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Oblique versus Transforaminal Lumbar Interbody Fusion in Degenerative Spondylolisthesis: A Systematic Review and Meta-analysis

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Abstract

BACKGROUND: This meta-analysis compared transforaminal interbody fusion (TLIF) and oblique lumbar interbody fusion (OLIF) techniques for degenerative lumbar spondylolisthesis.

AIM: The aim is to evaluate Oswestry Disability Index (ODI), Japanese Orthopedic Association Back Pain Evaluation Questionnaire, visual analog scale improvement for back and leg pain, disc height, slipped percentage, blood loss, surgical time, and complication rates in both groups.

METHODS: A systematic literature search was carried out to obtain a study that compared OLIF and TLIF for degenerative lumbar spondylolisthesis. A literature search was performed using PubMed, Scopus, EuropePMC, and EBSCOHost. While the intervention was the OLIF technique, the control was the TLIF technique. The primary outcome was clinical outcome (ODI, Japanese Orthopaedic Association Back Pain Evaluation Questionnaire [JOABPEQ], visual analog scale [VAS] improvement for back, and leg pain). The Newcastle-Ottawa Scale was used to assess the quality of the studies.

RESULTS: Total of 384 patients from four studies were included in this study. OLIF group was better than TLIF group in terms of disc height, slipped percentage, and blood loss. ODI, JOABPEQ, VAS improvement for back pain (standardized mean difference [SMD] 0.06 [−0.18, 0.29], p = 0.63, I2 = 0%, p = 0.87) and leg pain (SMD 0.12 [−0.36, 0.60], p = 0.63, I^2 = 74%, p = 0.02), surgical time, and complication rates were similar in both groups.

CONCLUSION: OLIF technique was better than TLIF technique in terms of radiologic outcome and surgical blood loss. Both techniques showed similar outcomes in clinical outcome, complication, and surgical time.

Introduction

Degenerative spondylolisthesis (DS) is a slip of one vertebral spine caused by degenerative changes without the rupture of the posterior arc [1], [2]. DS often presents with spinal stenosis which usually occurs at level lumbar 4–5 (73% of cases) and L3–L4 (18% of cases) with an estimated prevalence 2.7% in males and 8.1% in females with ratio 1:6.4 [3]. The previous study observed 4000 elderly ≥65 years and showed prevalence of DS up to 19.1% in males and 25% in woman with ratio 1:1.3 [1]. Frequently, such forward slippage of a vertebra occurs in older women, especially those who are postmenopausal [1]. There are many pathological contentions how DS happens, for instance, increased sagitalization of the facet joints in patients with DS has been observed. It is concluded malorientation of the facet joints facilitates slippage of the vertebrae. Several study observed the loss of soft-tissue resistance preceded facet joint failure, while others showed that facet joints malorientation was resulted by degenerative remodeling and not the cause of DS [3], [4], [5], [6], [7].

The treatment of DS consists of non-operative and surgical decompression. Non-operative treatment in DS remains to be the first-line choice including activity restriction, physical therapy, and pain medications. In SPORT study, non-operative treatment showed better outcome in DS Grade 1 compared to Grade 2 and hypermobile compared to stable DS [8]. In the meanwhile, surgical decompression and stabilization are considered in patients who fail treated nonoperatively or develop symptomatic spinal stenosis condition. There are various surgical approached for managing DS consisted of anterior lumbar interbody fusion (ALIF), lateral lumbar interbody fusion (LLIF), transforaminal interbody fusion (TLIF), posterior lumbar interbody fusion (PLIF), and oblique lumbar interbody fusion (OLIF).

TLIF technique was developed to modified PLIF technique and offered better spinal stability by retaining ligamentous complex, contralateral lamina, and facet joints. In the meanwhile, OLIF technique provided less complication rate and better correction compared to LLIF. Minimally invasive surgery (MIS) is available for TLIF and OLIF technique. The aim of this study is to compare TLIF and OLIF approach in managing DS.

Methods

This systematic review was performed by following Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) Guideline.

