A Study Comparing Open and Minimally Invasive Surgery for One- or Two-level Thoracolumbar Intradural Extradmedullary Spine Tumors

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ABSTRACT

Background: The era of modern minimally invasive spine (MIS) surgery begins in the early 1990s with the report of the first case of tubular discectomy. Later, intradural tumor excision was reported in 2006. But most of us are still reluctant in accepting this new corridor due to lack of studies from India.

Aim: The aim of this study is to compare various aspects of minimally invasive resection of one- or two-spinal level thoracolumbar intradural extradural (IDEM) tumors with conventional open surgery.

Materials and methods: This study was conducted in patients admitted with a diagnosis of IDEM spinal tumor during the period of January 2016 January 2019. We compared 19 cases of one- or two-spinal level thoracolumbar IDEM tumors operated through MIS with 19 similar cases operated through open surgery.

Results: The mean intraoperative blood loss was 115 mL in the MIS group and 530 mL in the open group and the duration of surgery was 229.74 minutes for the MIS group and 230.26 minutes for the open group. The mean C arm exposure was 6.04 in the MIS group and 2.63 in the open group. Ten cases in the MIS group and eight cases in the open group were operated in one spinal level and 9 in the MIS group and 11 in the open group were operated in two spinal levels. One patient in both groups developed cerebrospinal fluid (CSF) leak and one patient in the MIS group and two patients in the open group had a postoperative wound infection. The mean postoperative pain score was 2 in the MIS group and 3.58 in the open group (assessed by the visual analog scale). Sensory and motor symptoms improved in all cases in both groups. The mean hospital stay was 5.16 days in the MIS group and 8.42 days in the open group. The mean size of incision was 2.73 in the MIS group and 8.18 in the open group. The patient satisfaction index (PSI 1–4) in terms of overall satisfaction was 1 (68.4%) and 2 (31.6%) in the MIS group and 1 (47.4%), 2 (31.6%), and 3 (21.1%) in the open group.

Conclusion: We conclude that MIS procedures are a safe and better alternative for one- or two-level thoracolumbar IDEM spinal tumors but its usefulness in tumors with more than two-level needs further studies.

Keywords: Intradural extradural, Minimally invasive, Spine tumors.

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INTRODUCTION

The era of modern MIS surgery begins in the early 1990s with the description of tubular retractors for access to the lumbar spine and the report of the first tubular discectomy.¹,² Minimally invasive means minimally destructive but not minimally effective, which minimizes approach-related morbidity by avoiding excessive muscle dissection with the help of self-retaining retractors and reduce iatrogenic tissue trauma during surgery.³,⁴ The indications for MIS surgery increased significantly nowadays, resection of intradural tumors using unilateral dilatation technique and self-retaining retractor system was introduced in 2006.²,⁴–⁶

IDEM spine tumors are usually benign tumors with an occurrence of 5–10 per one lakh population.⁶–⁸ Traditional surgical treatment include midline incision followed by a wide laminectomy and removal of the tumor.⁸ This procedure is associated with extensive muscle dissection and bone removal which may lead to the instability of the spine. The benefits of MIS surgery over traditional open surgery include smaller incisions, less soft tissue damage, reduced estimated blood loss, decreased postoperative pain, shorter hospital length of stay, faster recovery, and quicker return to work.²,⁴–⁶,⁹–¹¹

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Our institute is a tertiary care government medical college in the central Kerala, a southern state of India, where we started practicing various minimally invasive spinal procedures. Many other centers in our country are also practicing MIS procedures, but there are no good studies comparing various aspects of MIS and open surgeries for the treatment of IDEM tumors from India. As of our best knowledge, there are only a few studies¹²,¹³ in the literature comparing minimally invasive and open approaches for IDEM spine tumors. This prompted us to compare the various aspects of minimally invasive or open surgical excision of IDEM spine tumors in our scenario.

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Aim
The aim of this study is to compare various aspects of minimally invasive resection of one- or two-level spinal thoracolumbar IDEM tumors and conventional open surgery.

