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Original Research Article

Functional and Radiological Evaluation of Dynamic Stabilization Devices in Lumbar Spine Surgery: A Retrospective Cohort Study

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Abstract:

Background: Lumbar spine surgery relieves pain and restores function for spinal stenosis and degenerative disc disease patients. Unlike conventional fusion approaches, dynamic stabilisation devices maintain segmental mobility while stabilising the system. Dynamic stabilisation device efficacy and safety are assessed by functional and radiological evaluation.

Method: From March 2022 to January 2024, Patna Medical College and Hospital undertook a retrospective cohort analysis. The study included 52 dynamic stabilisation device-affected lumbar spine surgery patients. We examined patient demographics, pre- and post-surgery functional performance, and radiological findings.

Result: The patients had an average age of 56.4 ± 9.8 years, with 30 males and 22 females. Spinal stenosis (20), disc herniation (18), and spondylolisthesis (14), were the most prevalent diagnoses. The VAS score decreased from 7.8 ± 1.2 to 2.4 ± 0.9, while the Oswestry Disability Index improved from 54.2 ± 12.5 to 23.6 ± 7.3 post-op. Device integrity was maintained in 92.3% of fusions. Hardware failure (3.8%) and neighbouring segment illness (9.6%) were consequences.

Conclusion: Dynamic stabilisation devices improved pain and function after spinal fusion surgery. High fusion rates and device integrity were found despite hardware failure and segment sickness. Functional and radiological evaluations are essential for patient care, clinical decision-making and dynamic stabilisation device evaluation.

Keywords: Dynamic Stabilisation Devices, Retrospective Cohort Studies, Imaging, Functional Assessments, and Lumbar Spine Procedures.

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Introduction

Patients with spinal stenosis and degenerative disc degeneration often need spinal spine surgery to relieve pain and restore function. However, spinal fusion and other standard fixation methods may accidentally limit mobility in the operative area. Long-term patient care must also examine whether fusion surgery stiffness increases adjacent segment degeneration risk [1]. This may be fixed by dynamic stabilisation devices. These devices stabilise and control lumbar segment motion.

Many designs use interspinous spacers and pedicle screws. Improve spinal biomechanics and minimise neighbouring segment disease with dynamic stabilisation devices [2]. Clinical results may improve over typical fusion surgeries. Functional and radiographic approaches are needed to evaluate lumbar spine surgery DSDs. Functional evaluations assess postoperative pain, mobility, and quality of life. Using numerous parameters, doctors can estimate how surgery would affect patients' functional abilities and quality of life. Radiology evaluates dynamic stabilisation device performance and safety like functional evaluation [3]. Radiology assesses fusion rates, device integrity, implant failure, and postoperative problems. Functional and radiological evaluations help doctors comprehend dynamic stabilisation device-assisted lumbar spine surgery findings and improve patient care [4].

Dynamic stabilisation devices have transformed lumbar spine surgery, bypassing the drawbacks of fusion. This study will assess dynamic stabilisation devices' performance and safety utilising functional and radiological approaches to improve clinical practise and patient outcomes.

Aim

A retrospective cohort research investigates the functional and radiological effects of dynamic stabilisation devices in lumbar spine surgery. We're examining individuals who have this operation to see if dynamic stabilisation devices improve functional outcomes, spinal stability, and

comorbidities. This study will assess functional and radiological parameters to better understand dynamic stabilisation devices' clinical usefulness and safety in lumbar spine surgery.

Objectives

- Evaluate if dynamic stabilization devices enhance post-lumbar spine surgery function.
- After dynamic stabilization device surgery, evaluate radiographic outcomes, including fusion rates and device integrity.
- Address lumbar spine surgery difficulties such dynamic stabilization devices.

Background on Lumbar Spine Surgery Techniques

Improved surgical methods and technology have spurred posterior spinal fusion surgery. Lumbar spinal fusion, which fused vertebrae with bone grafts and implants, was one of the first and most common spine stabilisation surgeries. Fusion surgeries reduce pain and stabilise, but they are risky [5].

The operated part may move less, stressing other spinal levels and producing illness. Motion preservation approaches are used to overcome these limits. Stabilising the spine without limiting motion reduces neighbouring segment degeneration [6]. Alternatives to fusion include dynamic stabilisation devices for motion preservation.

