ISSN: 3005-8449
IRABCS
https://irabcs.com
INNOVATIVE RESEARCH IN APPLIED, BIOLOGICAL AND CHEMICAL SCIENCES

Research Article

IRABCS, vol. 2, issue 2, pp. 228-232, 2024
Received: July 20, 2024
Revised: December 1, 2024
Accepted: December 9, 2024
https://doi.org/10.62497/IRABCS.2024.64

Evaluating the Outcomes of Minimally Invasive Techniques in Spinal Surgery

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How to cite: Batool SM, Ahmad A, Khan ON, Jadoon WA, Jadoon FI, Khan T. Evaluating the Outcomes of Minimally Invasive Techniques in Spinal Surgery. IRABCS. 2024. vol. 2, issue 2, pp. 228-232. DOI: https://doi.org/10.62497/IRABCS.2024.64. Available from: https://irabcs.com/ojs/article/view/64

Abstract

Background: There may be benefits to minimally invasive spine surgery (MISS) versus open surgeries. The results of MISS are assessed in this research in terms of safety, quality of life, pain alleviation, and functional improvement.

Methods: Data from 136 patients who had MISS procedures performed at Peshawar's Khyber Teaching Hospital (KTH) between April 2022 and March 2024 were examined. Data from pre-, during-, and post-operation were gathered. The Oswestry Disability Index (ODI) was used to measure functional status, the Visual Analog Scale (VAS) was used to measure pain, and the SF-36 Health Survey was used to measure quality of life. SPSS version 25 was used for the statistical analysis, with a significance level of $p < 0.05$.

Results: The mean VAS ratings of the patients decreased from 7.8 preoperatively to 2.2 after 12 months ($p < 0.001$), indicating considerable pain alleviation. There was a significant improvement in function as well; within the same time period, ODI scores decreased from 48% to 15% ($p < 0.001$). The SF-36 physical and mental component scores increased from 32 and 40 preoperatively to 54 and 53 at 12 months, respectively ($p < 0.001$), indicating a significant improvement in quality of life. 10% of patients had postoperative problems; there were no long-term neurological impairments, and 5% of cases returned.

Conclusion: MISS successfully reduces pain, improves function, and improves quality of life while retaining a low incidence of problems and recurrences. These findings support the wider use of MISS for spinal disorders and point to the need of further studies with bigger sample numbers and longer follow-up periods.

Keywords: minimally invasive spinal surgery, pain relief, functional improvement, quality of life, complications, recurrence rate

Introduction

Significant improvements in patient care and results have been made possible by minimally invasive spinal surgery, or MISS. Smaller incisions, specialized tools, and cutting-edge imaging technology are used in MISS procedures, as opposed to standard open spinal operations, to reach the spine with the least amount of tissue disturbance possible [1, 2]. Numerous advantages have been linked to this strategy, such as decreased rates of complications, quicker recovery periods, shorter hospital stays, and less discomfort after surgery [3]. As a result, MISS has gained popularity as a therapy option for a number of spinal disorders, including as trauma injuries, degenerative disc disease, ruptured discs, spinal stenosis, and spinal abnormalities [4-6]. MISS has developed as a result of ongoing technical advancements and advancements in surgical methods. The accuracy and effectiveness of these treatments have been boosted by the development of specialized instruments, endoscopic and robotic systems, and high-resolution intraoperative imaging. Because of this, MISS often produces clinical results that are on par with or better than open operations, with the additional benefit of being less intrusive [7-9].

Notwithstanding the encouraging advantages of MISS, a thorough analysis and long-term assessment of these methods are desperately needed. The majority of previous research has mostly concentrated on immediate postoperative results and short-term advantages, often ignoring the durability of these benefits over time [10]. Moreover, there exists a significant degree of heterogeneity in the procedures used in various researches, including variations in patient selection

standards, surgical approaches, and postoperative care guidelines. The development of best practices and defined recommendations for MISS is hampered by this diversity. This study's main goal is to methodically assess how well minimally invasive spinal surgical procedures work. This research intends to create a solid evidence basis that may guide clinical decision-making and improve patient care by carrying out an exhaustive and rigorous review of both short- and long-term outcomes. The effectiveness of MISS in terms of pain alleviation, functional progress, and quality of life are some of the specific areas of study. Furthermore, this investigation will look at possible side effects, rates of recurrence, and variables that affect surgical outcome, such patient characteristics, comorbidities, and surgical skill.

