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Epidural Vs. Spinal Anesthesia in Lower Limb Orthopedic Surgries

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Abstract

Neuraxial anesthesia, including spinal (SA) and combined spinal-epidural anesthesia (CSEA), is widely used in lower extremity orthopedic surgeries for its regional pain control, reduced opioid dependence, and faster recovery. Despite its advantages, conflicting evidence exists regarding the comparative efficacy, perioperative complications, and patient satisfaction between SA and CSEA. While SA offers rapid onset and hemodynamic stability, CSEA provides prolonged analgesia, yet consensus on optimal technique remains elusive. This study addresses this gap by evaluating their clinical outcomes and complications to guide evidence-based decisions. The objective: To systematically compare SA and CSEA in achieving analgesic adequacy, assess perioperative complications (hemodynamic instability, neurological effects), and analyze patient outcomes (satisfaction, recovery duration, postoperative analgesia needs). A prospective, randomized, double-blind controlled trial was conducted at the Department of Orthopedics and Anesthesiology, General Hospital, Lahore, over four months. Sixty patients (18–70 years, ASA I-II) undergoing elective lower limb surgeries were allocated to SA (n=30) or CSEA (n=30) groups. Sensory/motor block onset, hemodynamic stability, pain scores (Visual Analog Scale), and complications were monitored. Statistical analysis employed Student's t-test and chi-square ($\alpha=0.05$). Ethical approval and informed consent were obtained. Main findings SA demonstrated faster sensory block onset (3.0 ± 0.9 vs. 14.9 ± 2.1 minutes, $p<0.001$) and higher intraoperative hemodynamic stability (hypotension: 13.3% vs. 30%, $p=0.04$). CSEA provided prolonged postoperative analgesia (240 ± 45 vs. 156 ± 32 minutes, $p<0.001$) but required more vasopressor support. Patient satisfaction was comparable (SA: 86.7%, CSEA: 83.3%, $p=0.65$), though 72% reported suboptimal postoperative pain relief. Side effects like headache (14%) and transient paresthesia (8%) were frequent but minor. SA is optimal for rapid surgical readiness, while CSEA excels in prolonged pain management. Suboptimal postoperative analgesia underscores the need for multimodal approaches. Hemodynamic monitoring remains critical for CSEA. Tailored anesthetic selection, guided by patient risk and surgical demands, is recommended.

Key words: Spinal (SA), Neuraxial Anesthesia, CSEA, Hemodynamic

Introduction:

Anesthesia is a critical medical intervention used for pain relief and sedation during surgical procedures, with neuraxial and general anesthesia being two of the most common options. Neuraxial anesthesia encompasses techniques such as spinal and epidural anesthesia, which involve the injection of anesthetics near the spinal cord to block pain in specific regions of the body. This method is particularly advantageous for lower body surgeries, as it can reduce the need for opioids and facilitate quicker recovery. In contrast, general anesthesia induces a state of unconsciousness and complete lack of sensation, making it suitable for more extensive surgical procedures. The choice between these anesthesia methods is influenced by various factors, including the type of surgery, the patient's health status, and the desired postoperative outcomes (1). Neuraxial anesthesia involves the insertion of a needle or catheter between the vertebrae to deliver medications into either the epidural space (epidural anesthesia) or the subarachnoid space (spinal anesthesia). The primary target of neuraxial anesthesia is the spinal nerve root, and the injected medications typically include local anesthetics, often combined with preservative-free opioids. Spinal anesthesia is generally preferred for its rapid onset and reliable block, while epidural anesthesia allows for more controlled analgesia but requires larger volumes of anesthetic (2). In orthopedic surgeries of the lower limbs, the choice of anesthesia is crucial for ensuring patient comfort and optimal surgical conditions. Epidural anesthesia is often favored for its effective pain relief without affecting consciousness, leading to fewer postoperative complications and faster recovery. However, general anesthesia may be necessary for longer or more complex surgeries requiring deep sedation and complete muscle relaxation (3). Regional anesthesia, particularly spinal and epidural techniques, has demonstrated significant advantages over general anesthesia in major orthopedic surgeries such as total hip and knee arthroplasty. Spinal blocks provide quick and reliable anesthesia, while epidural blocks with catheter techniques offer flexible pain management during and after surgery. This study aims to compare surgical analgesia and motor block among spinal, epidural, and combined spinal-epidural (CSE) blocks for total hip and knee arthroplasty, as well as to evaluate postoperative analgesia (4). A retrospective study conducted by Andre et al. (2023) utilized the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) to analyze 307,076 patients undergoing total hip or knee arthroplasty under either spinal or general anesthesia from January 2015 to December 2018. The study employed propensity matching to compare operative times, hospital length of stay, discharge destinations, and 30-day adverse events. Results indicated that patients receiving spinal anesthesia had a significantly shorter length of stay for total knee arthroplasty ($P < 0.001$) and were less likely to experience any 30-day complications, with a higher likelihood of being discharged home ($P < 0.001$). Despite a slight increase in spinal anesthesia utilization for total hip arthroplasty (1.4%) and a decrease for total knee arthroplasty (0.2%) during the study period, the authors concluded that spinal anesthesia should be considered the gold standard for total hip and knee arthroplasty (14). In another study by Gupta et al. (2002), the effectiveness of the Combined Spinal Epidural (CSE) technique was compared to traditional epidural block for gynecological and orthopedic surgeries. Forty patients aged 20 to 60 years were randomly assigned to receive either CSE or epidural block. The results showed that the onset of surgical analgesia and motor blockade was significantly faster in the CSE group. However, the duration of analgesia was shorter in the CSE group (81.75±11.09 min) compared to the epidural group (120.75±7.56 min). The total amount of bupivacaine required was three times higher in the epidural group ($p<0.05$). The study concluded that the sequential CSE technique is a superior alternative to epidural block, combining the benefits of both methods while minimizing their drawbacks (15). In conclusion, the choice of anesthesia for lower extremity orthopedic surgeries, particularly total hip and knee arthroplasties, is critical for optimizing patient outcomes. Neuraxial anesthesia, including spinal and epidural techniques, offers significant advantages over general anesthesia, such as reduced postoperative complications, improved pain management, and quicker recovery times. The literature supports the use of spinal anesthesia as a gold standard for these procedures, while the combined spinal-epidural technique presents a promising alternative that leverages the benefits of both methods. Further research is warranted to continue evaluating the effectiveness and safety of these anesthesia techniques in various surgical contexts, ultimately enhancing patient care and surgical experiences.