Search strategy and study selection

A systematic literature search was carried out to obtain study which compared OLIF and TLIF for degenerative lumbar spondylolisthesis. A literature search was performed using PubMed, Scopus, EuropePMC, and EBSCOHost. The keywords of this study used ("oblique lumbar interbody fusion" OR OLIF OR "anterior to psoas" OR ATP) AND ("transforaminal lumbar interbody fusion" OR TLIF OR MIS-TLIF OR MI-TLIF OR "minimally invasive transforaminal lumbar interbody fusion" OR "minimally invasive surgery transforaminal lumbar interbody fusion"). After removing of duplicate record, two independent reviewers performed title and abstract screening for eligibility criteria.

Eligibility criteria

All included studies should meet the following criteria: (1) Randomized and controlled trial, prospective or retrospective cohort study and (2) comparing OLIF and TLIF technique for DS. The exclusion criteria based on following items: (1) Literature review, case-report, commentaries, letters, editorial, animal experiments, and cadaveric studies, (2) non-comparative studies, (3) abstract-only publication or conference paper, and (4) duplicated studies.

Data extraction and analysis

Two reviewers independently performed data extraction from the included study. The relevant data were extracted as follow study design, population, outcome measure, and follow-up periods. Discrepancies were resolved by discussion with senior authors.

Outcome measures

The intervention group was OLIF and the control group was TLIF. The primary outcome of this study was Oswestry Disability Index (ODI) and Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ). The standardized mean difference (SMD) was performed to assess the effect size. The secondary outcome was visual analog scale (VAS) improvement for back pain and leg pain, disc height, slipped percentage, intra-operative bleeding, and complication (pseudoarthrosis, adjacent segment disease, screw deviation, revision surgery, cage sinking, cerebrospinal fluid leakage, post-operative ileus, hip flexion weakness, distal weakness, and sensory deficit). The effect estimate for these scores was SMD and odd ratio (OR) for the complication.

Definition

VAS improvement was defined by difference value of VAS between pre-operative and post-operative [9], [10]. Disc height was defined by posterior height between inferior and superior endplate of the listhesis vertebra [11]. Slipped percentage was defined by the calculation between the distance of the listhesis vertebra and the length of the inferior endplate of the listhesis vertebra body [12].

Quality assessment

The Newcastle-Ottawa Scale was used to assess the quality of the studies.

Statistical analysis

Statistical analysis was performed using Review Manager 5.4. We performed random-effect meta-analysis to calculate SMD and 95% confidence interval (CI) for VAS back pain, VAS leg pain, disc height, slipped percentage, blood loss, and surgical time. Complication significant difference was calculated using OR and 95% CI. Heterogeneity was defined by I-squared (I^2), an $I^2 > 50\%$ indicates significant heterogeneity.

Results

Baseline characteristic

Total of 384 patients from four studies were included in this study (Figure 1). Baseline characteristics of these studies were shown in Table 1.

Clinical outcomes

Clinical outcomes of this study were ODI, JOABPEQ, VAS backpain, and VAS leg pain. Koike *et al*. [13] and Kotani *et al*. [14] used JOABPEQ as

