Alqalam Journal of Medical and Applied Sciences. 2026;9(6):1516-1521
https://doi.org/10.54361/ajmas.269609

Original article

Comparative study of Ultrasound-Guided *versus* Anatomic Landmark-Guided Techniques for Nerve Block Anesthesia

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Abstract
Peripheral nerve blocks are widely used in orthopaedic surgery to provide effective perioperative analgesia and enhance postoperative recovery. Ultrasound-guided (USG) and landmark-guided (LMG) techniques are commonly employed; however, evidence comparing their effectiveness in Libya is limited. To compare the efficacy and safety of ultrasound-guided and landmark-guided peripheral nerve block techniques in patients undergoing elective orthopaedic surgery. A prospective multicentre observational comparative study was conducted between January and December 2025 at Sabratha Teaching Hospital, Mitaga Military Hospital, and Abu Salim Trauma Hospital. One hundred patients undergoing elective orthopaedic surgery were included and allocated equally to either the USG group (n = 50) or the LMG group (n = 50). The primary outcome was the blocking success rate, defined as the absence of pain during surgery without the need for supplemental anaesthesia. Secondary outcomes included block onset time, number of needle passes, complications, and patient satisfaction. Data were analysed using SPSS version 27, with statistical significance set at $p < 0.05$. Both techniques achieved comparable success rates, with no statistically significant difference between groups. However, the USG technique resulted in significantly shorter sensory and motor block onset times, fewer needle passes, a lower incidence of complications, and higher patient satisfaction scores compared with the LMG technique. While both ultrasound-guided and landmark-guided techniques were effective for peripheral nerve blocks in orthopaedic surgery, ultrasound guidance offered important advantages in terms of faster block onset, improved safety, and greater patient satisfaction. These findings support the wider adoption of ultrasound-guided nerve blocks where resources and expertise are available.
Keywords. Orthopaedic Surgery, Peripheral Nerve Block, Ultrasound-Guided Technique, Landmark-Guided Technique, Regional Anaesthesia.

Introduction

Orthopaedic surgery is a specialized field focused on conditions of the musculoskeletal system. It encompasses a wide range of procedures involving the upper and lower limbs, as well as the spine. These types of surgeries have been found to lead to increased morbidity, mortality, and functional dependency among adults. The field is experiencing significant global growth, driven by an aging population and an increasing demand for joint replacement [1]. This global demand places a considerable burden on healthcare systems; as such, surgeries are usually associated with severe pain, prolonged hospitalization, increased healthcare costs, and a significant decline in quality of healthcare [1]. Therefore, early surgical intervention is highly recommended to reduce any potential complications, making perioperative management a critical determinant of patient outcomes [2].

Anaesthesia plays a crucial role in orthopaedic surgery by ensuring patient comfort and effective pain management through various techniques, such as general anaesthesia (GA), neuroaxial anaesthesia, and regional anaesthesia. GA induces unconsciousness using intravenous medications and inhaled gases and is typically used for major orthopaedic procedures such as total joint replacement [3]. On the other hand, neuroaxial anaesthesia, including both spinal and epidural techniques, is commonly used for lower limb surgeries [4]. Traditionally, opioids and non-steroidal anti-inflammatory drugs have been used to treat pain in these patients. However, these medications are often associated with side effects, especially in the geriatric population [5].

In modern anaesthesia practice, peripheral nerve blocks have become an essential component. They offer excellent perioperative analgesia, muscle relaxants, and facilitate early recovery [6]. These blocks enable anaesthetists to isolate specific nerves and provide anaesthesia to targeted areas only. Therefore, the patient remains pain-free and conscious during surgery, or may receive mild sedation to alleviate anxiety [7]. There are two primary approaches for performing these blocks: the landmark-based technique and the ultrasound-based technique. The Landmark-based technique has traditionally been regarded as the standard approach, whereby the anaesthetist identifies anatomical landmarks, such as bony structure and surface anatomy, to guide needle placement toward the intended target [8]. This technique is well established and has been widely used in clinical practice for many patients in many years. However, questions remain regarding the accuracy and precision of this modality across the entire patient population. In recent years, the ultrasound-based technique has emerged as an effective alternative to the landmark-based technique. This technique has allowed visualisation of nerve structures and real-time monitoring of local anaesthetic distribution. Consequently, it improves the precision of needle placement and increases the success rate of peripheral