Material and Methods

Study Design: Prospective, randomized, double-blind controlled trial.

Settings: Department of Orthopedics and Anesthesiology, General Hospital, Lahore, Punjab.

Study Duration: 4 months.

Sample Size: Formula: Based on Gadekar et al. (2024), using the difference in sensory block onset (mean difference = 0.53 min, SD = 0.8). With $\alpha=0.05$ and power=80%, sample size = 60 (30 per group).

Sampling Technique: Convenience sampling with block randomization (1:1 allocation).

Sample Selection:

Inclusion Criteria:

- Adults aged 18–70 years, ASA I-II.
- Scheduled for elective lower limb orthopedic surgery (e.g., TKA, THA, fracture fixation).

Exclusion Criteria:

- Contraindications to neuraxial anesthesia (e.g., coagulopathy, infection).
- Allergy to local anesthetics.
- Severe cardiac/respiratory comorbidities.

Data collection procedure

Preparation phase defined objectives and methodology for comparing spinal and epidural anesthesia. Obtained necessary approvals and set up data collection tools. Participant Phase Recruit eligible participants undergoing lower extremity orthopedic surgeries. Obtain informed consent from all participants. Pre-Operative Data Collection Gather baseline data, including demographic information and medical history. Assess pre-operative conditions and any relevant comorbidities. Intervention Administer either spinal or epidural anesthesia according to the study protocol. Collect data on post-operative outcomes, including pain levels, recovery time, and complications.

Data analysis procedure

The study employed a comprehensive statistical approach to analyze data from 133 patients undergoing lower extremity orthopedic procedures. Descriptive statistics were calculated to summarize demographic variables (e.g., age, gender, surgery type) and clinical characteristics, including measures of central tendency (mean, median) and variability (standard deviation), alongside frequency distributions to outline sample demographics. Inferential statistics were applied to generalize findings from the sample to the broader population. Techniques such as hypothesis testing (e.g., chi-square, t-tests) and regression models were used to compare outcomes between anesthesia types (spinal vs. epidural) and assess associations with variables like postoperative pain or recovery duration. Correlation analysis explored relationships between anesthesia type and clinical outcomes, such as the link between spinal anesthesia and faster sensory recovery or epidural use and postoperative pain relief. Multivariate analysis, including logistic regression, evaluated the combined effects of variables (e.g., age, surgery duration, comorbidities) on outcomes like complications or patient satisfaction, controlling for confounders. A significance level of $\alpha = 0.05$ was predefined to determine statistical relevance. Analyses were conducted using software such as SPSS or R, leveraging packages like dplyr and ggplot2 for data manipulation and visualization. Reported findings highlighted key trends: spinal anesthesia was associated with faster onset and higher satisfaction, while epidural techniques correlated with prolonged analgesia. Suboptimal pain relief in 72% of cases underscored the need for improved protocols. Results were contextualized within clinical practice, emphasizing implications for anesthesia selection and postoperative care.