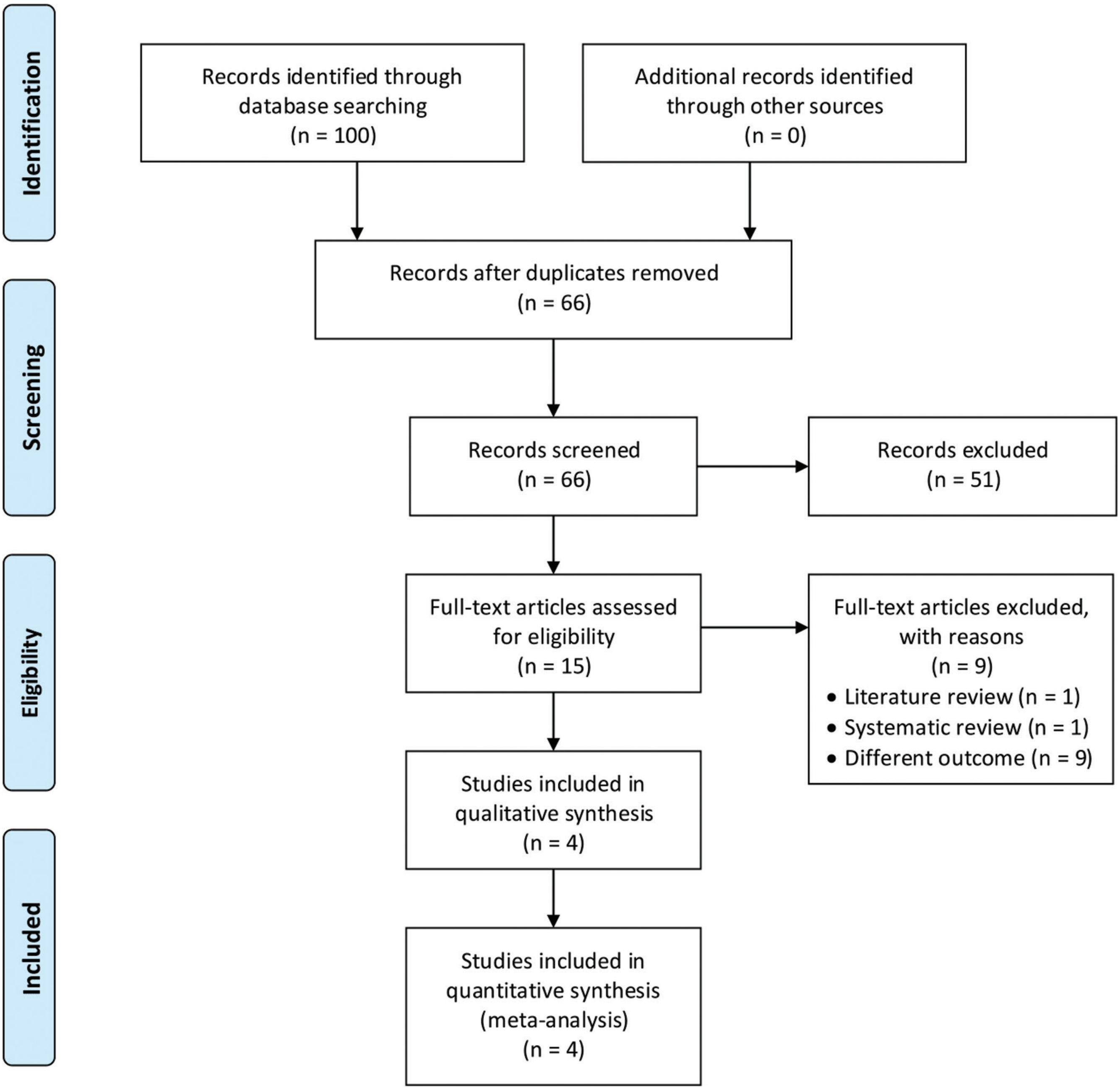

Figure 1: PRISMA flowchart

clinical outcome while Li *et al*. [15] and Sheng *et al*. [16] used ODI. Koike *et al*. [13] observed similar result in terms of low back pain, lumbar function, and social life in both groups with p = 0.303, 0.264, and 0.988, respectively. Kotani *et al*. [14] also showed similar JOABPEQ result in both groups with p = 0.061, 0.485, and 0.630, respectively. Li *et al*. [15] and Sheng *et al*. [16] showed similar ODI result in both groups with p = 0.101 and $p < 0.05$, respectively. We carried out meta-analysis for VAS back pain and VAS leg pain outcome. VAS back pain improvement (SMD 0.06 [−0.18, 0.29], p = 0.63, I^2 = 0%, p = 0.87) (Figure 2) and VAS leg pain improvement (SMD 0.12 [−0.36, 0.60], p = 0.63, I^2 = 74%, p = 0.02) (Figure 3) showed similar result between OLIF group and TLIF group.

