Clinical and Radiological Outcome following MIS-TLIF and Open-TLIF between Asian and African Population- A Comparative Retrospective Analysis in 104 Patients

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Abstract

Purpose: This study aimed to evaluate pre-operative and post-operative sagittal parameters using pelvic incidence (PI), lumbar lordosis (LL), and segmental lordosis (SL) between Asian and African population who underwent minimally invasive surgery-transforaminal lumbar interbody fusion (MIS-TLIF) and open-TLIF surgeries. Study compares blood loss, operative time, and hospital stay; and evaluates disability and pain by Oswestry disability index (ODI) and visual analog scale (VAS) score, respectively, in both groups.

Methods: This retrospective study included 104 patients with an average age of 52.1 ± 12.9 years. All were operated for open-TLIF and MIS-TLIF for one- or two-level lumbar canal stenosis or spondylolisthesis. Patients were divided into two groups according to race: Asian and African. Clinical improvements were evaluated using VAS and ODI scores. Modified MacNab's criteria were used to evaluate outcome. Estimated blood loss, hospital stay, operative time, perioperative morbidity, and complications were reviewed. On radiological parameters, patients' LL, PI, and SL were compared between two groups.

Results: Average follow-up was 40.6 ± 13.9 months. Both groups showed significant post-operative improvement in their VAS and ODI scores in both open- and MIS-TLIF ($P < 0.0001$); however, comparing clinical improvement between Asian and African groups, it did not show significant difference in VAS ($P = 0.103$) and ODI ($P = 0.077$). Both groups showed significant improvement in LL and SL in both open- and MIS-TLIF ($P < 0.0001$); however, there was no change in PI. It did not show any significant difference in improvement in LL ($P = 0.156$), PI ($P = 0.798$), and SL ($P = 0.179$) between Asian and African groups. Regarding post-operative complications, there were 4 (6.9%) and 3 (6.5%) complications occurred in Asian and African population, respectively. There were no difference in complication rates in both groups ($P = 0.939$).

Discussion: TLIF (MIS and open) gives similar clinical outcome between Asian and African population. Sagittal parameters were higher in African population than the Asian population. Attention should be paid to predetermine the value of LL to achieve during surgery.

Keywords: Transforaminal lumbar interbody fusion, Asian versus African, Sagittal parameters, Clinical outcome

Introduction

The disparities in the outcome of medical treatment have drawn the attention of doctors and stakeholders for a long time. African-American patients were found to receive poor results after several interventions including lung transplantation, acoustic neuroma resection, and cardiopulmonary resuscitation [1, 2]. Lumbar canal stenosis (LCS) and spondylolisthesis are among the most common spinal pathologies. Therefore, the significance of racial disparities in its treatment is especially important. Drazin et al. found that black patients were more likely to get fusion at the initial surgery [3]. They had shorter preoperative and postoperative follow-up intervals. Reviewing complications after the spinal fusion procedures, Cahill et al. mentioned that black patients had an increased risk of complications after cervical fusion, thoracic fusion and lumbar fusion [4].

Open-TLIF (transforaminal lumbar interbody fusion) and MIS-TLIF (minimally invasive surgery- transforaminal lumbar interbody fusion) are two of the most commonly performed

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surgeries in the treatment of LCS and spondylolisthesis. Open-TLIF was first reported by Harms in 1982 as a better alternative to traditional PLIF (posterior lumbar interbody fusion) surgery [5]. With the development in types of equipment, implants and techniques in spine surgery, the MIS-TLIF was developed by Foley et al [6]. Both of these surgeries have similar indications such as, LCS and spondylolisthesis. However, open-TLIF is associated with extensive stripping of the paravertebral muscles and prolonged retraction is needed for adequate exposure of the surgical field, which can be prevented by the minimally invasive approach of MIS-TLIF [7]. MIS-TLIF is often associated with a higher level of radiation exposure, steep learning curve and difficulty in decompressing the central spinal canal [8-12]. However, population-wise study is lacking for the outcome of open-TLIF and MIS-TLIF between Asian and African race. In this study, we aimed to compare the outcome of open-TLIF and MIS-TLIF surgery between Asian and African population by using the parameters such as, lumbar lordosis (LL), the segmental lordosis angle (SL) at the index level and pelvic incidence (PI) on preoperative, postoperative and final follow-up radiograms as well as the length of stay, operative time, estimated blood loss and the complication of surgery.