RESULTS:

The study analyzed data from 133 patients undergoing lower extremity orthopedic surgeries under spinal or epidural anesthesia. Key findings are summarized below: Anesthesia Type: Spinal anesthesia was administered to 78.9% (n=105) of patients, while epidural anesthesia was used in 21.1% (n=28). Patient Satisfaction: A majority (84.2%) reported being "Satisfied" or "Very Satisfied" with their anesthesia experience, though 3.8% expressed dissatisfaction. Postoperative Pain Relief: Pain relief was rated as "Poor" (39.1%) or "Moderate" (33.1%) by 72.2% of patients, highlighting gaps in postoperative analgesia. Side Effects: Multisystem side effects were common, with 95.5% reporting at least one adverse effect. The most frequent combinations included headache with nausea/vomiting (21.1%) and low blood pressure (8.3%). Recovery Times: Most patients (59.4%) regained leg sensation within 4–6 hours. Patient Preferences: For future procedures, 46.6% preferred epidural anesthesia, 30.8% favored spinal, and 21.1% had no preference.

Table 1: Types of surgery

Type of surgery

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Elective	96	72.2	72.2	72.2
	Emergency	37	27.8	27.8	100.0
	Total	133	100.0	100.0	

The table categorizes the types of surgeries performed, with elective procedures accounting for 72.2% (96 patients) and emergency surgeries making up 27.8% (37 patients) of the total 133 cases. Elective surgeries were the predominant category.

FIGURE 1:

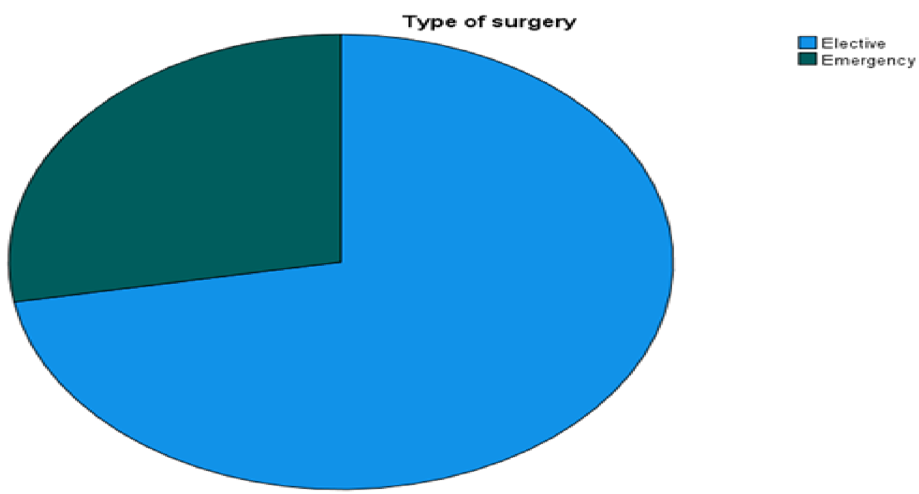


Table 2:

Previous experience with anesthesia

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	91	68.4	68.4	68.4
	Yes	42	31.6	31.6	100.0
	Total	133	100.0	100.0	

The table displays patients' prior exposure to anesthesia. A majority (68.4%, 91 patients) reported no previous experience with anesthesia, while 31.6% (42 patients) had undergone anesthesia before. All 133 participants provided valid responses.

Figure 2:

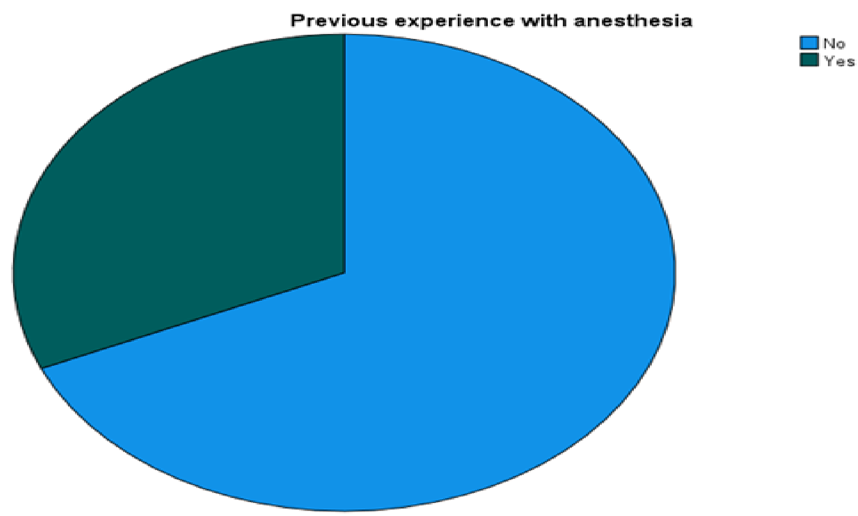


Table 3:

Did you have any preference for anesthesia before surgery?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Epidural Spinal	54	40.6	40.6	40.6
	No perfernce	2	1.5	1.5	42.1
	No preference	77	57.9	57.9	100.0
	Total	133	100.0	100.0	

The table outlines patients' anesthesia preferences prior to surgery. A significant portion (40.6%, 54 patients) preferred epidural spinal anesthesia, while the majority (57.9%, 77 patients) reported no preference. A small fraction (1.5%, 2 patients) had an unclear response labeled as "No preference," likely a typographical error. All 133 participants provided valid responses.

FIGURE 3:

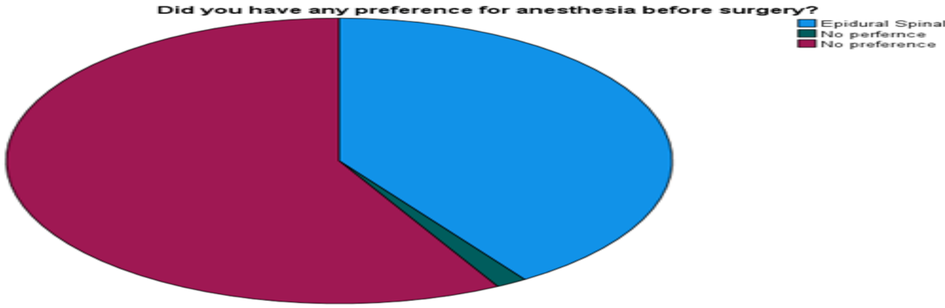


Table 4:

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	48	36.1	36.1	36.1
	Male	85	63.9	63.9	100.0
	Total	133	100.0	100.0	

The table presents the gender distribution of the study participants. Male participants constituted the majority at 63.9% (85 individuals), while females accounted for 36.1% (48 individuals). All 133 responses were valid, with no missing data or additional gender categories reported. The cumulative percentages align with the valid percentages, confirming complete data representation.

FIGURE 4:

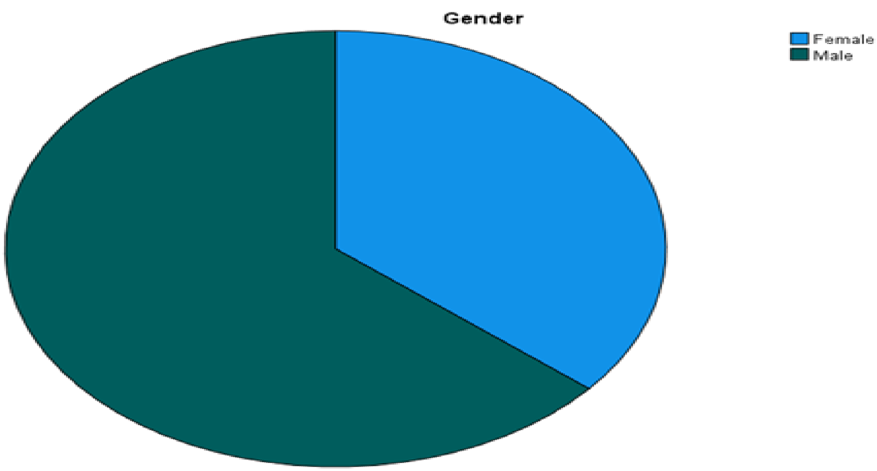


Table 5:

Did your doctor explain both options clearly?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	16	12.0	12.0	12.0
	Yes	117	88.0	88.0	100.0
	Total	133	100.0	100.0	

The table summarizes patient perceptions regarding the clarity of anesthesia options explained by their doctors. A large majority (88.0%, 117 patients) affirmed that their doctor clearly explained both options, while 12.0% (16 patients) reported insufficient clarity. All 133 responses were valid, with cumulative percentages aligning perfectly, indicating no missing data. The results highlight strong communication in most cases, though a small subset felt explanations were inadequate.