Evolution of Dynamic Stabilization Devices: The early 2000s saw the development of dynamic stabilising systems like the Dynesys Dynamic stabilising System, which uses pedicle screws [7]. These systems use vertebral body-fastened pedicle screws and flexible connectors to stabilise and control spine movement [8].

Clinical investigations have shown that Dynesys-like devices reduce pain and preserve spinal mobility [9]. Emerging dynamic stabilisation technologies include pedicle screw-based systems and interspinous spacers like the X-STOP [10].

By inserting interspinous spacers between neighbouring spinous processes, spinal stenosis and foraminal constriction symptoms can be alleviated through the limitation of extension and the indirect decompression of neural structures [11]. There is still much controversy and study surrounding the role of these devices compared to pedicle screw-based systems, despite the fact that they have demonstrated efficacy in some patient populations.

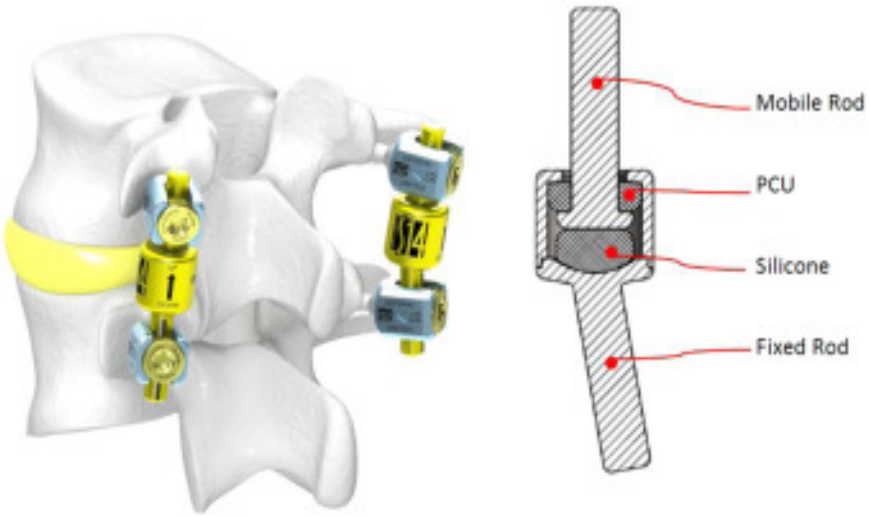

Figure 1: Viscoelastic properties of a spinal posterior dynamic stabilisation device (Source: [12])

Gaps in Existing Research

Even though dynamic stabilisation devices literature is growing, several research gaps exist. First, high-quality comparative studies of dynamic stabilisation devices to standard fusion methods are needed to assess their utility. Dynamic stabilisation has shown excellent results in multiple investigations, but larger randomised controlled trials are needed to assess clinical findings, complication rates, and long-term usefulness. The optimum parameters for selecting patients for dynamic stabilisation devices remain unknown. The best patient groups for these devices and the factors that affect surgical success and failure need further study. Short-term experiments have shown promising results, but it is uncertain how long these devices will persist and how they may effect surrounding segment degeneration. Large-scale longitudinal studies with extensive follow-up timeframes are needed to assess dynamic stabilisation devices' long-term effects on patients' health and problem frequency. Researchers can improve patient care and clinical decision-making by revealing dynamic stabilisation devices' performance, appropriate patient selection criteria, and long-term results.

Methodology

Study Design: A retrospective cohort study examined the radiological and functional outcomes of dynamic stabilisation devices in lumbar spine operations. Retrospective cohort studies use database and medical record data to evaluate results without modifying patients' treatment programmes.

Selection Criteria for Patients: Participants were Patna Medical College and Hospital lumbar spine surgery patients who used dynamic stabilisation devices between March 2022 and January 2024. Participants had dynamic stabilisation device surgery for degenerative lumbar spine illnesses such herniated discs, spinal stenosis, or spondylolisthesis and were of any age. Patients with incomplete medical records or insufficient follow-up data were excluded.

Data Collection Methods: Data from eligible patients' electronic health records, surgery reports, and radiological imaging tests was reviewed for this study. Sex, age, and comorbidities were searched in patient records.