Radiologic outcome

The OLIF approach was better than the TLIF approach in terms of disc height post-operative outcome. (SMD 0.91 [0.65, 1.18], $p < 0.0001$, I^2 = 23%, p = 0.27) (Figure 4). Furthermore, the OLIF approach provided better correction in slipped percentage compared to the TLIF approach (SMD −0.55 [−0.79, −0.31], $p < 0.0001$, I^2 = 0%, p = 0.77) (Figure 5).

Complication

Lower estimated blood loss was associated with the OLIF approach (SMD −1.13 [−2.00, −0.25], p = 0.01, I^2 = 92%, $p < 0.001$) (Figure 6). In the meanwhile, surgical time outcome was similar in

Table 1: Baseline characteristic of studies

Authors	Study design	Sample (n)	Male (%)	Age	BMI (kg/m^2)	Technique	Fixation method	L3 (%)	L4 (%)	L5 (%)	Follow-up (month)	NOS	Funding
Koike 2021	RC	86	44	70.98 ± 11.4	24 ± 4.4	OLIF-LPF versus MIS-TLIF	PS versus PS	12.8	87.2	0	21	6	None
Kotani 2020	PC	142	65	71.3 ± 10.4	24.5 ± 4.3	OLIF-LPF versus MIS-TLIF	PS versus PS	12.7	87.3	0	40	8	None
Li 2021	RC	63	31	58.5 ± 10.06	24.4 ± 2.8	OLIF versus TLIF	Anterolateral screw versus PS	6.3	85.7	7.9	6	6	None
Sheng 2020	RC	93	34	62.5 ± 11.3	N/A	OLIF-LPF versus MIS-TLIF	PS versus N/A	N/A	N/A	N/A	12	7	None

RC: Retrospective cohort, PC: Prospective cohort, BMI: Body mass index, MIS: Minimally invasive surgery, OLIF: Oblique lumbar interbody fusion, LPF: Percutaneous posterior fixation in the lateral position, TLIF: Transforaminal lumbar interbody fusion, PS: Pedicle screw, N/A: Not available, NOS: Newcastle-Ottawa Scale.