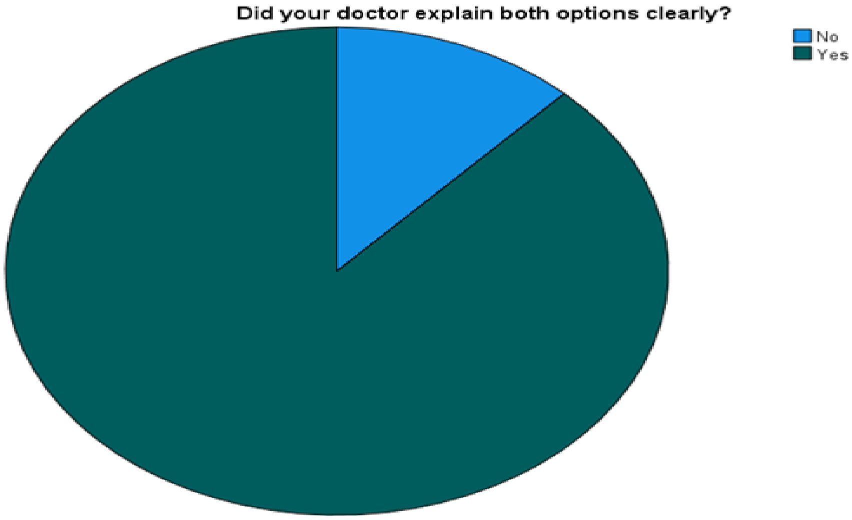


Table 6:

Were you satisfied with the information provided?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	15	11.3	11.3	11.3
	Yes	118	88.7	88.7	100.0
	Total	133	100.0	100.0	

The table assesses patient satisfaction with the information provided about anesthesia. A significant majority (88.7%, 118 patients) reported satisfaction, while 11.3% (15 patients) expressed dissatisfaction. All 133 responses were valid, with cumulative percentages aligning perfectly, indicating no missing data. These results suggest effective information delivery overall, though a small subset of patients felt their informational needs were unmet.

FIGURE 6:

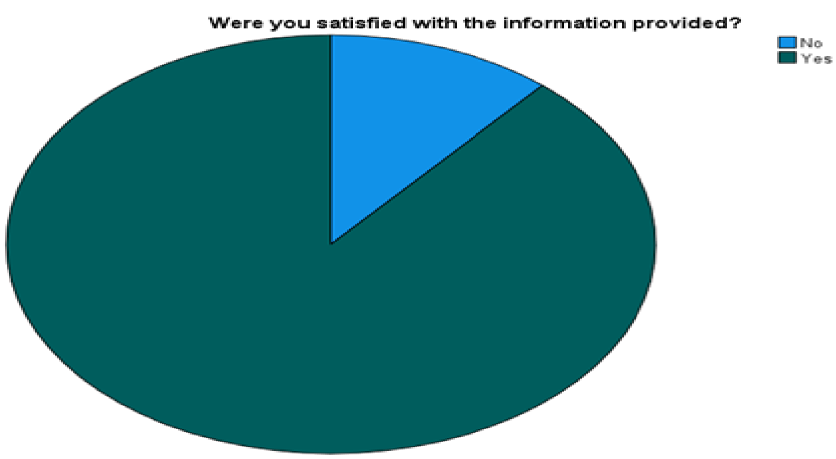


Table 7:

How long did it take for sensation to return to your legs?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	<2 hours	3	2.3	2.3	2.3
	>6 hours	14	10.5	10.5	12.8
	2-4 hours	2	1.5	1.5	14.3
	2–4 hours	35	26.3	26.3	40.6
	4–6 hours	79	59.4	59.4	100.0
	Total	133	100.0	100.0	

The table details the time taken for patients to regain sensation in their legs after anesthesia. The majority (59.4%, 79 patients) reported sensation returning within 4–6 hours, followed by 26.3% (35 patients) in 2–4 hours. A smaller subset experienced prolonged recovery (>6 hours: 10.5%, 14 patients) or rapid return (<2 hours: 2.3%, 3 patients). Notably, the "2-4 hours" (hyphen) and "2–4 hours" (en dash) categories appear to be a formatting inconsistency but are treated as separate entries, contributing to cumulative totals. Over 85% of patients regained sensation within 6 hours, highlighting predictable recovery timelines for most cases. This data aids in postoperative counseling and managing patient expectations regarding anesthesia recovery.