Received*: 02-04-2026 -* ***Accepted****: 01-06-2026 -* ***Published****: 08-06-2026*

nerve blocks [7]. This has been associated with reduced failure rates and fewer complications, as well as a shorter time to block onset [7]. On the other hand, the cost of ultrasound-guided technique machines, along with the need for specialized training and increased procedural time, may pose limitations, particularly in resource-limited settings. These factors may influence the decision to utilise the ultrasound-guided technique versus the landmark-based technique. There are limited studies comparing the efficacy of using the ultrasound-guided (USG) technique with the landmark-guided (LMG) technique in orthopaedic surgery in Libya. Therefore, this study aims to determine which technique (ultrasound-guided or landmark-based) offers the most reliable and effective outcomes for peripheral nerve blocks for orthopaedic procedures.

Methodology

Study design and settings

This prospective, multicentre, observational comparative study was carried out in the department of anaesthesia at Sabratha Teaching Hospital (STH), Mitaga Military Hospital (MMH), and Abu Salim Trauma Hospital. It was conducted from the 1st of January to the 31st of December 2025 after obtaining approval from the Biosafety and bioethics committee, approval number [081.H.24.59.86].

Study Population

The study included all patients of either gender presenting with elective orthopaedic surgery during the study period.

Preoperative assessment and preparation

All participants underwent a detailed pre-anaesthetic assessment, including patient medical history, physical examination, and relevant investigations. Patients were educated on the use of the Visual Analogue Scale (VAS) for pain assessment. Standard fasting guidelines were followed, and preoperative medication was administered.

Procedures

Nerve blocks were performed under either landmark guidance or ultrasound guidance using sterile gloves, antiseptic solution, a nerve block needle, and a local anaesthetic agent; ultrasound-guided procedures additionally utilized an ultrasound machine with a linear probe and gel. Patients were positioned according to the specific block. In the landmark-guided technique, anatomical landmarks were identified by palpation based on surface anatomy and/or arterial pulsations. In the ultrasound-guided technique, the target nerve and surrounding structures were visualized prior to needle insertion, which was performed using an in-plane or out-of-plane approach. In both techniques, negative aspiration was performed to exclude intravascular placement. In ultrasound-guided blocks, a small test dose (1–2 mL) was initially administered to confirm correct needle positioning. The local anaesthetic was then injected incrementally, with ultrasound visualization used when applicable. All patients were monitored for clinical evidence of successful anaesthesia and for any procedure-related complications.

Outcome Measures

Primary Outcome Measures

Success rate of the nerve block: defined as the absence of pain or discomfort during surgery, without the requirement of supplementation.

Secondary Outcome Measures

- Time to block
- Number of needle passes
- Incidence of complications
- Patient satisfaction scores assessed using a Likert scale

Data Collection

Baseline variables were documented pre-procedure; on the other hand, immediate outcomes and vital signs were recorded intraoperatively and in the post-anaesthesia care unit.

Statistical analysis

Data were cleaned and entered into Microsoft Excel and analyzed using SPSS version 27 (IBM, NJ, USA). Descriptive statistics were used as appropriate. Continuous variables were expressed as mean ±standard deviation (SD), and categorical variables were presented as frequencies and percentages. Associations between variables were assessed using the chi-square test, and the independent t-tests were used to compare means between the two groups. Results from all analyses were considered statistically significant when the p-value was less than 0.05.

Received*: 02-04-2026 -* ***Accepted****: 01-06-2026 -* ***Published****: 08-06-2026*

Results

A total of 100 patients were involved in this study and were equally divided into two groups: Group US (Ultrasound-Guided) and Group LM (Landmark-Guided), each containing 50 patients. (Table 1) compares baseline characteristics between the landmark and ultrasound groups. Overall, it shows that the two groups are similar, with no statistically significant differences in any variable. The mean age of the ultrasound-guided group was slightly older, 51.42 ± 17.73 years, in comparison with the landmark-guided group, which was 45.52 ± 15.80 years, but this variation is not statistically significant (p = 0.08). The ultrasound group had a slightly higher mean weight (77.86 vs. 73.90 kg) and BMI (28.10 vs. 26.87), while both groups had identical mean height (1.66 m); however, none of these differences were statistically significant (p = 0.13, p = 1.00, and p = 0.30, respectively).

