Journal of Pain Research

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ORIGINAL RESEARCH

The Analgesic Effect of Infraspinatus Teres Minor Block in Scapular Fracture Surgery: A Randomized Controlled Trial

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Background: The purpose of this study was to evaluate the analgesic effect of infraspinatus teres minor (ITM) block in scapular fracture (SFs) surgery.

Materials and Methods: A prospective, randomized, controlled trial was carried out on patients undergoing SFs surgery. These patients were randomly allocated to either receive an ultrasound-guided ITM block in conjunction with general anesthesia (ITM group) or a sham intervention along with general anesthesia (Sham group). The primary outcome measure was the postoperative pain intensity evaluated by the visual analog scale (VAS) at 0.5, 2, 6, 12, 24, and 48 hours after surgery. Secondary outcome measures included intraoperative opioid utilization, postoperative analgesic needs, the time to the first rescue analgesia, QoR-15 scores, and alterations in diaphragmatic activity.

Results: The ITM group showed significantly lower VAS_{pain} AUC within 48 hours postoperatively than the Sham group ($P = 0.009$). Repeated-measures two-way ANOVA revealed a significant group × time interaction for VAS_{pain} changes ($F_{5,350} = 10.39$, $P < 0.001$). VAS_{pain} was significantly lower in the ITM group at 0.5, 2, 6, 12, and 24 hours (all $P < 0.001$), but not at 48 hours ($P = 0.232$). Intraoperative sufentanil consumption was significantly lower in the ITM group ($P < 0.001$). Rescue analgesic use was also reduced in the ITM group within 24 hours ($P = 0.007$) and 48 hours ($P = 0.012$). The time to first rescue analgesia request was longer in the ITM group (*log-rank, HR* = 1.629; 95% *CI*: 1.104–2.583; $P = 0.005$). QoR-15 scores were higher in the ITM group at 24 hours ($P = 0.025$) and 48 hours ($P < 0.001$). No significant difference was observed in ipsilateral diaphragm function between groups ($P = 0.113$).

Conclusion: The ITM block demonstrates significant analgesic effectiveness in scapular surgery and holds promise for broader application.

Trial Registration: The study was registered with the Chinese Clinical Trial Registry (www.chictr.org.cn) on December 9, 2024, under registration number ChiCTR2400093589.

Keywords: scapular fracture, infraspinatus-teres minor block, analgesic effect, surgery

Introduction

Scapular fractures (SFs) typically arise from traumatic injuries and commonly manifest as edema, pain, and functional impairment in the posterolateral region of the shoulder.[1] Though less prevalent than other fractures, SFs hold clinical significance and may lead to significant distress if not managed properly. Surgical intervention is preferred for extensive displacement or comminuted fractures.[2]

The optimal analgesic regimen for patients undergoing surgical fixation of SFs has not been established. Currently, in clinical practice, surgical procedures predominantly employ general anesthesia alone.[3] Effective pain management for SFs continues to be challenging because of the intricate anatomical structures involved, such as the suprascapular nerve, axillary nerve, and lateral pectoral nerve.[3] At present, multimodal analgesic strategies are extensively utilized in clinical

https://doi.org/10.2147/JPR.S605358
Received: 26 February 2026
Accepted: 28 May 2026
Published: 2 June 2026

practice, which include pharmacological interventions like non-steroidal anti-inflammatory drugs (NSAIDs), opioids, and acetaminophen, as well as regional anesthetic techniques.[4]

Regional block has been proven to be an effective combined analgesic approach that can effectively alleviate the pain of surgical patients, reduce complications, and promote patient recovery.[5] However, in the analgesic practice of SFs, only a few types of nerve block methods have been applied, such as suprascapular nerve block, brachial plexus nerve block, dorsal scapular nerve block, and rhomboid muscle block.[6–9] Recent anesthesia literature has reported successful pain control achieved through targeted sonographic-guided approaches, such as the thoracic segmental spinal anesthesia (TSSA), in shoulder and scapular surgeries, but controversy still persists.[10,11] None of these nerve block techniques can achieve an optimal analgesic effect, and there is a potential risk of inducing side effects such as phrenic nerve block. Therefore, it is of great necessity to explore a more efficient and safe nerve block method and apply it to the analgesic process of scapular fracture surgery.