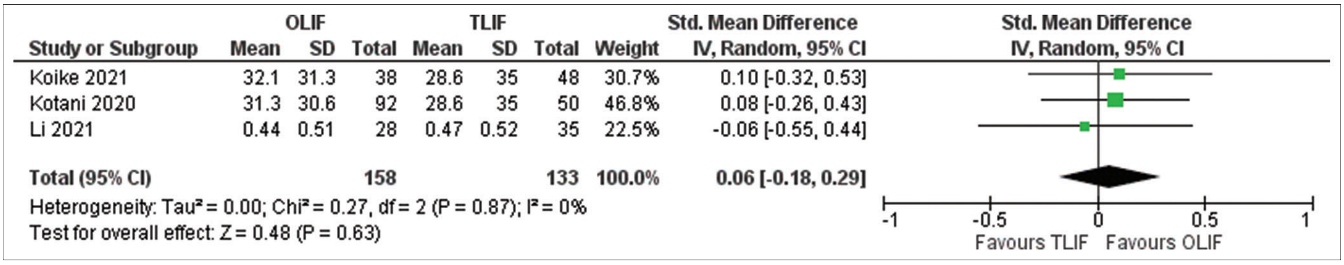

Figure 2: Visual analog scale improvement for back pain

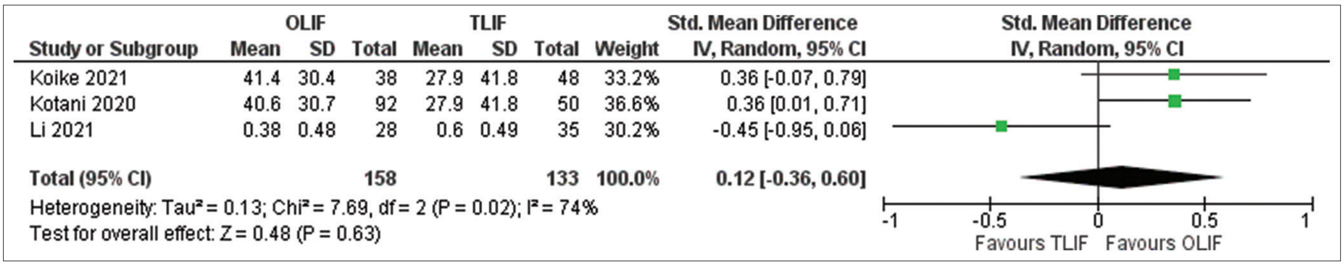

Figure 3: Visual analog scale improvement for leg pain

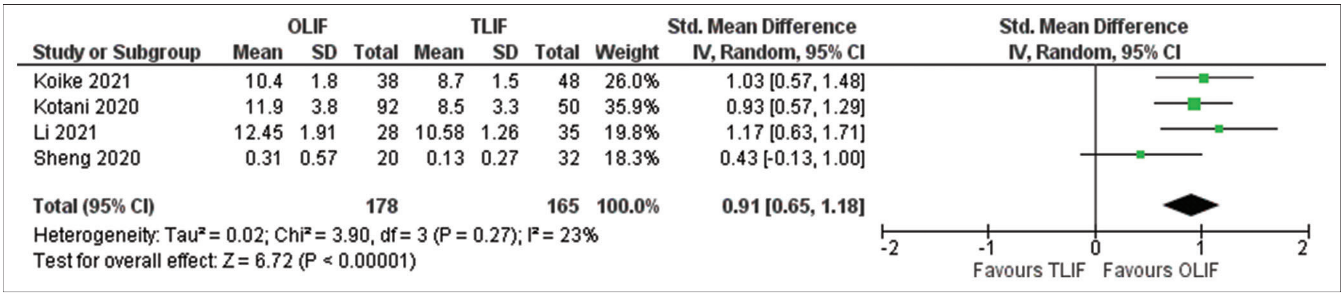

Figure 4: Disc height

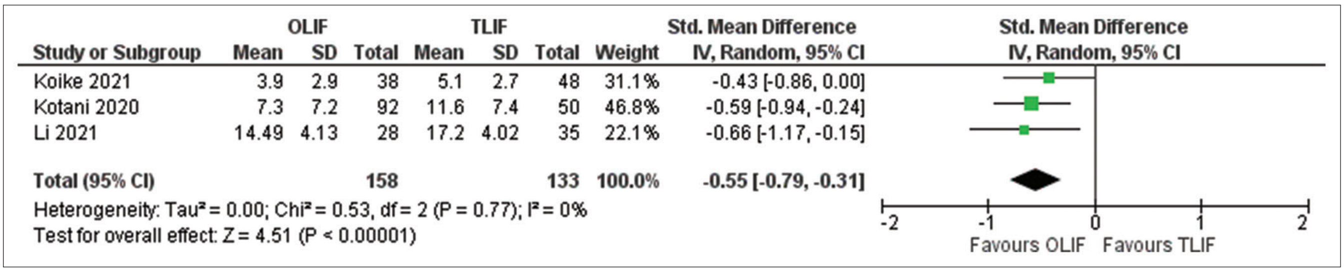

Figure 5: Slipped percentage

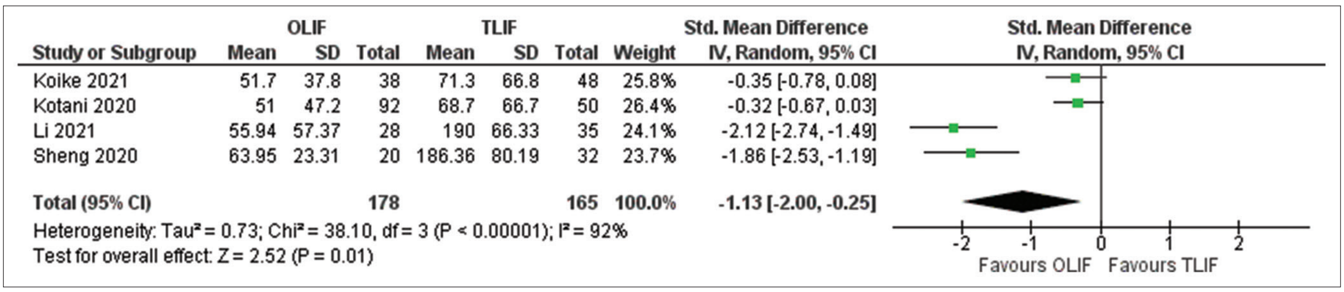

Figure 6: Blood loss