Table 1. Demographic Characteristics of Study Participants

Variable	Landmark (Mean ± SD)	Ultrasound (Mean ± SD)	p-value
Age (Years)	45.52 ± 15.80	51.42 ± 17.73	0.08
Weight (Kg)	73.90 ± 12.45	77.86 ± 13.62	0.13
Height (M)	1.66 ± 0.10	1.66 ± 0.12	1.00
BMI (kg/m²)	26.87 ± 4.97	28.10 ± 6.63	0.30

Statistical analysis using an independent t-test showed no significant difference between the two techniques (t = 0.000, p = 1.00), indicating equivalent effectiveness in achieving successful nerve blocks. The success rate of nerve block was similar between both techniques; however, the difference was not statistically significant (p = 1.00).

Table 2. Success Rate Descriptive Statistics

Variable	LM (Mean ± SD) N = 50	US (Mean ± SD) N = 50	t-test	P value
Success Rate (%)	0.915 ± 0.08	0.909 ± 0.09	0.000	1

Time to block

Block onset time

There was a notable and clinically significant difference in the onset time for the two techniques used to perform the block. The Ultrasound method showed a significantly quicker onset, with 42% of patients experiencing effects within five minutes or less. In contrast, the Landmark technique had a much longer onset time, with the majority of patients (76%) taking between 6 and 15 minutes to experience effects. This timeframe accounted for only 42% of the onset times observed with the Ultrasound technique, highlighting a distinct advantage in the speed of onset when using the Ultrasound approach.

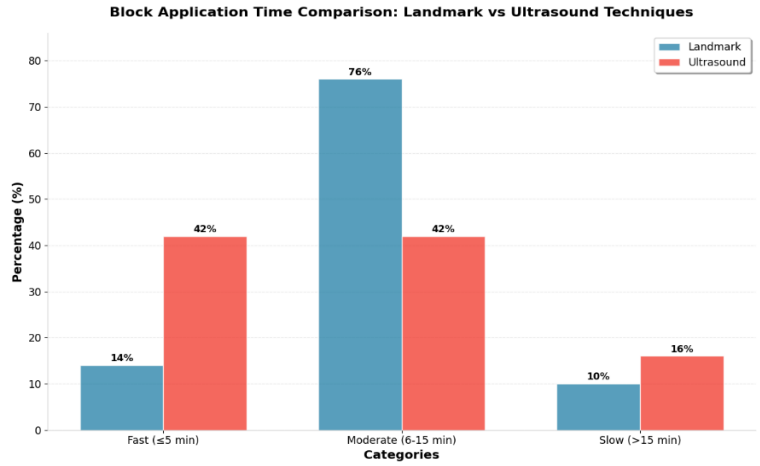

Figure 1. Comparison of block onset time between the Landmark and Ultrasound Groups

Duration of block anesthesia

The distribution of block duration categories revealed a potentially important clinical trend: The distribution of block duration categories revealed a potentially important clinical trend. In the UG, 66% of patients experienced anaesthesia lasting four hours or more (moderate to long duration). In contrast, the LMG was associated with a higher proportion of short-duration blocks (<4 hours), observed in 46% of patients in comparison to 34% in the UG. This observation suggests that, despite the absence of a statistically significant difference in mean duration, UG blocks may provide a more prolonged and consistent anaesthetic effect, potentially translating into improved clinical reliability and greater patient comfort.