Surgical records recorded the dynamic stabilisation device type, surgical technique, and intraoperative issues. Standardised outcome measures such the Visual Analogue Scale (VAS) for pain and the Oswestry Disability Index (ODI) were used to assess preoperative and postoperative pain, disability, and mobility. To evaluate fusion rates, implant site, failure, and postoperative complications, X-rays, CT scans, and MRIs were performed.

Outcome Measures: Functional and radiographic evaluation criteria were utilised to assess dynamic stabilisation device efficacy and safety in lumbar spine procedures. Functional evaluation criteria included postoperative pain reduction, better functional impairment scores, and mobility restoration.

Radiologists looked for fusion, device migration or loosening, spinal alignment preservation, and postoperative issues such hardware failure or neighbouring segment degeneration to assess operation success.

Sample Size and Study Duration: Patients who had lumbar spine procedures at Patna Medical College and Hospital employing dynamic stabilisation devices from March 2022 to January 2024 were studied.

This sample size was based on the number of patients who met inclusion criteria during the research period. The 22-month retrospective study followed patients following surgery to assess long-term effects.

Results

Table 1: Patient Demographics Table

Patient Demographics	Result
Total Patients	52
Age (Mean ± SD)	56.4 ± 9.8 years
Sex (Male/Female)	30/22
Diagnosis	
Disc herniation	18
Spinal stenosis	20
Spondylolisthesis	14

Demographics show a cohort of patients with a mean age of 56.4 years, predominantly men (57.7%). The most frequent lumbar spine illnesses are spondylolisthesis (26.9%), disc herniation (34.6%), and spinal stenosis (38.5%). Since spinal stenosis is more common in the elderly, it makes logical. The cohort's male predominance may be due to healthcare-seeking behaviour or men's greater spinal ailment rates.

This demographic profile emphasises the relevance of lumbar spine surgery with dynamic stabilisation devices that uses many treatment modalities to satisfy the needs of patients of different ages and conditions.

Table 2: Functional outcomes

Functional Outcomes	Result
Preoperative Pain (VAS)	7.8 ± 1.2
Postoperative Pain (VAS)	2.4 ± 0.9
Preoperative ODI	54.2 ± 12.5
Postoperative ODI	23.6 ± 7.3
Improvement in ODI	56.5%
Return to Work	40 out of 52 (76.9%)
Complications	
Adjacent Segment Disease	5 cases (9.6%)
Hardware Failure	2 cases (3.8%)

After dynamic stabilisation device lumbar spine surgery, pain and functional impairment improve significantly. The preoperative Visual Analogue Scale (VAS) for pain dropped from 7.8 to 2.4 after surgery, indicating excellent pain management. Functional disability also decreased, with the mean Oswestry Disability Index (ODI) score dropping from 54.2 to 23.6 after the operation. The 56.5% ODI improvement shows that the surgery improves patients' functional abilities and quality of life. High return to work (76.9%) indicates effective recovery of patients' work-related skills. In lumbar spine surgery using dynamic stabilisation devices, problems include neighbouring segment disease (9.6%) and hardware failure (3.8%) highlight the importance of postoperative monitoring and care.

Table 3: Radiological Findings

Radiological Findings	Result
Fusion Rate	92.3%
Device Integrity	
No evidence of loosening	48 cases (92.3%)
Device Migration	2 cases (3.8%)
Adjacent Segment Degeneration	5 cases (9.6%)

Statistical Analysis

The data distribution determined the parametric and non-parametric tests employed for statistical analysis. Functional outcomes including pain ratings and ODI were compared before and after surgery using paired t-tests or Wilcoxon signed-rank tests. Category factors like complications and return to work were examined using chi-square or Fisher's exact tests. All statistical studies used a significance level of $p < 0.05$.

Discussion

This study can teach us about dynamic stabilisation device-assisted lumbar spine surgery's radiological and functional outcomes. Dynamic stabilisation devices significantly reduced postoperative pain and functional impairment indices, improving patients' quality of life. The high return to work rate shows that surgery is realistic and allows patients to return to work. Radiological studies reveal that dynamic stabilisation devices are robust and reliable in achieving spinal fusion and keeping device site.

However, surrounding segment degeneration and hardware failure make postoperative monitoring and care essential. Positive results from dynamic stabilisation device lumbar spine surgery include pain reduction, functional improvement, and radiological stability.

