International Journal of Research in Orthopaedics
Rangnekar A et al. Int J Res Orthop. 2022 Nov;8(6):649-654
http://www.ijoro.org

DOI: https://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20222702

Original Research Article

Awake spinal fusion: a retrospective analysis of minimal invasive single level transforaminal lumbar interbody fusion done under spinal anaesthesia in 150 cases

Ameya Rangnekar, Mani K. Anand*, Praveen Goparaju, Amit Chugh, Abhijith Shetty, Saijyot Raut, Vishal Kundnani

Department of Orthopaedics, Bombay Hospital, Mumbai, Maharashtra, India

Received: 07 August 2022
Revised: 07 September 2022
Accepted: 08 September 2022

***Correspondence:**
Dr. Mani K. Anand,
E-mail: manikant.mann@gmail.com

ABSTRACT

Background: Spinal anaesthesia carries the advantage of having rapid onset, lesser blood loss, early recovery and hospital stay as compared to general anaesthesia. The present study evaluated outcomes of awake spinal fusion i.e., minimal invasive single level transforaminal lumbar interbody fusion (MIS-TLIF) under spinal anaesthesia. Current study is a retrospective analysis of prospectively collected data carried to assess patient related outcome benefits for a single level transforaminal lumbar interbody fusion done under spinal anaesthesia.
Methods: Patients who fit deemed criteria not responding to 6 weeks of conservative treatment to lumbar degenerative pathologies underwent MIS-TLIF. The demographic data, visual analogue pain scale (VAS), Oswestry disability index (ODI), blood loss, time from entering operation theatre to time of incision, time of bandaging to exit from operation theatre, time of stay in post anaesthesia care unit (PACU), duration of surgery, nausea/vomiting, urinary retention, requirement of analgesics, duration of stay in hospital, peri-operative complications, fusion rate and satisfaction score were compiled and assessed.
Results: 150 patients were operated with MISTLIF under spinal anaesthesia. VAS and ODI score improved significantly at final follow up ($p<0.05$). The mean duration of surgery was 148±18.24 minutes and blood loss were 109.64±110.45 ml. The average time from entering OT to incision and bandaging to exit was respectively 27.32±8.44 and 6.43±3.28 minutes. Mean PACU time was 36.74±6.32 minutes while duration of stay averaged 1.58±0.67 days. Post operative analgesia requirement was in 10.6% patients and radiographic fusion was observed in 96.6% patients. 90.6% patients were fully satisfied with spinal anaesthesia.
Conclusions: Awake spinal fusion should be considered as a novel surgical approach with newer minimal invasive surgical techniques and regional anaesthesia to improve patient satisfaction and overall surgical outcome.

Keywords: Spinal anaesthesia, Spinal fusion, TLIF, ODI, VAS, MIS TLIF

INTRODUCTION

The number of spinal fusion surgeries has seen a great surge in recent few decades owing to longevity and increased prevalence of degenerative pathology in elderly.[1] Cloward introduced technique of posterior lumbar interbody fusion (PLIF) using a spinous process autograft. Given the high pseudoarthrosis rate with stand alone grafts, the PLIF technique was augmented with instrumented fixation utilizing the Harrington rods in the 1950s, later, the Hartshill rectangle, and finally the pedicle screws.[2] Transforaminal lumbar interbody fusion

(TLIF), a posterolateral approach to lumbar fusion was initially described in 1982 by Harms and Rollinger which gained popularity in 1992 after work by Harms and Jeszenszky.[3,4] Unlike PLIF this technique reduces chance of injury to neural structures but involves significant muscle retraction and dissection. Open TLIF procedure carries the disadvantage of iatrogenic soft tissue and muscle injury and hence novel surgical technique of minimal invasive transforaminal lumbar interbody fusion by use of serial tubular dilators and muscle retracting approach was introduced by Foley et al in early 2005 which has now become more and more popular. Lumbar spinal fusion can be carried out in general as well as spinal anaesthesia.[6] Of these, general anaesthesia is most commonly preferred as it offers the advantage of secured airway in prone position.[7,8] On the other hand, spinal anaesthesia gives advantages to reposition the patient during surgery and avoid compression injuries in-addition to better neurocognitive dysfunction, reduces pulmonary complications and improves postoperative analgesia with reduced pain killer and antiemetic requirement apart from mitigating the need and side effects of reversal medication associated with general anaesthesia.[9-11]