Materials and Methods
This study was conducted in Government Medical College, Thrissur, which is a tertiary care government medical college in the central Kerala, a southern state of India. The patients admitted with a diagnosis of IDEM spinal tumor during the period of January 2016–January 2019 were selected for the study. One- or two-level thoracic or lumbar spinal tumors were included in the study. Spine tumors other than IDEM or tumors with more than two spinal levels and patients who are not willing were excluded from the study. Consent was taken from both patients and responsible relatives in all cases. Those cases which were initially planned for minimally invasive surgery but later converted to open due to various reasons were not included in both groups. We compared 19 cases of IDEM spinal tumors operated through MIS surgery with 19 similar cases operated through open surgery. Age and sex were matched. Patients with major comorbidities that may affect the outcome of surgery were excluded from the study. Detailed preoperative workup including contrast-enhanced magnetic resonance imaging (MRI) was taken in all cases. Demographic data including age and sex, estimated blood loss, C-arm exposure, duration of surgery, completeness of resection, postoperative pain visual analog score, postoperative complications, histopathology, cosmesis in terms of length of incision, and number of days of hospital stay were recorded.

We assessed the satisfaction of patients in each group with a questionnaire which was given during the follow-up period. The questionnaire was meant to calculate PSI in which the overall satisfaction after surgery is graded into four grades:

1. Surgery met my expectation
2. I did not improve as much as I had hoped but I would undergo the same operation for the same results
3. Surgery helped but I would not undergo the same operation for the same outcome
4. I am the same or worse as compared to before surgery

We used serial dilators and the tubular retractor system for minimally invasive surgery (Jayon Surgical Ltd, Palakad, Kerala or PITKAR India). As we do not have a neuronavigation facility in our hospital, we used preoperative marker X-ray and intraoperative C-arm to localize the desired spinal level. A microscope was used in all cases. After positioning the patient prone, MIS surgery included three main steps: locating space (Fig. 1), serial dilation (Fig. 2), and applying the retractor system (Fig. 3). The incision is a 2.5–3 cm sized paramedian incision which is 1.5 cm lateral to the midline. The crucial step is to locate the space, which requires serial AP and lateral C-arm confirmation. After applying the retractor system at the correct space which should be reconfirmed with AP and lateral C-arm, next is to clear the muscles or soft tissue from the lamina and then do a hemilaminectomy using the Kerrison rongeur. Dura is exposed properly exactly over the tumor and it is opened by splitting under the vision of a microscope. Tumor excision can be achieved by standard surgical techniques (Figs 4 and 5). Dura is closed with continuous or interrupted sutures depending on the preference of a surgeon (Fig. 6) and fibrin glue was applied in some cases and reinforced with muscle or fat to make the dural closure perfect (Figs 7 and 8). Open surgery was done by a conventional adequate sized midline incision over the spinous processes after localizing the tumor level using preoperative marker X-ray and C-arm. Muscles dissected out laterally from spinous process and lamina to expose lamina. This is followed by a proper laminectomy, exposing the dura and removal of the tumor under microscope vision. Postoperative MRI was not taken routinely in all cases unless the patient develops any symptoms of recurrence as most of our patients cannot afford the cost of MRI.

Results
Data were analyzed using the SPSS software (Table 1). The mean age in the MIS group and the open group was 44.37 and 46.0 years, respectively, and most of the patients were in the age group of 20–60 years. Females were 63.2% and males were 36.8% in both groups. Tumors extending one spinal level constitute 10 in the MIS group and 8 in the open group and two levels constitute 9 in the MIS group and 11 in the open group. The average estimated blood loss in the MIS group and the open group was 115 and 530 mL, respectively (p value 0.002). No patient required a blood transfusion in the MIS group, whereas two patients required blood transfusion in open category. The average size of the incision is 2.73 cm in the MIS group and 8.18 cm in the open group (p value <0.001). C-Arm exposure roughly corresponds to the number of shots which was 6.05 in the MIS group and 2.63 in the open

