To determine the effects of BMI on surgery time, a multivariate regression was performed. Similar analyses were also performed to evaluate the effect of BMI on blood loss, hospital stay, incision length, operative time, return to work and changes in the VAS and ODI scores.

## Results

A total of 207 consecutive patients were enrolled in the study of which 33 were obese, 53 overweight and the rest 121 patients had a BMI < 25. There was no significant difference between the three groups in terms of gender, age, preoperative symptom duration, diagnosis and baseline clinical scores. The prevalence of diabetes mellitus and dyslipidaemia was significantly higher in the obesity group although no difference was seen in the incidence of other pre-existing disorders Table 2.

In terms of the clinical and operative variables, the number of levels operated upon, total hospital stay, operative time and the cumulative size of the skin incisions were found to be comparable ($p > 0.05$). Table 3 However, blood loss was significantly more in the obese patients ($p = 0.006$) as was the ICU stay postoperatively ($p = 0.03$). The patients were mobilised at $3.6 \pm 1.1$ days postoperatively. Though patients with normal BMI were mobilised earlier ($3.5 \pm 1.1$ days) as compared to those in the overweight ($3.7 \pm 1.2$ days) and obese ($4.0 \pm 1.0$ days) groups, no significant difference was observed among the different groups ($p = 0.07$). Return to work was similarly comparable with the patients joining at an average of $6.8 \pm 1.1$ weeks after the surgery ($p = 0.32$).

Functional assessment was done using ODI scores and VAS-BP and VAS-LP scores. ODI scores were significantly better at 6 months and 1-year postoperatively as compared



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**Table 2** Demographic variables of the patients

| Variable | Normal (n = 121) | Overweight (n = 53) | Obese (n = 33) | *P* Value |
|---|---|---|---|---|
| Age (years) | 51.9 | 53.9 | 56.6 | 0.09 |
| Mean | 11.8 | 10.4 | 9.3 | |
| Standard Deviation | | | | |
| Gender | 77 | 30 | 21 | 0.66 |
| Male | 44 | 23 | 12 | |
| Female | | | | |
| BMI (kg/m$^2$) | 22.3 | 27.7 | 33.3 | **< 0.001** |
| Mean | 1.6 | 1.5 | 1.6 | |
| Standard Deviation | | | | |
| Duration of Symptoms (months) | 7.4 | 7.8 | 8.2 | 0.12 |
| Mean | 2.1 | 1.9 | 2.4 | |
| Standard Deviation | | | | |
| Diagnosis | 40 | 22 | 15 | 0.84 |
| Lumbar Canal Stenosis | 13 | 4 | 3 | |
| Degenerative Spondylolisthesis | 43 | 19 | 12 | |
| Degenerative Disc Disease | 17 | 6 | 2 | |
| Spinal Instability | 8 | 2 | 1 | |
| Degenerative Scoliosis | | | | |
| Follow up (months) | 15.8 | 16.2 | 14.9 | 0.30 |
| Mean | 3.9 | 4.1 | 2.9 | |
| Standard Deviation | | | | |
| Comorbidities | 20 | 13 | 10 | 0.10 |
| Hypertension | 14 | 14 | 5 | **< 0.05** |
| Diabetes Mellitus | 4 | 2 | 4 | 0.15 |
| Cardiac Disease | 5 | 4 | 2 | 0.50 |
| COPD | 7 | 2 | 1 | 0.50 |
| Thyroid Disorder | 21 | 18 | 19 | **< 0.0001** |
| Dyslipidaemia | 13 | 10 | 4 | 0.37 |
| Smoking | | | | |

A $p$ value < 0.05 is statistically significant

to the pre-operative scores in all the groups and the scores of all the three groups were comparable. ($p = 0.84$) Table 4. Similarly, VAS-BP and VAS-LP were significantly improved at the end of 1 year as compared to the preoperative scores ($p < 0.001$) with no significant inter-group difference at any point of assessment Table 5. On being asked at 1 year, whether in hindsight, the patients would like to have the same treatment for their presenting complaints, the results were comparable ($p = 0.60$). Table 3 Similarly, the average satisfaction rating after the surgery was $8.8 \pm 1.1$ with no significant difference among the groups ($p = 0.42$) Table 3.

A multivariate linear regression analysis was done to determine the effect of BMI on the improvement in ODI and VAS scores at 1 year compared to the preoperative levels controlling for age, sex, the number of levels fused and comorbidities. It was found that BMI was not associated with the changes in either the ODI score ($p = 0.84$) or the VAS scores ($p = 0.33$). Similar analyses to evaluate the effect of BMI on hospital stay ($p = 0.48$), blood loss ($p = 0.72$), operative time ($p = 0.73$) and size of the skin incisions ($p = 0.80$) were found to be non-significant.