Fewer studies have been done to compare spinal anaesthesia versus general anaesthesia in spine surgeries. Studies have implicated shorter surgical time, less time in recovery room, lesser incidence of urinary retention, postoperative pain, nausea-vomiting and most importantly less financial implications in spinal anesthesia.[12,13] The increased rate of fusion surgeries with minimal invasive technique has brought major improvements in techniques of surgery, anaesthetic procedures and rehabilitation protocols, aimed at limiting the post-operative hospital stay and early return to work.[14] Spinal Anaesthesia with added advantages and reduced post operative issues is an addition to safety of spine surgery in single level minimal invasive spine surgeries. Also awake fusion has been a recent upgrade in spine surgery with better neurocognitive functions post operatively compared to general anaesthesia. Despite encouraging results with spinal anaesthesia, the literature evaluating efficacy of spinal anaesthesia in lumbar fusion surgeries is scanty. This study intends to evaluate the safety, efficacy and techniques with advantages of spinal anaesthesia as an alternative option to general anaesthesia in minimal invasive transforaminal lumbar interbody fusion surgery for symptomatic lower lumbar pathologies requiring fusion.

METHODS

Our study was retrospective analysis of prospectively collected data of 150 patients who underwent single level minimally invasive transforaminal lumbar interbody fusion at a single institute (Bombay hospital and medical research centre, Mumbai) by a senior spine surgeon from March 2015 to March 2017. Patient inclusion and exclusion criteria were laid stringently and same clinical pre operative and post operative protocols were followed for patient selection, surgery and post op rehabilitation.

Inclusion criteria

Inclusion criteria were; patients with symptomatic lumbar pathology (mechanical low back pain and radiculopathy, claudication with or without neuro-deficit) at level L3-4/L4-5/L5-S1 due to various etiologies (degenerative/ dysplastic/isthmic-spondylolisthesis, degenerative lumbar canal stenosis with instability, prolapsed intervertebral disc) with follow up of minimum two years.

Exclusion criteria

Exclusion criteria were; patients requiring revision spine surgery, having infection, tumour or other pathological causes, extraspinal cause of back pain / radiculopathy, requiring multi-level surgery, requiring surgery at higher lumbar levels i.e. L1-L2 or L2-L3 levels, severe co-morbidities like cardiac dysfunction or short follow up. All surgeries were managed by a single anaesthesiologist with similar anaesthetic technique. Demographic characteristics and American society of anaesthesiologists (ASA) physical status of the patients were all noted. According to the inclusion and exclusion criteria, those included were counselled for surgery. The patients who fit the deemed criteria for study were offered both choices to choose either spinal or general anaesthesia. They were thoroughly counselled and explained pros and cons associated with each technique and allowed to opt anaesthesia as per their choice. The choice of anaesthesia was chosen by the patient and not observer of the study. 150 patients who opted for spinal anaesthesia gave consent and satisfied the selection criteria.

Anaesthesia technique

Spinal anaesthesia administered patients were first given a half a litre infusion of ringer lactate solution 20 minutes before giving spinal anaesthesia. After entering operating room patient was seated. Local infiltration of 2.5 ml of 2% lidocaine was given, SA was achieved via lumbar puncture, using a needle size of 25 gauze most commonly.