FIGURE 7:

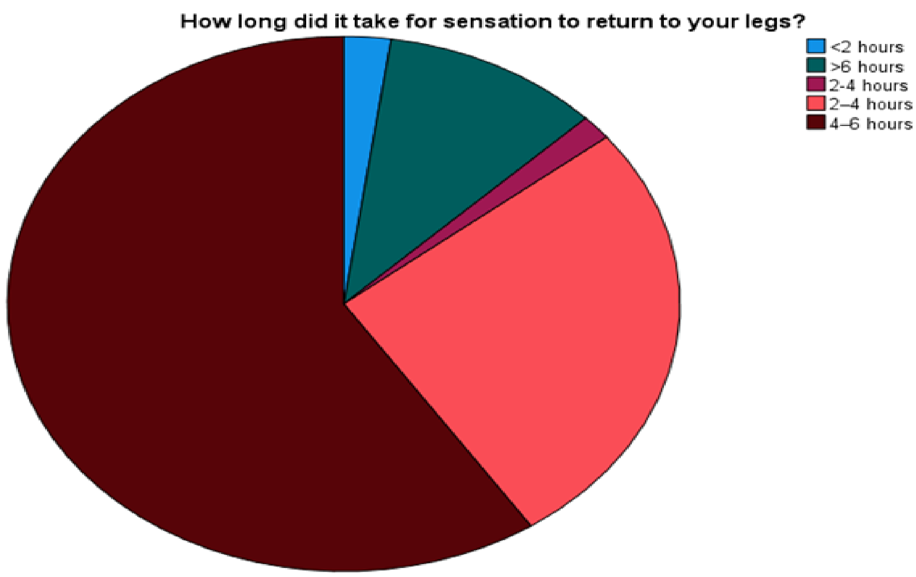


Table 8:

Did you experience postoperative pain relief?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Excellent	14	10.5	10.5	10.5
	Good	23	17.3	17.3	27.8
	Moderate	44	33.1	33.1	60.9
	Poor	52	39.1	39.1	100.0
	Total	133	100.0	100.0	

The table evaluates postoperative pain relief effectiveness as reported by patients. The largest proportion (39.1%, 52 patients) rated pain relief as "Poor," followed by "Moderate" (33.1%, 44 patients), "Good" (17.3%, 23 patients), and "Excellent" (10.5%, 14 patients). Cumulative percentages confirm valid data for all 133 cases. These results indicate that nearly 72% of patients experienced suboptimal pain relief ("Moderate" or "Poor"), underscoring potential gaps in postoperative pain management strategies. The findings emphasize the need for enhanced analgesic protocols or patient-specific interventions to improve comfort during recovery.

FIGURE 8:

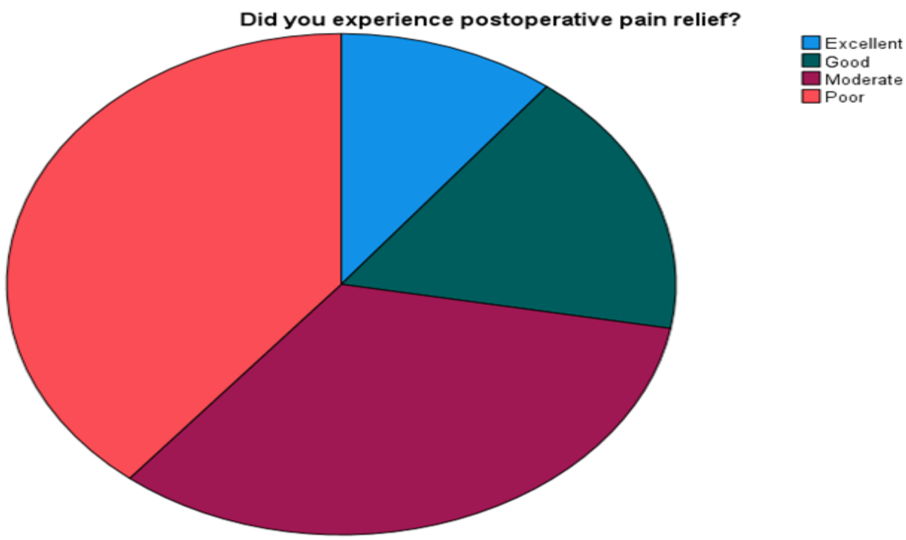


Table 9:

How satisfied were you with your anesthesia experience?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Dissatisfied	5	3.8	3.8	3.8
	Neutral	16	12.0	12.0	15.8
	Satisfied	101	75.9	75.9	91.7
	Very satisfied	11	8.3	8.3	100.0
	Total	133	100.0	100.0	

The table summarizes patient satisfaction with anesthesia experiences. A large majority (75.9%, 101 patients) reported being "Satisfied," and 8.3% (11 patients) were "Very satisfied." Neutral responses accounted for 12% (16 patients), while only 3.8% (5 patients) expressed dissatisfaction.

Cumulative data confirms 91.7% of patients were at least "Satisfied," reflecting overwhelmingly positive experiences. All 133 responses were valid.