Material and Methods

This retrospective study comprised 104 patients with an average age of 52.1 ± 12.9 years. All patients had one- or two-level LCS or spondylolisthesis and operated for open-TLIF and MIS-TLIF surgeries. All patients had back pain and/or radicular pain for minimum of 6 months which did not resolve after conservative treatment. Patients with three or more levels surgeries, trauma cases, case of any of the tumors, revision surgeries, lack of clear lateral lumbosacral X-ray at three different occasions, or poor-quality X-ray were excluded from the study.

All cases were operated by a single surgeon at a single institute and followed-up postoperatively at 6 weeks, 3 months, 6 months, 1 year, 2 years, and yearly thereafter. Cases were grouped into two categories according to their race (1) Asian and (2) African group. Based on the type of surgical technique open or MIS surgeries, groups were further divided into two subtypes in each category. Clinical improvement was evaluated using visual analog scale (VAS) and Oswestry disability index (ODI) and compared with pre-operative scores. Similarly, modified MacNab's criteria were used to evaluate overall results into excellent, good, fair, and poor outcome. Their EBL, hospital LOS, operative time, perioperative morbidity, and surgical complications were reviewed.

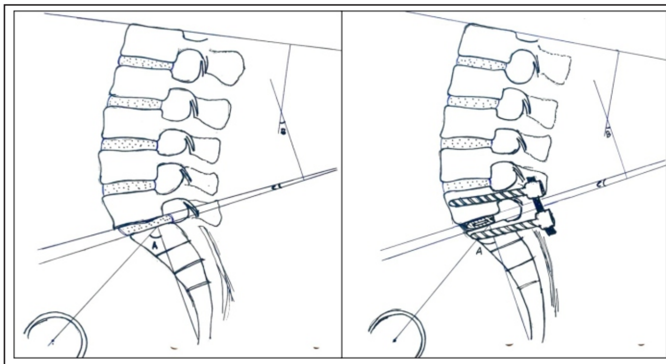

Figure 1: Schematic presentation of measuring pelvic incidence, lumbar lordosis, and segmental lordosis in (a) pre-operative and (b) post-operative radiogram.

Figure 2: Measurement of pelvic incidence, lumbar lordosis, and segmental lordosis in pre-operative radiogram using software in the department.

Radiological measurements: Measurement of parameters of sagittal balance was done on the lumbosacral radiographs taken preoperatively, postoperatively, and at final follow-up. All X-rays were taken in supine position with hip joints included in all radiograms. PI angle was measured between two lines; one from the mid-point of upper sacral endplate to the hip axis and the other line was perpendicular to upper sacral endplate. LL is defined as angle between upper endplate of L1 vertebra and upper endplate of sacrum and measured manually by Cobb's angle method. SL at index level is the angle between upper and lower endplate composing the disc space. SL of the disc space was measured where the interbody cage was placed. Parameters of sagittal spinal balance on X-rays taken at three different time, perioperative data, and functional outcome parameters were compared among these four groups. Measurements of different angles on radiograms were taken using radiology software in the department, as shown in Fig. 1 and 2.

Analysis of above data was done using SPSS software. Paired t-test/unpaired t-test/Chi-square test was used to analyze the data and $P < 0.05$ kept for the level of significance.