On visualization of cerebrospinal fluid, bupivacaine was injected combined with fentanyl into the intrathecal space. Bupivacaine was given as 15 mg dose of a 0.75% bupivacaine in 8.25% dextrose solution. 25 µg of fentanyl was given in combination with bupivacaine, in order to increase the spinal anaesthesia antinociceptive effect. Once the spinal anaesthesia was administered, adequate anaesthesia was verified on the lower back and extremities after the patient was put into a supine position. The patient was then turned into the prone position on the operating table. Oxygen was administered by nasal cannula and vitals monitored throughout the procedure.

Operative technique

Patients who underwent MISTLIF were approached with a 2.5 cm incision paramedian 3-5 cm from midline on the more symptomatic side. Tubular decompression with 22 mm tubes (METRx system, Medtronics) with partial unilateral laminotomy and inferior facetectomy was done under microscopic guidance. It was followed by discectomy, end plate preparation and insertion n of cage with locally obtained autograft. Cannulated pedicle screws were inserted after placement of guidewire through cook's needle and serial tapping over dilators and tap under fluoroscopy guidance. Placement of screw was done using same incision on ipsilateral side while two 1cm incisions on contralateral side. Rod was introduced with a device through a separate proximal stab incision. After placement of locking-cap screws through the screw extenders and later compression, the screws were torqued and the screw extenders were removed. Thorough wash was given followed by closure in layers. At completion of the procedure and the patient was transferred to the PACU for the recovery.

The patients remained in the post anaesthesia care unit (PACU) till hemodynamic stability was confirmed which was followed by transfer to the ward. Comprehensive demographic, clinical and radiological parameters were documented including age, gender, duration of symptoms, indication of surgery, pathology (large central disc herniation, facetal arthritis, spondylolisthesis), level of surgery, medical co-morbidities, BMI and presence of cardiopulmonary co-morbid conditions was documented. Pain and disability were assessed pre-operatively, post operatively and at final follow up using visual analog score and Oswestry disability index at sequential follow up. Fusion was assessed using Bridwell criteria at final follow up. Peri-operative parameters including duration of surgery, blood loss during surgery, time from entering OT to incision, CSF leak intraoperative with dural tear/dural needle prick, bandaging to exit time, requirement of post operative analgesia, post operative emesis episodes, urinary retention, PACU time, duration of stay in hospital were documented and data was extrapolated to assess results. Post operative complications were documented in general and neurological category and included general complications (fever, wound infection, cardiac /pulmonary issues, UTI), neurological (CSF leak post operatively and neurological deficit). Study approval from the Institutional review board and Ethics committee was taken with informed patient consent. Statistical Analysis was done using independent samples test and comparison of proportions was done using Pearson Chi-square test. A p value of <0.05 was taken as statistically significant.

RESULTS

Total 150 patients were included in the study undergoing MIS TLIF under spinal anaesthesia during the study period. The majority of patients were over 40 years in 90% of total patients studied. The mean follow-up period was 28.6 months. There was no conversion from MIS-TLIF to open TLIF. The average age of patients was found to be 58.06±9.46 years. There was female predominance in group with 62% patients were female and 38% male. (Table 1).

Table 1: Demographic data (n=150).

Parameter	Spinal anesthesia
Age (mean±SD) years	58.06±9.46
Gender N (%)	
Female	93 (62)
Male	57 (38)
BMI (kg/m^2)	28.32±2.5
Comorbidities	
Single	82
Two or more	37
Duration of symptoms (months)	8.6±7.8
Mean follow up duration (months)	28.6±4.5

Table 2: Clinical parameters (n=150).