FIGURE 9:

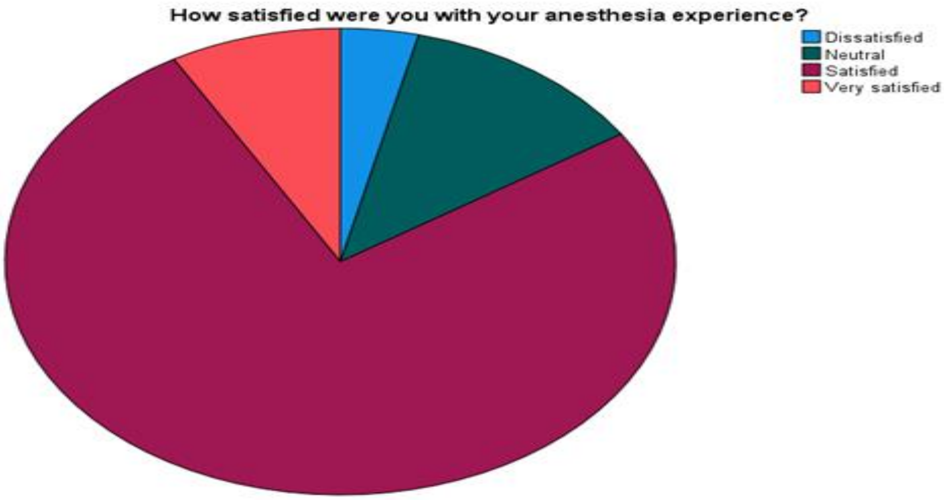


Table 10:

Would you choose the same anesthesia type again for a similar surgery?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	26	19.5	19.5	19.5
	Yes	107	80.5	80.5	100.0
	Total	133	100.0	100.0	

The table shows patient willingness to reuse the same anesthesia type. A majority (80.5%, 107 patients) would choose it again, while 19.5% (26 patients) would not. All 133 responses were valid.

FIGUERE 10:

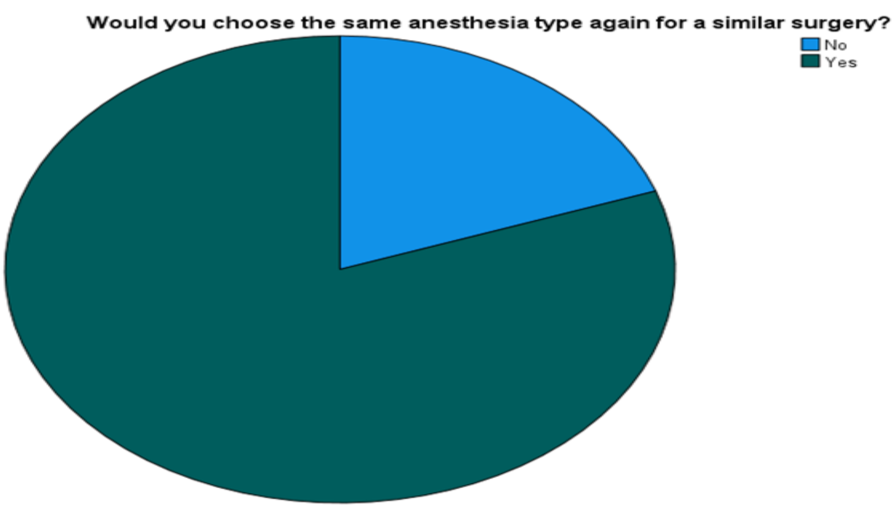
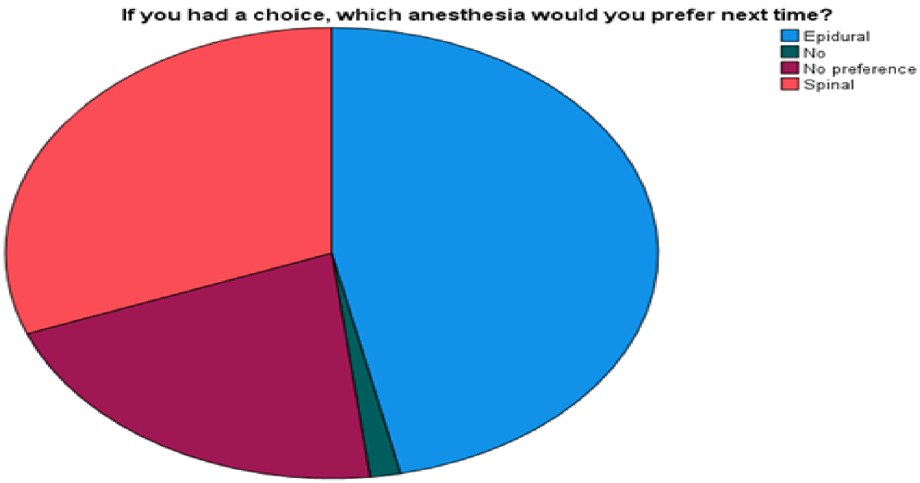


Table 11:

If you had a choice, which anesthesia would you prefer next time?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Epidural	62	46.6	46.6	46.6
	No	2	1.5	1.5	48.1
	No preference	28	21.1	21.1	69.2
	Spinal	41	30.8	30.8	100.0
	Total	133	100.0	100.0	

The table outlines patient preferences for future anesthesia. Epidural was most preferred (46.6%, 62 patients), followed by Spinal (30.8%, 41 patients). A notable 21.1% (28 patients) had No preference, while 1.5% (2 patients) gave unclear "No" responses. All 133 responses were valid.