Results

The average follow-up was 40.6±13.9 months. All details regarding numbers of patients, average follow-up, and demographics are shown in Table 1. Comparing the number of levels involved (single or double levels), age of patients, male versus female ratio, and average follow-up in both Asian and African groups, p value suggested 0.106 (Chi-square test), 0.166 (unpaired t-test), 0.427 (Chi-square test), and 0.206 (unpaired t-test), respectively, suggesting no statistical difference. Average operation time was significantly shorter in open-TLIF than MIS-TLIF in both groups ($P < 0.0001$ for Asian and $P = 0.0004$ in African); however, it was similar in both Asian and African groups ($P = 0.684$, unpaired t-test). Similarly, EBL is less is MIS-TLIF compared to open-TLIF in both groups ($P < 0.0001$ for Asian and $P < 0.0001$ in African); however, it was similar in Asian and African groups ($P = 0.068$, unpaired t-test). Average hospital stay was similar in both groups ($P = 0.194$, unpaired t-test); however, it was

Table 1

Group	Asian Group			African Group		
	Open-TLIF	MIS-TLIF	Total	Open-TLIF	MIS-TLIF	Total
Single Level	12	26	38	7	15	22
Double Level	14	6	20	17	7	24
Average Age (years)	54.3±11.2	53.2±12.0	53.7±11.5	50.8±16.1	49.4±12.2	50.1±14.3
Male/Female	9/17	13/19	22/36	10/14	11/11	21/25
Average FU (months)	45.5±16.8	39.5±13.5	42.2±15.2	50.2±13.9	40±12.2	38.7±11.9

Table 2

Group	Asian Group			African Group		
	Open-TLIF	MIS-TLIF	Total	Open-TLIF	MIS-TLIF	Total
Operation Time (min)	130.7±14.8	171.76±19.9	153.3±27	142.5±26.7	169.6±20.1	153.3±27
Estimated Blood Loss (mL)	266.6±56.1	133.1±34.1	192.2±80.2	319.0±80.7	130.7±36.6	228.9±114
Hospital Stay (days)	5.5±1.0	4.8±0.8	5.1±1	5.9±1.5	4.9±0.8	5.4±1.3

Table 3

Clinical Scores	Group	Asian Group			African Group		
		Open-TLIF	MIS-TLIF	Total	Open-TLIF	MIS-TLIF	Total
VAS Scores	Preoperative	8.5±0.5	8.3±0.7	8.4±0.6	8.5±0.7	8.6±1.1	8.6±0.9
	3-month FU	2.2±0.7	1.9±0.7	2.1±0.7	1.7±0.8	2.1±0.8	1.9±0.8
	Final FU	1.7±0.6	1.9±0.8	1.8±0.7	1.3±0.7	2.0±0.8	1.7±0.8
ODI Scores	Preoperative	58.6±6.6	55.6±4.1	57±5.5	54.8±6.7	57.3±5.8	56.0±6.3
	3-month FU	19.0±4.3	20.9±5.0	20.1±4.8	20.8±4.3	22.6±5.9	21.7±5.1
	Final FU	18.2±3.1	21.3±4.8	19.9±4.4	17.6±3.8	22.5±4.5	20±4.8

Table 4

Angles (°)	Group	Asian Group			African Group		
		Open-TLIF	MIS-TLIF	Total	Open-TLIF	MIS-TLIF	Total
Lumbar Lordosis	Preoperative	38.7±10.0	42.4±12.1	40.7±11.2	41.8±12.9	47.7±13.6	44.7±13.4
	3-month FU	42.8±10.5	46.9±12.6	45.1±11.8	44.8±12.2	51.7±13.6	48.2±13.2
	Final FU	43.3±10.3	46.3±12.7	45.0±11.7	46.1±12.1	51.1±13.6	48.6±13.0
Pelvic Incidence	Preoperative	48.0±8.5	53.3±9.9	50.9±9.6	53.4±12.7	57.1±12.8	55.2±12.7
	3-month FU	48.0±8.6	53.7±9.2	51.1±9.3	53.8±12.4	57.0±12.7	55.3±12.2
	Final FU	48.2±8.4	53.5±9.5	51.1±9.3	53.3±12.4	56.6±12.7	54.9±12.5
Segmental Lordosis	Preoperative	6.9±5.8	7.2±5.8	7.0±5.8	6.8±6.7	8.6±4.0	7.7±5.5
	3-month FU	9.6±6.9	10.1±5.7	9.9±6.2	8.7±6.2	11.4±4.1	10.0±5.4
	Final FU	9.8±6.8	9.2±5.5	9.5±6.1	9.0±6.2	10.5±3.9	9.7±5.2

significantly less ($P < 0.0001$, unpaired t-test) in MIS-TLIF (4.83 ± 0.8 days) than open-TLIF (5.70 ± 1.27 days).