Fig. 1: Locating space
group (p value <0.001). The duration of the procedure was 229.76 minutes and 230.26 minutes in the MIS group and the open group, respectively (p value 0.457). Among MIS cases, dural closure was continuous in 9 cases and interrupted in 10 cases, whereas in all cases of open, dura was closed with continuous sutures. The gross total resection was achieved in 78.9% of cases of the MIS group and 84.2% of cases of the open group (p value 0.676). No patient required spinal fusion in both groups. The postoperative pain score was assessed by the visual analog scale on the second postoperative day. The mean score was 2.0 in the MIS group and 3.58 in the open group on the second postoperative day (p value is 0.025). One patient each in both groups developed CSF leak and one patient in the MIS group and two patients in the open group developed postoperative wound infection which was resolved completely in both groups by conservative management and antibiotics. This was not statistically significant (p value is 1 in case of CSF leak and 0.547 in case of postoperative wound infection). Sensory and motor symptoms improved in all cases in both groups. Bladder or bowel symptoms were present in four patients of the MIS group and two patients of the open group. Bladder or bowel symptoms improved in two patients of the MIS group and one patient of the open group, whereas one patient

Fig. 2: Serial dilation under C-arm guidance

Fig. 3: Applying a tubular retractor system
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... statistically significant ($p$ value 0.014). After histopathological examination, 52.6% of tumors in the MIS group and 36.8% of tumors in the open group were meningiomas and 42.1% of tumors in the MIS group and 57.9% of tumors in the open group were schwannomas and others constitute 5.3%. This difference in histopathology was not statistically significant ($p$ value is 0.606). It has been observed that the PSI was 1 among 68.4% of MIS group patients and 47.4% of open group patients, whereas it is 2 in 31.6% of both groups. About 21.1% of the open group patients gave a PSI of 3 and none of them gave a PSI of 4. This indicates that patient satisfaction is slightly better in MIS surgery patients (Table 2 and Fig. 9) but this was not statistically significant ($p$ value 0.096).

**Discussion**

Evolution of minimally invasive techniques for the removal of intradural spinal tumors was not sudden. It took a lot of modifications over the years to develop the present serial dilator retractor system.²,³ In 1989, Chiou et al.¹⁵ published their 8-year experience in 256 patients operated by unilateral approaches for spinal tumors and this was followed by Yasargil et al.¹⁶ in 1991 who described unilateral partial hemilaminectomy for the removal of extra and intramedullary tumors and arteriovenous malformations. Later, this limited approach for intradural spine tumors was...
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Table 1: Results

| Variables                          | MIS (19 cases) | Open (19 cases) | p value |
|------------------------------------|----------------|-----------------|---------|
| Age in years (mean ± SD)           | 44.37 ± 15.17  | 46.0 ± 14.39    | 0.77    |
| Sex                                | Male           | Female          |         |
|                                    | 7 (36.8%)      | 12 (63.2%)      | 1       |
|                                    | 12 (63.2%)     |                 |         |
| Symptoms preoperative status       |                |                 |         |
| Sensory                            | 19             | 19              |         |
| Motor                              | 19             | 19              |         |
| Bladder or bowel                   | 4              | 2               |         |
| Symptoms postoperative status      |                |                 |         |
| Sensory                            | Improved       | Improved        |         |
| Motor                              | Improved       | 18              | 19      | 0.311 |
| No change                          | 1              | 0               |         |
| Bladder or bowel                   | Improved       | 2               | 1       | 0.687 |
| Worsened                           | 1              | 0               |         |
| No change                          | 1              | 1               |         |
| Estimated blood loss (mean ± SD mL)| 115 ± 36 mL    | 530 ± 172 mL    | 0.002   |
| Blood transfusion                  | –              | 2               | 0.146   |
| Muscle dissection                  | Less           | More            |         |
| C-arm exposure (mean ± SD number of shots) | 6.05 ± 1.03  | 2.63 ± 0.76     | <0.01   |
| Duration of procedure (mean ± SD minutes) | 229.74 ± 75  | 230.26 ± 68     | 0.457   |
| Gross total resection              | 15 (78.9%)     | 16 (84.2%)      | 0.676   |
| Dural closure                      | Continuous     | 9               | 18      |
|                                    | Interrupted    | 10              | –       |
| Number of spinal levels            | One            | 10              | 8       | 0.516 |
|                                    | Two            | 9               | 11      |       |
| VAS (2nd POD) (mean ± SD)          | 2 ± 1.33       | 3.58 ± 1.71     | 0.025   |
| CSF leak                           | 1              | 1               | 1       |       |
| Postoperative infection            | 1              | 2               | 0.547   |
| Hospital stay (mean ± SD days)     | 5.16 ± 2.83    | 8.42 ± 2.01     | 0.014   |
| Size of incision (mean ± SD cm)    | 2.73 ± 0.29    | 8.18 ± 2.74     | <0.01   |
| Histopathology                     |                |                 |         |
| Meningioma                         | 10 (52.6%)     | 7 (36.8%)       | 0.606   |
| Schwanoma                           | 8 (42.1%)      | 11 (57.9%)      |         |
| Others                             | 1 (5.3%)       | 1 (5.3%)        |         |