Parameter	Spinal anesthesia N (%)
Level of surgery	
L3-L4	13 (8.8)
L4-L5	88 (58.6)
L5-S1	49 (32.6)
Indication for surgery	
Degenerative	79 (52.7)
Isthmic	26 (17.3)
LCS with instability	34 (22.7)
PIVD	11 (7.3)
Duration of surgery (±SD) (minutes)	148±18.24
Blood loss (±SD) (ml)	109.64±110.45
Time of entering OT to incision (minutes)	27.32±8.44
Time from bandaging to exit (minutes)	6.43±3.28
Post anaesthesia care unit (PACU) (minutes)	36.74±6.32
Immediate post operative requirement of analgesia (within 4 hours after surgery)	16 (10.6)
Hospital stay (days)	1.58±0.67
Solid radiographic fusion	96.6
Satisfaction score	
Fully satisfied	90.6
Partially satisfied	8.6
Unsatisfied	0.8

The mean BMI of study population was 28.32±2.5 kg/m^2 while the average duration of symptoms was 8.6±7.8

months. Amongst our study population 82 patients out of 150 had one co-morbidity while 37 patients had two or more co-morbidities. The indication for surgery in our study were degenerative, isthmic, lumbar canal stenosis with instability and prolapse of intervertebral disc and majority of the patients underwent surgery due to degeneration (52.66%).

Table 3: VAS and ODI score.

Parameters	Pre-operative	Final follow up	P value
ODI	7.67±1.24	3.23±1.02	0.043
VAS	73.26±1.16	18.84±6.08	0.031

The most common level of surgery performed was at L4-L5 in 58.6% of patients followed by L5-S1 in 32.6% patients (Table 2). The mean duration of surgery was 148±18.24 minutes whereas the mean blood loss was 109.64±110.45 ml. The extent of spinal anaesthesia obtained was up to D8 level in majority of cases. The mean PACU time was 36.74±6.32 minutes and average hospital stay was 1.58±0.67 days. The effect of analgesia post operative was not required in most of the cases upto 4 hours. 10.6% patients required injectable pain killer within 8 hours after surgery. Significant improvement was observed in VAS and ODI scores at any time-point of follow-up when compared with the preoperative condition ($p<0.05$). Serial scoring was done preoperatively, post operatively at 7 days, 3 months, 6 months, 1 year and final follow up (Table 3). The incidence of nausea, vomiting was seen in 6.6% of patients while that of urinary retention was seen in 8.6% patients. The other complications encountered in our study were screw malposition, dural tear, screw loosening, cage slippage and implant failure seen in very less number (Table 4).

Table 4: Peri-operative and post-operative complications (n=150).

Parameter	Spinal anesthesia N (%)
Screw malposition	1 (1.1)
Dural puncture/tear	7 (4.6)
Screw loosening	4 (2.6)
Cage slippage	1 (1.1)
Implant failure	1 (1.1)
Nausea/vomiting	10 (6.6)
Urinary retention	19 (8.6)
Fever	4 (2.6)
Wound infection	3 (3.1)
Post operative CSF leak	0 (0)
Post operative neurological deficit	1 (1.1)
Post operative newly onset Paresthesia	2 (1.3)
Cardiopulmonary complications	0 (0)
UTI	1 (1.1)

Post operative neurological deficit (EHL 4/5) was seen in one of the patients while post operative new onset paraesthesia was seen in 2 patients. The mean time from entry of patient inside operation theatre to induction was 27.32±8.44 mintues and time of bandaging to exit from operation theatre was 6.43±3.28 minutes. Solid radiographic fusion (Bridwell 1 and 2) was achieved in 96.6% of patients. 90.6% of patients were satisfied, 8.6% were partially satisfied and 0.8% were unsatisfied. Patients who reported no pain, no nausea, no vomiting, and no headache were considered satisfied. Those who reported one or more of them were considered partially satisfied while those who reported all of them were considered unsatisfied with spinal anesthesia.[16]

DISCUSSION

Despite all the encouraging results of spinal anaesthesia over general anaesthesia, there is lot of lacunae in literature and studies to prove its efficacy and perioperative outcomes. ‘awake spinal fusion’ i.e. lumbar spine fusion under regional anaesthesia employs minimal invasive technique. Our study emphasizes awake spinal fusion under conscious sedation which can be efficiently done in a non-endoscopic minimal invasive technique through tubular retractors with bupivacaine for longer duration surgeries over 2 hours.[17]