Received*: 02-04-2026 -* ***Accepted****: 01-06-2026 -* ***Published****: 08-06-2026*

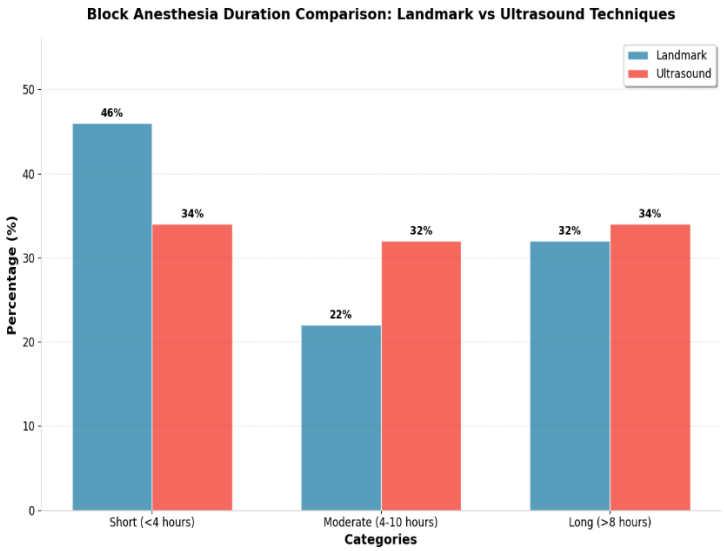

Figure 2. Duration of block anesthesia between the Landmark and Ultrasound Groups

Needle redirections in both groups

The number of needle redirections required during the procedure was significantly lower in the UG. This group required a mean of (1.68 ± 0.87) redirections, compared to (2.44 ± 0.84) in the LMG. This difference was highly statistically significant ($p < 0.001$). These results suggest that UG allows for more precise needle placement, reducing the need for redirections. This may contribute to a faster and more reliable onset of anaesthesia, likely due to improved visualization of needle position and local anaesthetic spread.

Table 3. Comparison of Landmark vs Ultrasound

Variable	Landmark Group (Mean ± SD)	Ultrasound Group (Mean ± SD)	P-value
Needle redirections	2.44 ± 0.84	1.68 ± 0.87	<0.001

The evaluation of complication incidence demonstrated a statistically significant advantage for the UG. The overall chi-square test confirmed a significant difference in complication profiles between the two groups ($x^2 = 29.13$, $p < 0.001$). Clinically, this finding is highly relevant. The UG showed a significantly higher proportion of complication-free procedures compared to the LMG (74% vs. 22%, $p < 0.001$). In addition, vascular complications were markedly lower in the UG (4% vs. 20%), and nerve-related complications were reduced (6% vs. 26%). Hematoma formation occurred in 10% of LMG procedures but was absent in the UG. Conversely, dyspnea or nausea was reported only in the UG (4%); however, this incidence was low and likely patient-specific. Overall, these findings support the use of UG as a safer and more precise technique for peripheral nerve blocks, significantly reducing the risk of major complications, including vascular puncture, nerve injury, and hematoma formation.

Table 4. Complication Profile Analysis

Complications	Group LMT	%	Group UGT	%	x^2	df	p-value
No complication	11	22%	37	74%	29.13	5	<0.001
Vascular issues	10	20%	2	4%			
Pain related	11	22%	6	12%			
Hematoma	5	10%	0	0%			
Nerve related	13	26%	3	6%			
Dyspnea or Nausea	0	0%	2	4%			

Patient satisfaction, assessed through a postoperative survey, was significantly higher in the UG ($p = 0.033$). In this group, 52% of patients reported being "very highly satisfied," compared to 24% in the LMG. Conversely, poor satisfaction was reported by 8% of patients in the UG versus 14% in the landmark group

Table 5. Distribution of satisfaction level (Likert scale)

Satisfaction Level	Group LMT	Group LMT %	Group UGT	Group UGT %	Chi-Square	df	p-value
Poorly Satisfied	7	14%	4	8%	8.74	3	0.033
Moderately Satisfied	12	24%	6	12%			
Highly Satisfied	19	38%	14	28%			
Very Highly Satisfied	12	24%	26	52%			

Received: *02-04-2026* - ***Accepted***: *01-06-2026* - ***Published***: *08-06-2026*

Discussion

The present randomized controlled trial compared the clinical efficacy and safety of the ultrasound-guided technique (UGT) and landmark technique (LMT) in patients undergoing orthopaedic surgery. The findings demonstrated that both techniques achieved comparable success rates, with no statistically significant difference between the groups. Nevertheless, UGT was associated with a shorter onset time for both sensory and motor blockade, a lower incidence of complications, and higher patient satisfaction than LMT. These findings add to the growing body of evidence supporting the clinical utility of ultrasound guidance in regional anaesthesia. Previous studies have reported higher success rates with UGT than with LMT [6, 7, 9, 10]. In contrast, the present study demonstrated comparable success rates between the two techniques. This finding may be attributable to the high level of operator experience and the use of standardized procedural protocols, which may have minimized differences in technical performance and contributed to the favourable outcomes observed in both groups.