Pre-operative, post-operative, and final VAS score in both groups are described in Table 3. Both groups showed significant post-operative improvement in their VAS and ODI scores in both open-TLIF and MIS-TLIF ($P < 0.0001$, paired t-test); however, comparing clinical improvement between Asian and African groups, it did not show any statistically significant difference in VAS ($P = 0.103$, unpaired t-test) and ODI ($P = 0.077$, unpaired t-test). All improvements remained maintained at the final follow-up in both groups.

Pre-operative, post-operative, and final LL, PI, and SL angles are described in Table 4. Both groups showed significant improvement in LL and SL in both open-TLIF and MIS-TLIF ($P < 0.0001$, paired t-test); however, there was no change in PI ($P = 0.187$ for open TLIF and $P = 0.491$ for MIS-TLIF, paired t-test). If we compare improvement in angles in Asian and African groups, it did not show any significant difference in LL ($P = 0.156$, unpaired t-test), PI ($P = 0.798$, unpaired t-test), and SL ($P = 0.179$, unpaired t-test).

Regarding post-operative complications, there were 4 (6.9%) and 3 (6.5%) complications occurred in Asian and African population, respectively. There was no significant difference found in terms of complication rates in both groups ($P = 0.939$, Chi-square test). There was one patient each in Asian group with adjacent level degeneration, dural injury, malpositioning of one pedicle screw, and mild back out of cage. Patients with adjacent level degeneration and malpositioning of screw were revised with complete resolution of symptoms after surgery. There were two and one patients with back out cage causing severe radiculopathy and breakage of pedicle screw in African group, respectively. All three had to undergo revision surgery with complete resolution of symptoms postoperatively. There were no other complications seen in either series. There was statistically no difference in revision rates in both groups ($P = 0.466$, Chi-square test).

Discussion

TLIF is the most commonly performed spinal procedure in the treatment of LCS and spondylolisthesis. Literature suggested significant differences in sagittal spinopelvic parameters among races such as African-Americans, Caucasians, and Asians [13]. Therefore, it should be considered when planning for spinal surgery. When we perform TLIF procedures (open or MIS) in the conditions of single- or double-level LCS or spondylolisthesis, will it make any difference in terms of clinical and radiological improvement between African and Asian population? Such studies have not been published, to our knowledge, in literature. In this study, we reported our findings while performing single or double-level TLIF procedure between Asian and African population for the 1st time. In addition, we have also reported successful outcomes of open-TLIF and MIS-TLIF in both groups.

Comparing surgical outcome of cauda equina syndrome among various races by Jain et al., they noted that compared to Caucasian patients, length of hospitalization was 1.92 days longer in African-American patients, 1.34 days longer in Hispanic patients, and 2.24 days longer in Asian-American patients [14]. Similarly, in a retrospective data analysis for short-term outcome after laminectomy and fusion surgeries between Caucasian and African-American patients, African-American patients continued to have longer hospital stay by 1 day than Caucasian patients [15]. Rest of other parameters such as operation time, blood loss, and clinical improvements, however, were similar. In our study, we did not found any significant difference in hospital stay between two groups. We although have seen that in open-TLIF, hospital stay was slightly longer in African group (5.9 ± 1.5 days vs. 5.5 ± 1.0 days) than Asian group; however, the difference was not statistically significant ($P = 0.248$, unpaired t-test). We have also found similar EBL and operation time while comparing both groups additionally. Our study proves that performing single- or double-level TLIF (open or MIS) procedures between Asian and African population do not make any significant difference in terms of blood loss, operation time, and hospital stay. This would in fact help surgeons explain surgery-related information to their patients.