Table 2: Patient satisfaction index (PSI)

| PSI  | MIS (%)  | Open (%) | p value |
|------|----------|----------|---------|
| 1    | 13 (68.4)| 9 (47.4) | 0.094   |
| 2    | 6 (31.6) | 6 (31.6) |         |
| 3    | –        | 4 (21.1) |         |
| 4    | –        | –        |         |

Fig. 9: Patient satisfaction index (PSI)

described by a lot of other authors like Sarioglu et al., Oktem et al., and Pompili et al. In 2006, Tredway et al. published a study in which they included six patients (four males and 2 females), all underwent successful, complete surgical resection of IDEM tumors by minimally invasive unilateral approach. They used unilateral dilation technique and self-retaining retractor system. This may be considered as the earliest study which concluded that IDEM neoplasms can be safely and effectively treated with minimally invasive techniques with reduced blood loss, less hospital stay, and minimal disruption to local tissues and they suggested that this technique was a good alternative to traditional open tumor resection.

Mannion et al. studied 13 cases of IDEM tumors of the spine operated by muscle splitting, tube-assisted paramedian oblique approach with hemilaminectomy with preservation of spinous process and ligaments. They used fluoroscopy and navigation to determine the level. They were able to achieve satisfactory tumor resection in almost all cases with comparable surgical time and intraoperative blood loss with open technique cases. This study was not a direct comparative study between open and minimally invasive surgery for IDEM tumors. Yong-Jian Zhu et al. described
in their study that IDEM lumbar tumors, especially schwannomas, can be completely and safely resected through minimally invasive approach and, according to them, this approach was better because due to less bone destruction, postoperative spinal stability was better in these patients and none required fusion and also the functional recovery was faster in all patients.

Wong et al. directly compared MIS and open approaches for IDEM tumors in their retrospective review in which data were collected from 45 patients treated by open resection or minimally invasive for IDEM tumors spine tumors over a period of 9 years. They concluded that thoracolumbar IDEM tumors can be treated safely with open or minimally invasive approach, with similar gross total resection, perioperative complication rate, and operative time but less blood loss and shorter hospital stay with the minimally invasive approach. Almost similar results were obtained in another large comparative study (65 patients) which was published in the same year by Raygor et al.

There was no significant difference in age, sex, number of spinal levels, and final diagnosis in both groups. Symptomatic improvement was similar in both groups. Both sensory and motor symptoms were improved from preoperative status in all cases in both groups. There was a slight difference in the improvement of bowel or bladder symptoms noted but this was statistically not significant (p value 0.067). The estimated blood loss was less in the MIS group (115 mL) compared with the open group (530 mL) which is statistically significant (p value 0.002) and this finding is consistent with earlier studies like Wong et al. in which estimated blood loss (EBL) is 133.7 mL and 558.8 mL, respectively. Previous studies showed that estimated blood loss associated with MIS intradural extramedullary tumor excision may range from 56 mL to 238.8 mL. No patient required a blood transfusion in MIS surgery in our study, whereas two patients required a blood transfusion in open surgery cases (p value 0.146). This minimizes blood transfusion-associated problems that may occur during or after the procedure. Muscle dissection and tissue damage were significantly less in the MIS group as compared with the open group which was described earlier by many authors.