In contrast to conventional TLIF, the minimal invasive (MIS TLIF) comes with the advantage of decreased pain, early ambulation, early discharge from the hospital.[18] In alignment to the above benefits, use of regional anaesthesia drugs come with lot of advantages. It avoids incidences of nausea-vomiting, transient neurocognitive dysfunction arising as a result of general anaesthesia.[19] Although patients with haemodynamic instability and cardiac dysfunction are contraindicated to spinal procedures. In the present study, the preoperative VAS and ODI score was significantly improved post operatively at 7 days, 3 months, 6 months, 1 year and at final follow up ($p<0.05$). The findings in study done by Patel et al, Wang et al also showed significant difference in preoperative and post operative VAS and ODI score in MIS TLIF done under general anaesthesia. It implied that the pain outcome of MISTLIF was independent of choice of anaesthesia.[20,21] Mean blood loss reported in our study was 109.64±110.45 ml whereas, Habib et al recorded mean blood loss of 163 ml in MIS TLIF versus 366.8 ml in open TLIF. Schwender et al in his study reported estimated blood loss of 140ml done in general anaesthesia.[22,23] It shows blood loss was relatively less in patients undergoing MIS TLIF in spinal anaesthesia. Although the exact cause could not be known but relative hypotension achieved during spinal anaesthesia may play a contributory role. In our study, mean duration of surgery was 148±18.24 minutes which is comparable to the results found by Jhala et al and Patel et al.[18,20] It implied that the total duration of surgery was independent of type of anaesthesia. Though the duration of surgery is a large component of operative time parameter, we

recorded two additional time landmarks, time from entry into operation theatre to incision time and bandaging to exit time. We found a significantly shorter operation theatre to incision time and also time from bandaging to the exit in our study group, which is comparable to study done by Pierce et al.[24] This highlighted higher efficiency with quicker operation theatre turnover rates and cost effectiveness. The shorter duration in spinal anaesthesia was because of skip of general anaesthesia perioperative events like pre-anaesthetic medication taking time to prepare before induction and intubation as well as post-operative anaesthesia reversal time.

The patients in our study group required lesser PACU time as compared to Jellish et al where there was longer PACU stay post-surgery. We observed a shorter hospital stay 1.58±0.67 days similar to studies done by Garg et al.[14,25] Since this study was performed at lower lumbar levels i.e. below L3, the chance of neuro-deficit was very less. Also, author did not experience any event of neuro-deficit in his period of study. Although general anaesthesia offers the advantage of observation of motor recovery soon after reversal of anaesthesia, a sensible motor evaluation is difficult to obtain as patient is in drowsy state. Spinal anaesthesia offered excellent control of post operative pain which gave the advantage of early shifting of patient from PACU to ward. The mean hospital stay in our study was lesser as spinal anaesthesia offered early ambulation, early start to oral feeds with less throat irritation, early bowel function return and less neurocognitive changes which favoured early discharge from hospital.