Conventional lumbar fusion technique is often associated with significant morbidity in view of the extensive dissection and its harmful effects have been well documented in literature [16, 17, 18, 19, 20]. The objective of MIS-TLIF is same as conventional procedures but through a less traumatic unilateral paraspinal approach. It leaves the posterior tension band and the contralateral musculature intact. However, both techniques give a similar clinical outcome for the treatment of LCS and spondylolisthesis. Results of TLIF procedure might vary in different races, which were the purpose of our study; and it has successfully compared outcome of TLIF procedures between Asian and African population. We have found that clinical outcomes in both open- and MIS-TLIF procedures between both groups were significant (Table 3); and interestingly, improvements in VAS and ODI scores between Asian and African groups were also similar. Our findings would help surgeons while explaining clinical outcomes to such patients preoperatively during the consultation. Such findings have not been compared previously to the best of our knowledge.

In the past 30 years, understanding of regional and global spinal alignment has continued to evolve from which it can be concluded that the spinopelvic balance is a concept that the spine and pelvis in the sagittal plane represents an open linear chain linking the head to the pelvis, where the shape and orientation of each anatomic segment are closely related and influence the adjacent segment [21, 22, 23, 24]. PI is the only anatomical and constant parameter (remaining are positional) and it is a reliable value for interindividual variations of the sacral slope [25]. In this way, PI has prime importance as a fundamental pelvic parameter for three dimensional regulations of spinal sagittal curves and subsequently measured in this study on pre-operative, post-operative, and final follow-up X-rays. Several studies have found that LL and PI were higher in the African-American population than Caucasian and Asian population [13, 26]. Comparative analysis done be Arima et al. [13] who showed that the mean values for PI were greater in the African-American (57.7°) than Asian (48.7°). In our study, PI is found to be higher in African population (55.2°) than Asian population (50.9°) (P = 0.05, unpaired t-test). Similarly, LL was also higher in African group (44.7°) than Asian group (40.7°); however, difference was not significant (P = 0.108, unpaired t-test). Sullivan et al. and Mac-Thiong et al. after regression analysis in a cohort have given equation for relationship between LL and PI as LL = 0.66(PI)+24.2 and LL = 0.62(PI)+17.59, respectively [27, 28]. Our study has also shown significant correlation between PI and LL preoperatively, postoperatively, and at the final follow-up in both Asian and African groups (Pearson correlation coefficient: r = 0.66, 0.63, and 0.64 preoperatively, postoperatively, and at final follow-up, respectively, in Asian group; r = 0.73, 0.75, and 0.77 preoperatively, postoperatively, and at final follow-up, respectively, in African group). Thus, we can draw a conclusion that pre-operative assessment of sagittal balance knowing the value of PI is important and surgery should be planned according to these values to maintain appropriate LL. We emphasize here that post-operative LL should be predetermined, and effort should be made intraoperatively to maintain LL at that level to prevent adjacent segment disease. In our series, based on pre-operative PI, rod bending and compression-distraction maneuver were performed to achieve desired LL.

Our study has provided a comprehensive comparative study with an adequate number of patients included in comparative analysis of MIS-TLIF and open-TLIF in terms of sagittal parameters between Asian and African population. Ould-Slimane et al. reported open-TLIF to be significantly effective in improving pelvic tilt, sacral slope, and lordosis [29]. However, Recnik's finding was the opposite [30]. Our study found MIS-TLIF and open-TLIF equally effective in correcting LL and SL in both Asian and African population. Scanty data exist regarding MIS-TLIF and sagittal balance correction. Some of those studies revealed success in improving SL and pelvic tilt, simultaneously, the minimally invasive nature of the approach has raised controversy regarding its capacity to do so [31, 32, 33]. Few studies have compared the results regarding sagittal balance correction after lateral, posterior, and anterior approaches. Such comparative studies have proved the superiority of anterior and lateral approaches over TLIF regarding the correction of SL and disk height [34, 35]. As this study included only MIS-TLIF and open-TLIF procedures, the study of other approaches is beyond the scope of this study. Similarly, values of pre-operative, post-operative, and final PI values further emphasized the fact that PI acquired during individual development, is definitively stabilized in adults [36].

MIS-TLIF and open-TLIF both were equally effective to address LCS and spondylolisthesis in Asian and African population with similar clinical improvement. While comparing the Asian and African populations, we found that sagittal balance parameters were higher in African population than in the Asian population. Special attention should be paid to predetermine the value of LL and should be achieved during surgery.

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