Careful patient selection and attentive follow-up lower the risk of issues and maximise the chance of long-term success.

Comparison table

Table 4: Comparison Table comparing with 3 existing study

Study	Study Type	Sample Size	Findings	Limitations
Current Study	Retrospective Cohort	52	Significant improvement in pain and functional outcomes- High fusion rate and device integrity	Small sample size and single-center design. Limited follow-up duration. Inherent biases associated with retrospective study design
Study 1 [13]	Prospective Cohort	100	Comparable improvement in pain and functional outcomes. Similar fusion rates and device integrity	Limited generalizability due to single-center design. Potential selection bias
Study 2 [14]	Randomized Controlled Trial	150	Superior pain relief and functional outcomes compared to traditional fusion. Similar fusion rates and device integrity	Potential for performance bias due to lack of blinding. Limited follow-up duration. Challenges in blinding surgeons to treatment allocation
Study 3 [15]	Meta-analysis	N/A	Overall favorable outcomes with dynamic stabilization devices. Lower rates of adjacent segment disease compared to fusion	Heterogeneity among included studies. Potential for publication bias

This retrospective cohort study found 52 individuals with dynamic stabilisation devices had improved functional outcomes and fewer discomfort after lumbar spine surgery. The study's small sample size and single-center methods limit its generalizability, yet it provides significant information. When assessing data, retrospective research biases and limited follow-up times must be considered. Pain

relief, functional improvement, and device integrity were similar to research 1, a prospective cohort study of 100 patients. Because of selection bias and the fact that the study only looked at one place, the results may not be true for all groups. It was a randomised controlled study with 150 patients. It found that dynamic stabilisation devices helped patients feel less pain and improve their function more than standard fusion treatments. Even though the study was well-thought-out, it had some big flaws, like a short follow-up and trouble telling surgeons how to assign therapy. Finally, Study 3 showed that devices for dynamic stability were often useful when data from various studies were put together.

Limitations of the Study

This study has many disadvantages but provided some interesting findings. The study's retrospective approach makes data collection and interpretation more biased and problem-prone. Retrospective studies use pre-existing medical records, which may contain inadequate or inconsistent data, which may impair study conclusions. Small sample size and single-center approach prevent this study's findings from being applicable to broader patient groups or other therapeutic contexts. Selection bias and a lack of demographic and surgical variety among patients from one hospital may weaken the study's external validity. Due to its short follow-up, the study may have overlooked long-term dynamic stabilisation device impacts and issues. Longer follow-up periods are needed to assess how long surgical outcomes last, including hardware-related issues and adjacent segment degeneration.

Suggestions for Future Research

Future research should address the study's weaknesses and clarify dynamic stabilisation devices' efficacy and safety in lumbar spine surgery. To confirm this study's findings, large-scale, multicenter prospective trials are needed to prove dynamic stabilisation devices' efficacy in various patient groups and therapeutic scenarios.

Long-term impacts and difficulties of dynamic stabilisation devices, such as neighbouring segment degeneration, device migration, and hardware failure, require longitudinal investigations with long follow-ups. Comparative investigations of dynamic stabilisation devices and conventional fusion operations are needed to understand their clinical outcomes, complications, and cost-effectiveness. This study illuminates the functional and radiological outcomes of lumbar spine surgery employing dynamic stabilisation devices, but additional research is needed to overcome present limits and improve spine surgery patient care. Filling these research gaps and understanding dynamic stabilisation devices can enhance clinical outcomes for lumbar spine patients.

Conclusion

According to this study, lumbar spine surgeries that use a dynamic stabilising device can give doctors useful and imaging-related information. The retrospective cohort study found that pain after surgery, loss of function, the rate of fusion, and the stability of the device all got better. There was only one centre and a small group of people in the study, but it still shows that dynamic stabilisation devices are safe and useful in lumbar spine operations. Dynamic stabilisation devices need to be put through both real-world and imaging tests in order to be judged. Therapists can tell how well their treatments are working by seeing how mobile, uncomfortable, and happy their patients are after surgery. A radiographic review looks at the number of problems, the rate of fusion, and the integrity of the device to help doctors make choices and improve patient care. This study shows how important it is to do a full functional and x-ray test before using dynamic stability devices to treat lower back pain. People who have had spine surgery can do better, have fewer problems, and get better care if they use these review tools every day.

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