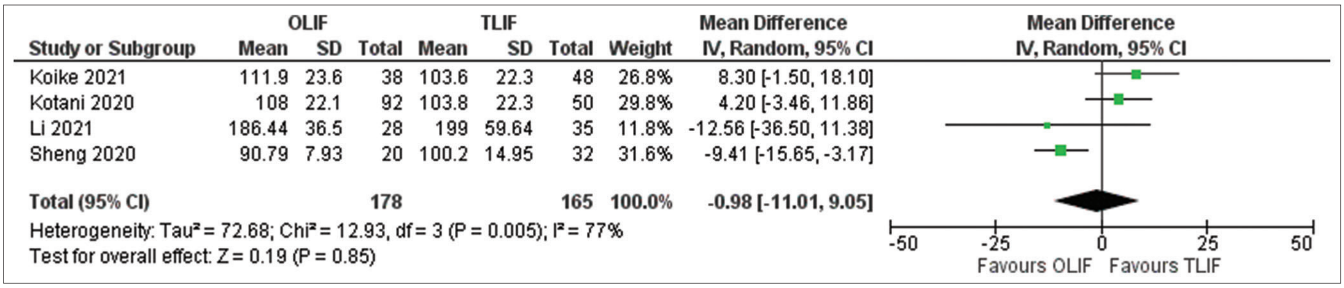

Figure 7: Surgical time

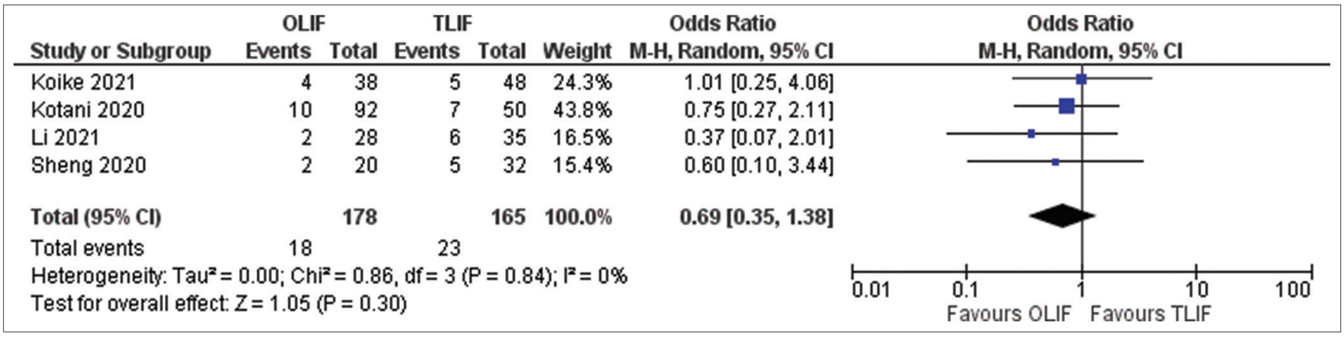

Figure 8: Complication rates

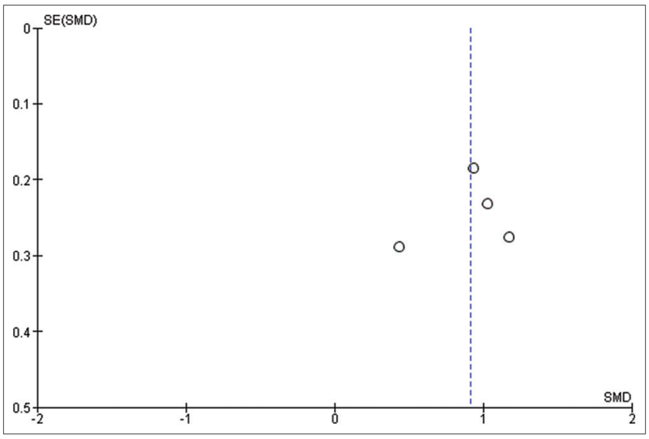

Figure 9: Funnel plot analysis for disc height

both groups (SMD −0.98 [−11.01, 9.05], p = 0.85, I^2 = 77%, p = 0.005) (Figure 7). Complication outcome in both groups showed similar result with OR 0.69 [0.35, 1.38], p = 0.30, I^2 = 0%, p = 0.84 (Figure 8).