The infraspinatus-teres minor (ITM) block shows promise in managing shoulder analgesia and is a technique for achieving combined suprascapular and axillary nerve blockade.[4,12] Theoretically, the ITM block could potentially offer specific analgesic effects on the scapula by blocking the suprascapular and axillary nerves.

This randomized controlled trial investigates the efficacy of the ITM block as an adjunct to general anesthesia in significantly lowering postoperative pain scores, reducing opioid requirements, and enhancing postoperative recovery. This study seeks to address the current gap in regional anesthesia approaches for scapular surgery by providing evidence-based justification for incorporating ITM blocks into clinical practice, thereby improving postoperative patient recovery and enhancing surgical comfort.

Methods

This study adopted a prospective, double-blind, randomized controlled trial design in accordance with the most recent version of the Declaration of Helsinki, as approved by the World Medical Association during the 75th World Medical Assembly held in Helsinki, Finland, in October 2024.[13] The work has been reported in line with the CONSORT criteria.[14] Ethical approval for this study was granted by the Ethics Committee on June 6, 2024 (Approval No. 2024–47). The study was registered with the Chinese Clinical Trial Registry (www.chictr.org.cn) on December 9, 2024.

Patient Enrollment

Patients who were eligible for internal fixation of SFs were enrolled in the study at a large-scale trauma center between January 1, 2025, and October 31, 2025. Patients scheduled for surgical fixation of scapula fractures were randomly assigned to receive either an ultrasound-guided ITM block combined with general anesthesia (ITM group) or a sham intervention along with general anesthesia (Sham group).

Inclusion criteria: 1) Full understanding of the study and provision of voluntary informed consent; 2) Age between 18 and 65 years (inclusive); 3) American Society of Anesthesiologists (ASA) physical status classification I to III; 4) Body mass index (BMI) within the range of 18.5–30.0 kg/m^2. Exclusion criteria: 1) Participation in other clinical intervention trials; 2) Known contraindications to nerve blocks or medications used in this study; 3) Presence of communication difficulties or cognitive impairments that may affect comprehension or compliance; 4) Diagnosed psychiatric disorders requiring treatment; 5) Severe multiple trauma or critical illness (such as combined craniocerebral injury, hemodynamic instability, the need for ventilator support, and fractures in other parts requiring surgery). Elimination criteria: 1) Failure to achieve a successful nerve block puncture (If the puncture has been performed more than three times and the target position has not been reached, or if the target structure cannot be identified by ultrasound because of the patient's body shape or anatomical variations); 2) Voluntary withdrawal of consent by the participant; 3) Loss to follow-up during the study period; 4) Occurrence of severe surgical complications rendering further participation unfeasible; 5) Requirement for reoperation within a short interval after initial surgery.

Randomization and Blinding

This study employed a computer-generated random number table to allocate participants into separate groups, guaranteeing an impartial and equitable distribution procedure. To further safeguard the allocation sequence and

preclude any possible selection bias, the concealed envelope method was strictly executed, thus upholding the integrity and objectivity of the group assignment throughout the entire study. The random numbers were generated by an independent researcher who had no involvement in patient assessment or treatment to guarantee the fairness and unpredictability of the randomization procedure. Patients were randomly allocated to the ITM group or the Sham group at a 1:1 ratio.

Throughout the study, a double-blind design was implemented, indicating that neither the patients nor the researchers directly involved in the study knew the group allocations. The anesthesiologists responsible for conducting the nerve block and administering anesthesia were also unaware of the group's details. All injection medications were prepared by a nurse not participating in the study, and any identifiable information was masked. The doctors who carried out the nerve block did not take part in subsequent anesthesia management or postoperative data collection. The anesthesiologists performing the anesthesia were also uninformed of the group allocations. All outcome assessments were conducted by blinded research personnel who were not involved in the intervention delivery, utilizing standardized protocols to ensure consistency.

Anesthesia and Remedial Analgesia

In this study, to ensure the reliability and generalizability of the results, general anesthesia was induced in all enrolled patients using a standardized protocol. This involved the administration of intravenous propofol (2 mg/kg) and sufentanil (0.3 μg/kg) for induction, followed by maintenance with sevoflurane (1% to 2%) in an oxygen-air mixture. Muscle relaxation was achieved with rocuronium (0.6 mg/kg) to facilitate intubation.