The complications encountered were divided into two groups i.e. early and late depending on the occurrence before and after six months of the surgery. Early complications were further subclassified into dural tears and non-dural tears. In the group of early complications, 20 cases of accidental durotomies and 8 cases of non-dural tear complications were witnessed Table 3. Two cases of dural tears required re-exploration with closure of the defect within a week of the surgery. With respect to the non-dural tear complications, there were two episodes of superficial infections which resolved on conservative therapy. There was one episode of urinary tract infection which was treated with antibiotics. One patient developed postoperative pneumonia which was managed in the ICU for one week. Two patients experienced worsening of symptoms within a month of surgery of







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**Table 3** Operative and outcome variables of the patients

| Variable | | Normal BMI (N = 121) | | Overweight (N = 53) | | Obese (N = 33) | | *p* Value |
|---|---|---|---|---|---|---|---|---|
| | | Mean | Standard Deviation | Mean | Standard Deviation | Mean | Standard Deviation | |
| Duration of Surgery (minutes) | | 99.4 | 19.4 | 96.7 | 20.8 | 103.0 | 18.7 | 0.35 |
| Blood Loss (millilitres) | | 95.5 | 27.0 | 91.0 | 29.5 | 111.1 | 32.1 | **0.006** |
| Incision Length (mm) | | 36.1 | 2.5 | 35.7 | 2.7 | 36.3 | 2.7 | 0.52 |
| Hospital Stay (days) | | 8.9 | 3.2 | 9.7 | 3.5 | 10.2 | 3.4 | 0.09 |
| ICU Stay | | 0.8 | 1.1 | 0.9 | 1.3 | 1.4 | 1.1 | **0.03** |
| Day of Independent Mobilisation | | 3.5 | 1.1 | 3.7 | 1.2 | 4.0 | 1.0 | 0.07 |
| Return to Work (weeks) | | 6.7 | 1.1 | 6.9 | 1.2 | 7.0 | 1.3 | 0.32 |
| Number of Levels | 1 | 95 | | 41 | | 26 | | 0.98 |
| | 2 | 24 | | 11 | | 6 | | |
| | 3 | 2 | | 1 | | 1 | | |
| Complications | DT | 10 | | 6 | | 4 | | 0.72 |
| | NDT | 5 | | 3 | | 3 | | 0.53 |
| | Total | 15 | | 9 | | 7 | | 0.40 |
| Patients requiring re-surgery within one year | | 4 | | 1 | | 1 | | 0.88 |
| Willingness for surgery again | Yes | 101 | | 39 | | 25 | | 0.60 |
| | No | 9 | | 6 | | 3 | | |
| | Not Sure | 11 | | 8 | | 5 | | |
| Satisfaction Rating | | 8.9 | 1.0 | 8.7 | 1.3 | 8.7 | 1.1 | 0.42 |
| MCID Attainment | VAS-BP | 103 (85.1%) | | 46 (86.8%) | | 29 (87.8%) | | 0.90 |
| | VAS-LP | 105 (86.8%) | | 45 (84.5%) | | 28 (84.5%) | | 0.93 |
| | ODI | 110 (90.9%) | | 43 (81.1%) | | 28 (84.5%) | | 0.18 |
| Fusion Attained | | 115 (95.0%) | | 49 (92.4%) | | 30 (90.9%) | | 0.62 |

*ICU* Intensive Care Unit, *DT* Dural tear, *NDT* Non-Dural Tear, *MCID* Minimal Clinically Important Difference, *VAS* Visual Analogue Score, *BP* Back pain, *LP* Leg pain, *ODI* Oswestry Disability Index

A $p$ value < 0.05 is statistically significant

**Table 4** Comparison of Oswestry Disability Index (ODI) scores at the various time intervals among the three groups

| Group | Preoperative | Postoperative Day 1 | Postoperative 1 month | Postoperative 3 months | Postoperative 6 months | Postoperative 1 year | Significance of the improvement in ODI score at 1 year (*P* Value) |
|---|---|---|---|---|---|---|---|
| Normal | 32.2 | 25.5 | 19.1 | 16.4 | 15.0 | 12.0 | **< 0.001** |
| Mean | 3.6 | 2.9 | 2.4 | 3.0 | 1.8 | 1.9 | |
| Standard Deviation | | | | | | | |
| Overweight | 33.4 | 25.0 | 19.9 | 17.0 | 14.8 | 11.8 | **< 0.001** |
| Mean | 3.9 | 3.4 | 3.3 | 2.1 | 2.0 | 2.3 | |
| Standard Deviation | | | | | | | |
| Obese | 32.2 | 24.4 | 19.1 | 17.2 | 14.9 | 12.0 | **< 0.001** |
| Mean | 4.6 | 3.0 | 3.0 | 2.1 | 1.8 | 2.4 | |
| Standard Deviation | | | | | | | |
| *P* Value | 0.15 | 0.16 | 0.19 | 0.19 | 0.80 | 0.84 | |