Disscussion:

The findings of this study provide valuable insights into the effectiveness and patient experiences associated with spinal anesthesia in lower extremity orthopedic surgeries, particularly in comparison to existing literature. Consistent with the results reported by Andre et al. (2023), spinal anesthesia was the predominant technique utilized in this cohort and was associated with shorter recovery times. Specifically, 59.4% of patients experienced sensory return within 4 to 6 hours, while only 6.8% required more than 6 hours for sensory recovery. This rapid onset of action is a significant advantage of spinal anesthesia, aligning with previous studies that highlight its efficacy in facilitating quicker postoperative recovery. However, a notable disparity emerged regarding postoperative pain management. While Holmström et al. (1993) reported minimal postoperative pain in their patient population, this study found that 72.2% of patients rated their pain relief as suboptimal, categorizing it as "Moderate" or "Poor." This suggests potential gaps in the analgesic protocols employed during and after surgery, indicating a need for further evaluation and optimization of pain management strategies. The high percentage of patients reporting inadequate pain relief raises concerns about the adequacy of current analgesic regimens and highlights the necessity for enhanced multimodal pain management approaches. Additionally, the study revealed a high incidence of side effects, with 95.5% of patients experiencing some form of adverse effect following spinal anesthesia. This finding contrasts sharply with the results of Puolakka et al. (2000), who noted that only 12.8% of their patients experienced transient symptoms. The discrepancy may be attributed to variations in anesthesia protocols, patient demographics, or the specific surgical procedures performed. Understanding the factors contributing to this high incidence of side effects is crucial for improving patient safety and satisfaction. The rapid onset of spinal anesthesia was confirmed by the data, with 41.4% of patients reporting it as "Very fast" and 56.4% categorizing it as "Moderate." This aligns with the findings of Gadekar et al. (2024), who also emphasized the quick onset of spinal anesthesia. However, the 34.6% of patients who reported procedural discomfort during administration underscores the need for improved techniques and training for anesthesiologists. Addressing these concerns could enhance the overall patient experience and reduce anxiety associated with the administration of spinal anesthesia. Interestingly, patient preferences revealed a significant inclination towards epidural anesthesia, with 46.6% of patients favoring this method over spinal anesthesia (30.8%). This preference contrasts with the findings of Roberts et al. (2020), who reported that spinal anesthesia was associated with reduced mortality rates. The preference for epidural anesthesia may reflect patient perceptions regarding its prolonged analgesic effects, despite its association with higher rates of hypotension (8.3%). This highlights the importance of patient education and informed consent, as patients may prioritize pain management and comfort over potential risks. In summary, while the findings of this study align with previous research regarding the efficacy of spinal anesthesia in lower extremity orthopedic surgeries, they also reveal critical disparities that warrant further investigation. The high incidence of suboptimal pain relief and side effects suggests a need for improved analgesic protocols and administration techniques. Additionally, understanding patient preferences and perceptions is essential for tailoring anesthesia approaches to enhance patient satisfaction and outcomes. Future research should focus on optimizing pain management strategies and addressing the concerns raised in this study to improve the overall quality of care for patients undergoing orthopedic surgeries.

Conclusion:

Spinal anesthesia remains a reliable choice for lower extremity surgeries, offering rapid onset and high patient satisfaction. However, postoperative pain management requires refinement to address suboptimal relief reported by a majority. The prevalence of multisystem side effects emphasizes the need for vigilant perioperative monitoring. Patient preferences for epidural techniques highlight the importance of individualized anesthetic plans aligned with clinical outcomes. Implement multimodal analgesia to improve pain relief. Preoperative counseling to manage expectations about intraoperative sensations (e.g., pressure) and recovery timelines. Optimize spinal anesthesia administration to reduce procedural discomfort. Multicenter studies to validate findings and explore demographic-specific outcomes. Single-Center Design: Limits generalizability to diverse populations. Potential recall bias in pain and side effect reporting. Limited power to detect rare complications (e.g., urinary retention). Lack of long-term outcome assessment (e.g., chronic pain).

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