The incidence of nausea- vomiting and urinary retention was seen in 6.6% and 8.6% patients respectively. McLain et al found a higher incidence of nausea in general anaesthesia group, while reported a significantly lower incidence of urinary retention in spinal anaesthesia induced patients.[9] Prolonged sensory loss and analgesia after bupivacaine perhaps could be the reason of higher incidence of urinary retention in patients. All those patients who had urinary retention episode had temporary retention and not permanent one. The patients with retention problem were managed by inserting foley's catheter in situ and keeping it for 24 hours which was later removed. Patients were discharged comfortably only after urine was passed. Even though there were dural puncture/tear in 4.6% of patients, there was no incidence of CSF leak. No active intervention was done for dural puncture. It was managed with water tight closure. Fall-off of muscles after removal of tube leaving no dead space possibly could be a reason for prevention of CSF leak. One patient in our study had EHL weakness 4/5 and two patients had post operative paraesthesia which was managed conservatively under closed observation. Symptoms fully recovered within 6 weeks. In our study, radiographic fusion was achieved in 96.6% patients. The results by Schwender et al was also comparable that had fusion of almost 100% cases.[23] We tried to quantify satisfaction rate of patients who underwent MISTLIF in spinal anaesthesia. 90.6% of patients were satisfied, 8.6% were partially satisfied and 0.8% were unsatisfied from the procedure. The criteria cites patients who reported no pain, no nausea, no vomiting, and no headache were considered satisfied. Those who reported one or more of them were considered partially satisfied while those who reported all of them were considered unsatisfied with spinal anesthesia.[16] Patients with pre-existing apprehension may feel uncomfortable due to loud sounds during orthopaedic procedures especially during instrumentation. This may lead to intraoperative haemodynamic variations to the patient, music therapy has offered great benefits.[26] Though it may seem that spinal anaesthesia has certain advantages over general anaesthesia but this method cannot be followed for all patients. Loss of spinal anaesthesia effect can happen although not reported in any of our patients. Another disadvantage being time constraint, contraindications in patients with morbid obesity, obstructive sleep apnoea and cardiopulmonary dysfunction. Hence, patient selection needs to be careful.

Limitations

Limitations of current study were; intraoperative haemodynamic changes were not considered and this was not compared to general anaesthesia group.

CONCLUSION

Awake spinal fusion technique is an excellent newer addition to day care services. MIS TLIF done under spinal anaesthesia offers less post operative pain, early ambulation, return to work and hence reduced cost. It offers operating room efficiency with reduced total operative time with lesser stay in PACU. Hence, spinal anaesthesia can be safely used as an alternative choice for elective lower lumbar level fusion surgeries with relatively lower adverse events.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the institutional ethics committee

REFERENCES

1. Rajaee SS, Bae HW, Linda EA, Delamarter RB. Spinal fusion in the United States. Spine. 2012;37(1):67-76.
2. Cloward RB. The treatment of ruptured lumbar intervertebral discs by vertebral body fusion. I. Indications, operative technique, after care. J Neurosurg. 1953;10:154-68.
3. Harms J, Rolinger H. A one-stager procedure in operative treatment of spondylolisthesis: dorsal traction-reposition and anterior fusion. Orthop Ihre Grenzgeb. 1982;120:343-7.