Comparison between MIS-OLIF and MIS-TLIF

In the present pooled study, we performed subgroup analysis by removing Li *et al*. [15] study due to different surgical approach. The VAS improvement for back pain was associated similar result with SMD 0.09 [−0.18, 0.36], p = 0.50, I^2 = 0%, p = 0.5 meanwhile VAS improvement for leg pain was observed better in OLIF group with SMD 0.36 (0.09, 0.63), p = 0.009, I^2 = 0%, p = 0.009.

OLIF group was associated with better radiologic outcomes in terms of disc height and slipped percentage with SMD 0.84 (0.53, 1.16), p < 0.001, I^2 = 31%, p < 0.001 and OLIF SMD −0.52 [−0.80, −0.25], p < 0.001 I^2 = 0%, p = 0.002, respectively.

Surgical time, blood loss, and complication rate showed similar result in both group with SMD 0.60 (−10.48, 11.68), p = 0.82, I^2 = 84%, p = 0.05, SMD −0.89 (−1.84, 0.05), p = 0.06 I^2 = 92%, p = 0.92, and OR 0.78 (0.37, 1.66), p = 0.53, I^2 = 0%, p = 0.53, respectively.

Sensitivity analysis

Sensitivity analysis was performed to exclude Sheng *et al*. [16] study due to different in fixation method. The outcome was associated with better disc height in OLIF group (SMD 1.01 [0.76, 1.26], p < 0.001, I^2 = 0%, p < 0.001). In the meanwhile, surgical time and blood loss showed similar result in both groups with SMD 4.39 (−2.67, 11.45), p = 0.22, I^2 = 21%, p = 0.22 and SMD −0.89 (−1.84, 0.05), p = 0.06, I^2 = 92%, p < 0.001, respectively.

Publication bias

The funnel plot was symmetrical for VAS for back pain improvement, VAS for leg pain improvement, disc height, and blood loss (Figure 9). Egger's test was non-significant for VAS for back pain improvement (p = 0.66), VAS for leg pain improvement (p = 0.12), disc height (p = 0.61), slipped percentage (p = 0.94), and complication (p = 0.62).

Discussion

Conventionally, conventional open ALIF and PLIF techniques provided acceptable results with their advantages and disadvantages for managing degenerative disc disease [17]. Recently, developed MIS techniques, such as LLIF, TLIF, and OLIF, have been introduced to reduce surgical trauma, minimize blood loss, reduce infection rates, and shorten the hospital stay [17]. The stabilization of DS has changed since the introduction of the new techniques. The aim was to minimize soft-tissue injury and neural retraction while maintained adequate neural decompression and fusion rate [18].

Harms and Rolinger [19] introduced a TLIF approach as an alternative to the PLIF and have since been implemented initially by Foley and Lefkowitz [20]. TLIF is indicated for all degenerative conditions such as degenerative disc disease, recurrent disc herniation, broad-based disc prolapses, pseudoarthrosis, and symptomatic spondylosis [21]. Considering the primacy of TLIF in overcoming the excessive thecal sac and nerve root retraction previously caused by PLIF, this less invasive and unilateral approach provides comparable clinical and radiologic outcomes with shorter surgical times and reduced intraoperative complications [17], [22], [23]. In addition, TLIF has the biomechanical benefits in retaining ligamentous complex and preserving contralateral lamina as well as facet joints. However, the technique of TLIF is very different from a standard open approach, and there are notable implications related to the surgical learning curve [18]. In addition, TLIF, like PLIF, is associated with significant paraspinal iatrogenic injury with prolonged muscle retraction [21], [24].