We used the C-arm for localizing the level which was associated with radiation risks. Many hospitals in developing countries which cannot procure neuronavigation which is very expensive can start doing MIS procedures without much difference in the outcome with the C-arm. Our study showed that there was a statistically significant higher risk for radiation (6.05 in the MIS group vs 2.63 with the C-arm. Our study showed that there was a statistically significant difference. We found that the overall satisfaction was 229.74 minutes and that of the open group was 230.26 minutes (p value 0.457). Earlier studies like Mannion et al. (150 minutes) and Dahlberg et al. (126 minutes) showed less time with MIS tumor excision. Dural closure was one of the difficult steps in initial few cases of MIS IDEM excision which later became less difficult with practice. We did dural closure with interrupted or continuous sutures depending on the surgeon's preference. In all cases of open procedures, dural closure was done by continuous sutures. Theoretically, CSF leak should be less associated with MIS procedures because in the open case, an incision is at the level of fascia but in MIS case, it is small and paramedian and the approach is through the muscle. So after closure, the paraspinal muscles should give a tight protection (not the fascia as in open) which may prevent CSF leak and this fact was supported by a previous study. But in our experience, one case in both groups developed postoperative CSF leak and this was statistically not significant (p value 1). One case in MIS and two cases in open developed postoperative wound infection (p value 0.547), which was controlled with conservative management. This difference was also not statistically significant.

Our learning is that you can choose any method in which you are confident for closing dura and this will not affect the outcome but the closure should be proper and meticulous.

Postoperative pain was assessed by the visual analog scale on the second postoperative day which showed that there is a significant reduction in the pain score (p value <0.025) among the MIS group (2.0) compared with the open group (3.58). No previous studies compared pain status in case of open or MIS IDEM surgeries but according to Mobbs et al., the amount of postoperative pain relief (change in the VAS score) provided by both procedures was not statistically significant in case of spinal fusion for the treatment of degenerative lumbar spine pathologies. There was a significant (p value 0.014) reduction in the mean hospital stay in the MIS group (5.16 days) compared with the open group (8.42 days) and the patient can be discharged earlier after MIS surgery. This will reduce the treatment-associated cost to the patient and also reduce the hospital burden, especially in government hospitals of developing countries where the bed-to-patient ratio is very low and most of the hospitals are overcrowded with patients. The slightly higher mean hospital stay in our study compared to some previous studies may be because most of the patients opted to stay in the hospital for a long period although they could be discharged early as they were coming from far places where immediate neurosurgery follow-up may be difficult.

Cosmesis was significantly better in the MIS group (p value <0.01) which was assessed by measuring the size of incision which is less in the MIS group (2.63 cm) compared with the open group (8.75 cm). Some patients, especially saree wearing Indian female population, as their back is exposed, may be more satisfied with improved cosmesis associated with MIS procedures. In this study, we made an attempt to assess the overall satisfaction of patients with a questionnaire method and measured the PSI. We found that the overall satisfaction was better in the MIS surgery compared with the open group; however, the difference was statistically not significant (p value 0.094) (Table 2 and Fig. 9). Earlier studies showed that MIS is equally safe in terms of postoperative outcome and our study also supports this fact. Hence, we undoubtedly propose that MIS surgery is a safe alternative to open surgery in one- or two-level thoracolumbar IDEM spine tumors and it can be started anywhere if the surgeons have proper experience in open spine tumor surgery also.

**Conclusion**

We conclude that MIS IDEM excision is superior in terms of intraoperative blood loss, postoperative pain, hospital stay, and cosmesis. Improvement of symptoms and duration of the procedure are comparable. There is a significantly increased risk of radiation in MIS procedures if we use C-arm for intraoperative localization of the tumor. The technique of dural closure has no effect on CSF leak. Patient satisfaction is better in MIS surgery even though this is not statistically significant. We conclude that MIS procedures are safe alternative to one- or two-level thoracolumbar IDEM spinal
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tumors but its usefulness in tumors with more than two level needs further studies.

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