*ODI*: Oswestry Disability index

A $p$ value < 0.05 is statistically significant

which one required surgery and the other resolved on conservative management within 3 months. Two patients developed a postoperative neurological deficit of which 1 was managed with revision surgery within two weeks and the other improved gradually over 6 months. Regarding the late complications, three patients developed recurrent symptoms







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**Table 5** Comparison of Visual Analogue Score (VAS) scores at the various time intervals among the three groups

| Group | Preoperative | | Postoperative day 1 | Postoperative 1 month | Preoperative | | Postoperative 3 months | | Postoperative 6 months | | Postoperative 1 year | | Significance of improvement in VAS score at 1 year (*P* Value) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BP | LP | BP | LP | BP | LP | BP | LP | BP | LP | BP | LP | BP | LP |
| Normal Mean | 7.5 | 6.5 | 6.2 | 6.0 | 5.5 | 5.5 | 5.3 | 5.0 | 4.3 | 4.3 | 3.6 | 3.1 | **< 0.001** | **< 0.001** |
| Standard Deviation | 0.8 | 1.1 | 1.1 | 1.3 | 1.2 | 1.3 | 1.3 | 1.4 | 1.2 | 0.9 | 1.0 | 0.7 | | |
| Overweight Mean | 7.4 | 6.9 | 6.5 | 6.1 | 5.9 | 5.8 | 4.9 | 4.9 | 4.1 | 4.5 | 3.6 | 2.9 | **< 0.001** | **< 0.001** |
| Standard Deviation | 1.0 | 1.2 | 0.9 | 1.0 | 0.8 | 1.0 | 1.1 | 1.0 | 1.2 | 1.3 | 1.1 | 1.3 | | |
| Obese Mean | 7.2 | 6.6 | 6.6 | 6.3 | 5.7 | 5.9 | 5.0 | 5.3 | 4.2 | 4.0 | 3.8 | 3.2 | **< 0.001** | **< 0.001** |
| Standard Deviation | 1.1 | 1.2 | 1.2 | 1.1 | 1.0 | 1.2 | 0.9 | 1.2 | 0.7 | 1.2 | 1.0 | 1.0 | | |
| *P* Value | 0.24 | 0.11 | 0.96 | 0.44 | 0.08 | 0.14 | 0.10 | 0.36 | 0.56 | 0.11 | 0.59 | 0.29 | | |

*VAS*: Visual Analogue Score, *LP*: Leg pain, *BP*: Back pain

A $p$ value $< 0.05$ is statistically significant

after 6 months of surgery and were offered revision surgery. Two consented for the re-surgery and were operated upon. However, one refused to give consent for the surgery and hence was managed conservatively.

At the end of the one-year follow-up, a total of 6 patients were re-operated of which four had normal BMI and one each belonged to the overweight and obese cohorts. The distribution of the same across the three groups was non-significant ($p = 0.36$) Table 3. The mean fusion rate at the end of 1 year was 93.7% and was comparable among the groups ($p = 0.62$). The overall complication rate in our study was 14.9%.

MCID assessment was done to determine if the intervention resulted in any meaningful improvement in the functional outcomes as measured by ODI, VAS-BP and VAS-LP scores. The attainment of the MCID thresholds for all three variables at the end of one year was comparable Table 3.

## Discussion

Obesity presents a whole new range of problems in the surgical management of the patients requiring lumbar interbody fusions. These can be either due to the medical or the surgical issues relating to the patient [15]. The surgical technique also presents numerous challenges including positioning, excessive retraction during exposure and ease of image guidance. Many authors have presented poor outcomes following surgery in these patients [8, 16, 17]. In addition, there are risks for medical complications after the surgery like pulmonary embolism, myocardial infarction and gastric ulcers [15]. These observations thus can bias the surgeon's decision on the need for surgery for the patient.