OLIF was introduced by Grob *et al*. [25], whereas the first clinical trial was performed by Birkenmaier *et al*. [26]. OLIF was indicated for degenerative pathologies and considered the solution to the drawbacks of both ALIF and LLIF [17], [21]. OLIF, similar to LLIF, is excellent for sagittal and coronal deformity correction, in particular, and lumbar degenerative scoliosis with laterolisthesis [21], [27]. This antero-oblique trajectory avoids both anterior vessels and psoas muscles to access the spine, making lumbar plexus and psoas injury unlikely, while allowing comprehensive disc space clearance, aggressive deformity correction, and high fusion rates. However, potential risks include sympathetic dysfunction and vascular injury [17], [21], [28].

A total of four studies with 384 patients included in this study. Three studies [13], [14], [16] observed the comparison between MIS-OLIF and MIS-TLIF while Li *et al*. [15] observed the comparison between MIS-OLIF and TLIF. The DS segment involved in this study was L3, L4, and L5. The mean follow-up of the included studies ranged from 6 to 40 months.

The primary outcomes in this study were ODI and JOABPEQ. Unfortunately, we were unable to perform a meta-analysis in the and JOABPEQ due lack of data. Koike *et al*. [13] and Kotani *et al*. [14] used JOABPEQ for the clinical outcomes and showed similar results of the JOABPEQ between the OLIF group and the TLIF group. On the other hand, Li *et al*. [15] and Sheng *et al*. [16] used ODI and showed no statistical differences in both groups. The results showed no differences in the functional outcomes between the OLIF group and the TLIF group.

VAS improvement for back pain and leg pain in both groups showed similar results. However, VAS improvement for leg pain showed moderate heterogeneity. It may be caused by different types of surgery. Li *et al*. [15] performed the open TLIF approach while other studies performed the MIS-TLIF approach. Hammad *et al*. [29] performed a study to compare between open TLIF and MIS-TLIF and showed lower VAS leg pain score in MIS-TLIF compared to open TLIF. We carried out subgroup analysis in VAS improvement for leg pain by excluding Li *et al*. [15] and showed lower VAS improvement for leg pain in the TLIF group. OLIF approach may be associated with lower leg pain since this approach avoids psoas muscle and spinal nerve injury [30].

Disc height and slipped percentage were better in the OLIF group than in the TLIF group. OLIF technique offers indirect posterior decompression to restore disc height. Subgroup analysis and sensitivity analysis were performed, and the result favored the OLIF group in post-operative disc height outcome. OLIF cage contributes to retaining the disc height in the following time since the OLIF technique promotes larger cage size in terms of width and height compared to the TLIF technique [31]. Furthermore, VAS improvement in back pain and leg pain was associated with the degree of deformity correction [32], [33].

In the present study, the lower blood loss was associated with the OLIF group, while the surgical time showed a similar result in both groups. There was no statistical difference in complication outcome. OLIF technique provided indirect neural decompression. Hence, several conditions may cause OLIF technique to become challenging, such as thickening of ligamentum flavum, severe spinal stenosis, foraminal stenosis, or calcification of disc herniation [34]. Direct neural decompression may be preferred to manage these conditions [34].

Clinical implication

OLIF group was associated with better radiologic outcomes and lower operative blood loss with similar clinical outcome and complication rates compared to the TLIF group. OLIF technique may be preferred to treat DS than the TLIF technique in terms of the radiological outcome. However, the OLIF procedure is relatively newer than the other procedures. The learning curve, procurement of the instrument, and miscellaneous cost should be considered in the OLIF technique. Furthermore, it is technically challenging to perform OLIF in DS cases with lumbar level L5–S1. Hence, other approaches are recommended to manage the condition [35].

Limitation

Most of the included studies were retrospective designs which prone to bias, while one study carried out a prospective cohort design. The included study showed a relatively short follow-up duration. Further higher evidence studies with longer follow-up are recommended.

Conclusion

OLIF technique was better than TLIF technique in terms of radiologic outcome and surgical blood loss. Both techniques showed similar outcomes in clinical outcome, complication, and surgical time.

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