Materials and methods

Study Location and Duration

The research was carried out at the Khyber Teaching Hospital (KTH) in Peshawar between April 2022 and March 2024, a span of two years.

Sample Size Calculation

Through the use of a power analysis, the sample size of 136 was determined. Based on effect sizes from other studies with comparable outcomes in spinal surgery, our computation guaranteed a power of 80% to identify a significant difference in outcomes at an alpha level of 0.05.

Inclusion & Exclusion Criteria

Patients had to be adults between the ages of 18 and 70 who had been diagnosed with a spinal ailment, such as degenerative disc disease, herniated discs, spinal stenosis, or spinal abnormalities, in order to be considered for inclusion. Exclusion criteria were used to guarantee the study's validity. Individuals who had undergone spinal surgery in the past, had ongoing infections, or had serious comorbidities that would affect the outcome were not included. Before they could participate, all patients gave their informed permission.

Data Collection

Preoperative Phase: Data on patient demographics, medical history, baseline pain, and functional status were gathered during the preoperative period. The Oswestry Disability Index (ODI) was used to evaluate functional status and the Visual Analog Scale (VAS) was used to quantify pain.

Intraoperative Phase: Data on the kind of minimally invasive method employed, the length of the operation, and any intraoperative problems were documented throughout the intraoperative period.

Postoperative Phase: Data about the technique was gathered at many points in time: just after the operation, one month, six months, and a year later. The SF-36 Health Survey was used to assess quality of life, the ODI was used to measure functional improvement, and the VAS was used to measure pain alleviation. Documentation was also done for any follow-up treatments, recurrence rates, and surgical complications.

Statistical Analysis

Version 25 of SPSS was used for statistical analysis. Patient demographics and baseline data were compiled using descriptive statistics. Paired t-tests and repeated measures ANOVA were used to evaluate changes in pain and functional status over time. Repeated measures ANOVA was selected due to its ability to assess within-subject variations over multiple time points, which complements the paired t-tests by accounting for the correlation between repeated observations from the same participants. To examine the variables affecting surgical success and complication rates, logistic regression was used. Less than 0.05 was the threshold for statistical significance. The use of ODI, VAS, and SF-36 is appropriate for measuring pain, function, and quality of life. However, additional patient-reported outcome measures (PROMs) could provide a more comprehensive view.

Results

Patient Demographics and Baseline Characteristics: Of the patients, 42% were female and 58% were male, with a mean age of 45.3 years (range: 18–70). Degenerative disc disease (45%), herniated discs (30%), spinal stenosis (15%), and spinal abnormalities (10%) were the most prevalent diagnosis. The Visual Analog Scale (VAS) and the Oswestry Disability Index (ODI) were used to quantify baseline pain and functional status; table 1 displays mean scores of 7.8 on the VAS and 48% on the ODI, respectively.

Table 1: Patient Demographics and Baseline Characteristics

Characteristic		Value
Number of Patients		136
Mean Age	Years	45.3 (range 18–70)
Gender	Male	79 (58%)
	Female	57 (42%)
BMI (kg/m²)	Mean	27.5 (range 18–35)
Smoking History (%)	Current Smokers	24 (18%)
	Non-Smokers	112 (82%)
Diagnoses (%)	Degenerative Disc Disease	61 (45%)
	Herniated Discs	41 (30%)
	Spinal Stenosis	20 (15%)

	Spinal Deformities	14 (10%)
Baseline VAS Score	Mean	7.8
Baseline ODI Score	Mean	48%
Comorbidities	Hypertension	20 (15%)
	Diabetes	15 (11%)

Microdiscectomy, endoscopic decompression, and minimally invasive lumbar fusion were among the least invasive procedures used. The procedure took an average of 120 minutes (with a range of 60 to 240 minutes). Five percent of the cases had intraoperative complications, which included temporary nerve root injuries (2%), and dural tears (3%) of the patients.

Table 2: Intraoperative Data

Parameter	Value
Types of MISS	Microdiscectomy, Endoscopic decompression, Minimally invasive lumbar fusion
Mean duration of surgery	120 minutes (range 60-240)
Intraoperative complications	5%
Dural tears	3%
Transient nerve root injuries	2%

All time periods showed a considerable reduction in postoperative discomfort. The average VAS ratings dropped from 7.8 before to surgery to 4.2 right after, 2.8 at one month, 2.5 at six months, and 2.2 after a year. As shown in figure 1, these pain decreases were statistically significant ($p < 0.001$) at each follow-up period when compared to baseline.