The present study also demonstrated a significantly faster onset of sensory blockade and a prolonged duration of motor blockade in the UGT group compared with the LMT group. These findings are consistent with previous studies [6, 7, 10], which has suggested that real-time UGT enables more accurate deposition of local anaesthetic around the target nerve sheath, thereby enhancing block efficacy. Furthermore, it has been reported that UGT improves procedural safety by reducing the risk of inadvertent intramuscular or intravascular injection while facilitating more effective spread of the anaesthetic agent around neural structures. These mechanisms may explain the improved block characteristics observed in the UGT group. Patient safety is a fundamental principle of healthcare delivery and a key determinant of optimal clinical outcomes [11].

In the present study, no major complications were observed in either group, further supporting the overall safety of regional anaesthesia techniques. However, minor complications occurred exclusively in the LMT group, highlighting the potential safety advantages of UGT. These findings are consistent with multiple clinical studies demonstrating lower complication rates with UGT [10, 12]. In contrast, a study [7] reported similarly low complication rates in both groups, suggesting that operator expertise and procedural experience may substantially influence safety outcomes irrespective of the technique employed. Patient satisfaction was significantly greater in the UGT group than in the LMT group. This finding may be attributed to improved analgesic efficacy, fewer needle redirections, and reduced procedural discomfort associated with ultrasound guidance. The present results are consistent with previous studies demonstrating that UGT improves patient comfort and procedural efficiency (6, 7, 10).

Similarly, Vastrad et al [13] reported that UGT reduced the number of needle passes and enhanced overall procedural performance. Taken together, the findings of the present study indicate that UGT offers several procedural and clinical advantages over the conventional landmark technique, including a faster onset of blockade, fewer minor complications, and greater patient satisfaction, while maintaining comparable success rates. These results support the growing evidence that ultrasound-guided regional anaesthesia can enhance procedural precision, efficiency, and patient-centred outcomes when performed by appropriately trained practitioners.

Limitations

Despite the multicentre design and inclusion of a range of orthopaedic procedures, several limitations should be acknowledged. The sample size was relatively small, which may have limited the ability to detect differences in some outcomes. In addition, operator experience was not formally assessed, although it may have influenced procedural performance, complication rates, and block characteristics. Furthermore, long-term postoperative outcomes were not evaluated, limiting the assessment of the sustained clinical benefits of the two techniques.

Conclusion

The findings of this randomized controlled trial demonstrated that both the UGT and LMT achieved comparable block success rates in patients undergoing orthopaedic surgery. However, UGT was associated with a faster onset of sensory and motor blockade, fewer minor complications, reduced needle redirections, and higher patient satisfaction. These advantages are likely attributable to the real-time visualization of anatomical structures, which facilitates more accurate needle placement and local anaesthetic deposition. Collectively, the findings support the growing body of evidence that UGT can enhance the precision, efficiency, and safety of regional anaesthesia. Therefore, UGT may be considered a valuable approach for optimizing procedural and patient-centred outcomes in orthopaedic surgical practice.

Recommendations

Further large-scale multicentre studies with standardized operator training and cost–benefit analyses are recommended to confirm these findings and support the integration of UGT into standard clinical practice guidelines. Further large-scale multicentre randomized controlled trials are warranted to validate these findings and assess their applicability across diverse clinical settings. Future studies should incorporate standardized operator training, evaluation of learning curves, long-term postoperative outcomes, and cost-

Received*: 02-04-2026 -* ***Accepted****: 01-06-2026 -* ***Published****: 08-06-2026*

effectiveness analyses to provide a more comprehensive assessment of the role of ultrasound-guided regional anaesthesia and to inform future clinical practice guidelines.

Conflict of interest. Nil

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Received: *02-04-2026* - ***Accepted***: *01-06-2026* - ***Published***: *08-06-2026*