4. Harms J, Jeszenszky D. The unilateral transforaminal approach for posterior lumbar interbody fusion. Orthop Traumatol. 1998;6:88-99.
5. Foley KT, Holly LT, Schwender JD. Minimally invasive lumbar fusion. Spine (Phila Pa 1976). 2003;15:S26-35.
6. Demirel CB, Kalayci M, Ozkocak I, Altunkaya H, Ozer Y, Acikgoz B. A prospective randomized study comparing perioperative outcome variables after epidural or general anesthesia for lumbar disc surgery. J Neurosurg Anesthesiol. 2003;15:185-92.
7. De Rojas JO, Syre P, Welch WC. Regional anesthesia versus general anesthesia for surgery on the lumbar spine: a review of the modern literature. Clin Neurol Neurosurg. 2014;119:39-43.
8. Pflug AE, Halter JB. Effect of spinal anesthesia on adrenergic tone and the neuroendocrine responses to surgical stress in humans. Anesthesiology. 1981;55:120-6.
9. McLain RF, Tetzlaff JE, Bell GR, Uwe-Lewandrowski K, Yoon HJ, Rana M. Microdiscectomy: spinal anesthesia offers optimal results in general patient population. J Surg Orthop Adv. 2007;16:5-11.
10. Rodgers A, Walker N, Schug S. Reduction of postoperative mortality and morbidity with epidural or spinal anaesthesia: results from overview of randomised trials. BMJ. 2000;321:1493.
11. McLain RF, Bell GR, Kalfas I, Tetzlaff JE, Yoon HJ. Complications associated with lumbar laminectomy: a comparison of spinal versus general anesthesia. Spine. (Phila Pa 1976) 2004;29:2542-7.
12. Chen HT, Tsai CH, Chao SC. Endoscopic discectomy of L5-S1 disc herniation via an interlaminar approach: prospective controlled study under local and general anesthesia. Surgical Neurol Int. 2011;2:93.
13. Greenbarg PE, Brown MD, Pallares VS, Tompkins JS, Mann NH. Epidural anesthesia for lumbar spine surgery. J Spinal Disord. 1988;1:139-43.
14. Garg B, Ahuja K, Sharan AD. Awake spinal fusion. J Clin Orthop Trauma. 2020;11(5):749-752.
15. Bridwell KH, Lenke LG, McEnery KW, Baldus C, Blanke K. Anterior fresh frozen structural allografts in the thoracic and lumbar spine: do they work if combined with posterior fusion and instrumentation in adult patients with kyphosis or anterior column defects? Spine. 1995;20:1410-8.
16. Ahmad AS, Abdullah TS, Alhasan AH, Sugati FT, Namnqani RM, Safaa M. Al-Hasani. Satisfaction outcomesafter spinal anesthesia for caesarean section in Kauh in Jeddah and in MCH in Makkah. Int J Adv Res. 2008;2:1292-8.
17. Kai-Hong Chan A, Choy W, Miller CA, Robinson LC, Mummaneni PV. A novel technique for awake, minimally invasive transforaminal lumbar interbody fusion: technical note. Neurosurg Focus. 2019;46(4):E16.
18. Jhala A, Singh D, Mistry M. Minimally invasive transforaminal lumbar interbody fusion: Results of 23 consecutive cases. Indian J Orthop. 2014;48(6):562-7.
19. Wang MY, Grossman J. Endoscopic minimally invasive transforaminal interbody fusion without general anesthesia: initial clinical experience with 1-year follow-up. Neurosurg Focus 2016;40(2):E13.
20. Patel J, Kundnani V, Raut S, Meena M, Ruparel S. Perioperative complications of minimally invasive transforaminal lumbar interbody fusion (MI-TLIF): 10 years of experience with MI-TLIF. Global Spine J. 2021;11(5):733-9.
21. Wang A, Yu Z. Surgical outcomes of minimally invasive transforaminal lumbar interbody fusion for highly migrated lumbar disc herniation. J Pain Res. 2021;14:1587-92.
22. Habib A, Smith ZA, Lawton CD, Fessler RG. Minimally invasive transforaminal lumbar interbody fusion: a perspective on current evidence and clinical knowledge. Minim Invasive Surg. 2012;2012:657342
23. Schwender JD, Holly LT, Rouben DP, Foley KT. Minimally invasive transforaminal lumbar interbody fusion (TLIF): technical feasibility and initial results. J Spinal Disord Tech. 2005;18:S1-6.
24. Pierce JT, Kositratna G, Attiah MA, Kallan MJ, Koenigsberg R, Syre P, et al. Efficiency of spinal anesthesia versus general anesthesia for lumbar spinal surgery: a retrospective analysis of 544 patients. Local Reg Anesth. 2017;10:91-8.
25. Jellish WS, Shea JF. Spinal anaesthesia for spinal surgery. Best Pract Res Clin Anaesthesiol. 2003;17(3):323-34.
26. Lin P-C, Lin M-L, Huang L-C, Hsu H-C, Lin C-C. Music therapy for patientsreceiving spine surgery. J Clin Nurs. 2011;20(7-8):960-8.

Cite this article as: Rangnekar A, Anand MK, Goparaju P, Chugh A, Shetty A, Raut S, et al. Awake spinal fusion: a retrospective analysis of minimal invasive single level transforaminal lumbar interbody fusion done under spinal anaesthesia in 150 cases. Int J Res Orthop 2022;8:649-54.