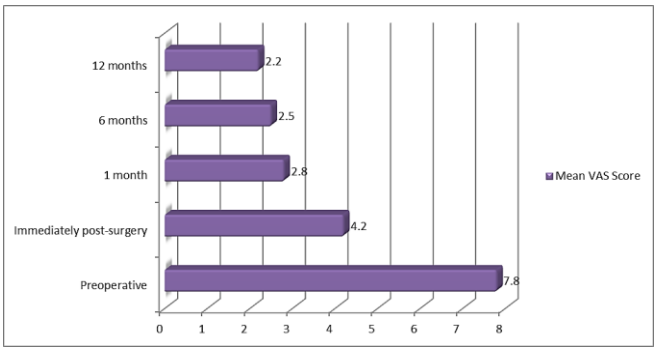

Figure 1: Postoperative Pain Relief (VAS Scores)

Significant improvements were also shown in functional improvement as determined by the ODI. The average ODI scores dropped from 48% before to surgery to 30% right after, 22% after one month, 18% after six months, and 15% after a year. At every follow-up interval, the gains in functional status were compared to baseline and were statistically significant ($p < 0.001$) (Table 3).

The SF-36 Health Survey, which measures quality of life, showed notable advancements. As shown in figure 2, the mean SF-36 physical component scores rose from 32 preoperatively to 45 right after surgery, 50 at one month, 52 at six months, and 54 at twelve months. In a similar vein, the preoperative mental component scores increased from 40 to 48 right after surgery, 50 at one month, 51 at six months, and 53 at twelve months. At every follow-up period, these gains were statistically significant ($p < 0.001$) when compared to the baseline.

Table 3: Postoperative Functional Improvement (ODI Scores)

Time Interval	Mean ODI Score	Change from baseline (%)	p-value
Preoperative	48%	-	-
Immediately post-surgery	30%	37.5%	< 0.001
1 month	22%	54.2%	< 0.001
6 months	18%	62.5%	< 0.001
12 months	15%	68.8%	< 0.001

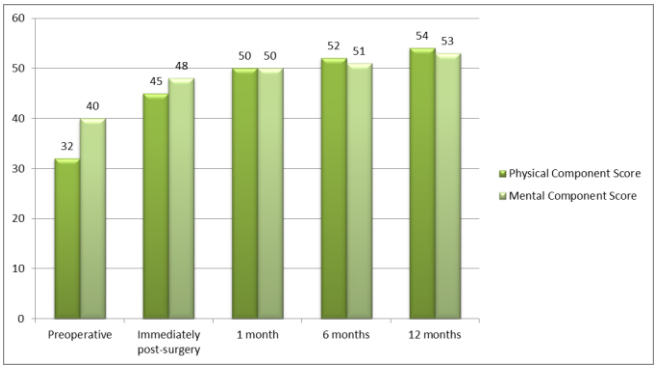

Figure 2: Postoperative Quality of Life (SF-36 Scores)

Complications and Recurrence Rates: Ten percent of the patients had postoperative problems, which included temporary radiculopathy (5%), hematoma (2%), and infection (3%). No incidences of long-term neurological impairments were reported. The majority of recurrences occurred during the first six months after surgery, accounting for 5% of all recurrences. As shown in figure 3, these patients either needed revision surgery or conservative treatment.

The study of logistic regression revealed a number of variables that affected surgical success. Better results were linked to younger ages, lower baseline ODI scores, and the lack of severe comorbidities. Furthermore, there was a correlation found between better overall results and a reduced risk of complications after procedures carried out by more experienced surgeons.