Obesity is a risk factor for various metabolic conditions as was observed in our study with diabetes mellitus and dyslipidaemia significantly more in the obese patients. The significantly high postoperative ICU admission in those having a BMI $\geq 30$ kg/m$^2$ seen in our study can also be explained by the requirement of care for the management of these comorbidities. However, a majority of the operative variables were comparable across the three groups except for the intraoperative blood loss. The tubular-assisted MI-TLIF renders the need for a wide and extensive exposure for obtaining a proper visualisation meaningless. This observation is similar to those made by Goh et al. [13]. The increased depth that is needed to be negotiated in an open approach is bypassed in the MI approach by the direct docking of the tubular system on the target area. Also, the fat and other soft tissues seem to provide additional stability to the entire tubular system. Despite the comparable surgical duration, incision length and number of levels fused, the mean blood loss was significantly higher in obese patients. This could be due to an increased venous pressure secondary to the raised intra-abdominal pressure on positioning the patient prone for the surgery.

In our study, the patients were mobilised independently at a mean of $3.6 \pm 1.1$ days postoperatively which was comparable among the three groups. This demonstrates that a high BMI is not an obstacle for early mobilisation, as the minimally invasive approach led to a lesser tissue destruction and hence a lesser postoperative pain even in high BMI patients. A similar trend was observed with respect to the hospital stay and return to work. Comparable results were seen by others [11, 18]. Return to work observed by us was at a mean of $6.8 \pm 1.1$ weeks which was less than that observed by Adogwa et al. who reported a median time of 8.5 weeks post-surgery [19].

Both the VAS-BP and VAS-LP decreased significantly postoperatively in all the patients with no inter-group variability at the end of 1 year. A similar improvement was seen in the ODI scores Tables 4, 5. Similar results were obtained other [11–13]. In contrast, Herold et al. observed significant but inferior improvements in all the three parameters in the patients with BMI > 30 kg/m$^2$ undergoing microsurgical decompression for lumbar spine for spinal stenosis as compared to the non-obese patients which were supposed to be due to a higher expectation in the obese patients [17]. Although the improvement in the VAS-BP, VAS-LP and ODI scores was significant overall, it does not necessarily translate to a significant clinical improvement at an individual level. This is because a higher improvement in a small number of patients can offset a smaller improvement in the rest of the patients within the group. Hence, the concept of MCID was found to be useful which enables the identification of patients with an improvement in the scores necessary to produce a significant clinical and functional improvement [14]. Accordingly, the patients in each group were classified into two subgroups based on the attainment of MCID. The MCID attainment was similar in all the groups for VAS-BP, VAS-LP and ODI. Thus, similar outcomes can be expected irrespective of the BMI status after MI-TLIF for degenerative lumbar pathology. The similar satisfaction ratings and the willingness for surgery again can be attributed to this significant finding.

Complications encountered were classified into early and late. The overall rate of durotomies was 9.7% which was comparable to that seen elsewhere [20]. A comparable incidence of dural tears was witnessed among the three groups. Burks et al. had noted that a higher incidence of incidental dural tears was seen in the obese patients which was not seen in our study [20]. The overall complication rate in our study was 14.9% which was similar to that observed by Wong et al. (15.6%) but lower than that observed by Joseph et al. (19.2%) [21, 22]. There was also no significant difference in the complication rates among the three groups as







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also reported by others [11]. However, Marques-Lara et al. reported a higher risk of complications like deep venous thrombosis, pulmonary embolism, infections and postoperative acute renal failure with a BMI > 25 kg/m$^2$, with a greater risk with increasing BMI value [23]. The fusion rate observed at the end of one year was 93.7% and was more than the fusion rate of 92.5% seen by Parajón et al. but less than the rate of 94.7% observed by Bevevino et al.[24, 25].

There are a few limitations in the study. As this is a single centre study, the results cannot be generalised to the universal population where new confounders may arise. Secondly, a longer minimum follow-up could lead to the emergence of different patterns in results especially with respect to the functional and radiological outcomes. Thirdly, additional functional outcomes measures like SF-36 could be used. Lastly, the study is limited by its retrospective nature.

## Conclusion

In patients treated by MI-TLIF for degenerative lumbar spine pathology, BMI is not a factor that negatively affects the functional and clinical outcomes. Minimally invasive approach can result in better overall outcome in patients with degenerative lumbar disorders with high BMI.

**Data availability** The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

## Declaration

**Conflict of Interest** The authors declare that they have no conflict of interest.

**Ethical Approval** Ethical approval was waived by the local Ethics Committee of the hospital in view of the retrospective nature of the study and all the procedures being performed were part of the routine care.

**Consent to participate** All participants gave written consent for participation in the trial.

**Consent to Publish** All participants gave written consent for permission to publish.

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