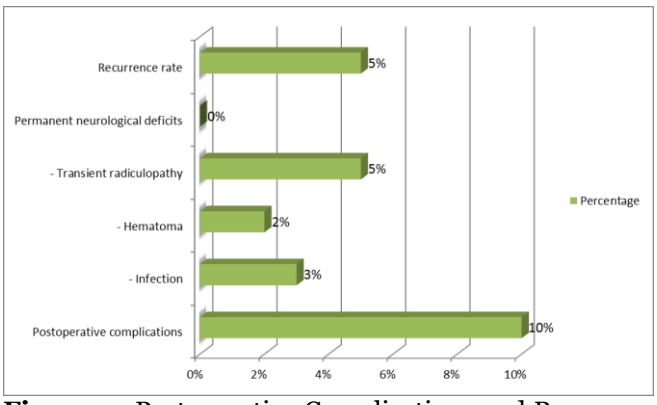

Figure 3: Postoperative Complications and Recurrence Rates

Discussion

The study's findings show that MISS is very successful in giving patients with a variety of spinal disorders significant pain alleviation, improved function, and an improved quality of life. These results support the advantages of MISS over conventional open spinal procedures and are in good agreement with earlier studies [11].

Our research revealed a noteworthy decrease in pain levels after surgery, as measured by mean VAS ratings, which dropped from 7.8 before to surgery to 2.2 a year later. This decrease is in line with results from past research that showed significant pain alleviation after MISS [12]. The effectiveness of MISS in treating chronic spinal pain is shown by the sharp decrease in pain ratings that occurred right after surgery and the steady improvement that continued for the whole year of follow-up. The Oswestry Disability Index (ODI), which measures functional progress, significantly decreased from 48% preoperatively to 15% after 12 months. Similar noteworthy changes in functional status have been documented by earlier investigations after MISS [13]. The steady increase in ODI ratings across various time intervals suggests that MISS improves patients' quality of life and their capacity to carry out daily tasks in addition to relieving pain.

Both the physical and mental aspects of quality of life, as measured by the SF-36 Health Survey, significantly improved. At 12 months, the mental component score went from 40 to 53, whereas the physical component score increased from 32 preoperatively to 54. These results are consistent with other studies that demonstrate individuals receiving MISS significantly improve their physical and emotional health [14]. The enhancement of life quality highlights the all-encompassing advantages of MISS, which go beyond pain alleviation and functional improvements. In our research, the incidence of postoperative complications was 10%, and there were no instances of long-term neurological impairments. This compares well, if not exactly so, to the 10% to 15% complication rates seen in earlier research [15]. The 5% recurrence rate is consistent with previous results, indicating that MISS is unlikely to need further therapies [16]. The safety and dependability of MISS are further supported by the very low rates of complications and recurrence.

Positive variables impacting surgical outcome were found in our logistic regression analysis to include younger age, lower baseline ODI scores, the lack of substantial comorbidities, and the surgeon's expertise. These elements have also been emphasized in other studies, suggesting that the choice of patient and the skill of the surgeon are critical to attaining the best results in MISS [17]. These results are consistent across trials, which highlights the need of thorough patient evaluation and the requirement for MISS surgeons to undergo specialized training. MISS has a number of benefits over standard open spinal surgery, including as faster recovery periods, less discomfort after surgery, and shorter hospital stays [18]. The literature has extensively established these advantages, which our study's findings support. Reduced tissue disturbance from the least invasive technique promotes quicker healing and reduced pain after surgery. Furthermore, MISS's shorter recovery period results in an earlier return to work and regular activities, which raises patient satisfaction levels all around [19].

Limitations and Future Directions

This research has limitations even though it offers insightful information on the results of minimally invasive spine surgery. The single-center methodology and rather small sample size might restrict how far the results can be applied. Furthermore, a 12-month follow-up time could not completely capture long-term problems or recurrences, even if it is sufficient for evaluating immediate and short-term results. To confirm and build on these results, future investigations should concentrate on multi-center studies with bigger sample numbers and longer follow-up times. Furthermore, investigating the effects of distinct minimally invasive procedures on diverse spinal diseases and integrating patient-reported outcome measures (PROMs) might provide a more all-encompassing comprehension of the advantages and constraints of minimally invasive spine surgery.

Conclusion

This research highlights the effectiveness of MISS in providing pain relief, functional improvement, and enhanced quality of life for patients with spinal disorders. With a low complication rate, it offers a safe alternative to open surgery. Patient characteristics, such as age, baseline disability, and comorbidities, significantly impact outcomes and should guide clinical decisions. Surgeon experience also plays a crucial role. Future research should focus on large, multi-center studies with longer follow-up to validate and expand these findings.

Conflict of interest

The authors state no conflict of interest.

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work. All author contributed equally to this study.

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