For patients in the ITM group, an ultrasound-guided ITM block was performed after the induction of general anesthesia but before the surgical incision. In contrast, patients in the Sham group received a sham intervention that mimicked the procedural aspects of the ITM block by administering normal saline.

Throughout the procedure, hemodynamic parameters, including heart rate, blood pressure, and oxygen saturation, were continuously monitored. Intraoperative intraoperative pain was assessed by the anesthesiologist based on the patient's hemodynamic indicators. Additional sufentanil 0.1 μg/kg was given incrementally when the patient's heart rate or mean arterial pressure increased by more than 20% of the baseline value after skin incision. No other analgesics were used intraoperatively except sufentanil. Patients were transferred to the post-anesthesia care unit for structured recovery and close observation after surgery.

No baseline analgesic drugs were routinely administered to all patients during the perioperative period. When the patient's visual analog scale for pain (VAS_{pain}) is ≥ 4, the nurse will administer 5 mg of dezocine via intramuscular injection for rescue analgesia. If the pain is not alleviated after 15 minutes, the administration can be repeated once. The total dose should not exceed 15 mg within 4 hours. Alternatively, parecoxib sodium can be used in combination (5 mg dezocine is equivalent to 40 mg parecoxib sodium).

Ultrasound-Guided ITM Block

All blocks were carried out by seasoned anesthesiologists skilled in regional anesthesia techniques. Following sterile skin preparation and draping, a linear high-frequency ultrasound transducer (8–15 MHz) was positioned transversely across the posterior shoulder region (The midpoint of the line that connects the greater tubercle of the humerus and the inferior angle of the scapula, which is parallel to the posterior midclavicular line).[12] The target site was the plane situated between the infraspinatus and teres minor muscles, which was identified by visualizing the hyperechoic fascial plane, which lies deep to these muscles yet superficial to the underlying scapula. Employing an in-plane technique, a 22-gauge, 80-mm insulated needle was carefully advanced under real-time ultrasound guidance toward the targeted fascial plane. After confirming negative aspiration, 30 mL of 0.375% ropivacaine was gradually injected (The sham group was injected with saline), with meticulous visualization employed to verify the distribution of the local anesthetic within the fascial plane encompassing the suprascapular and axillary nerves. Successful spread was characterized by the separation of the fascial layers and fluid distribution enveloping the target nerves (Figure 1).

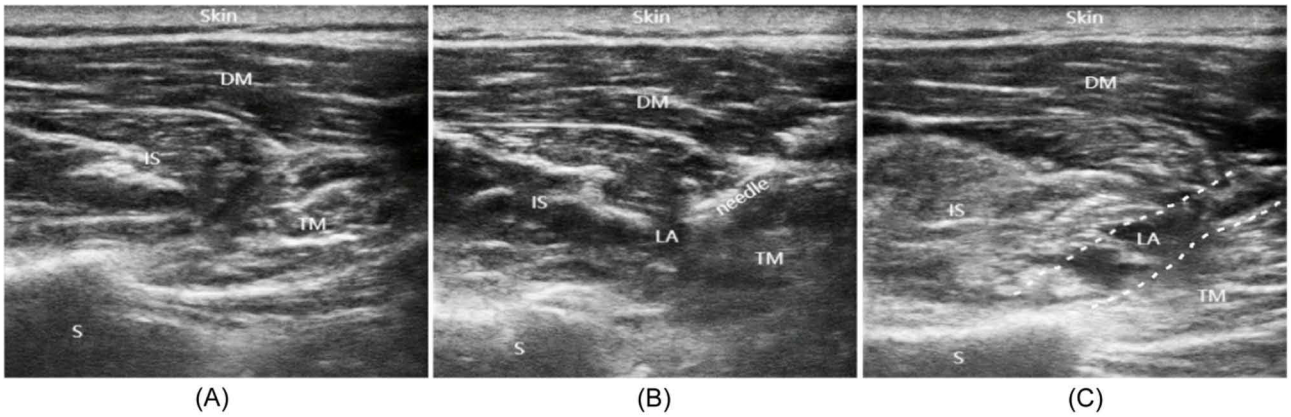

Figure 1 Ultrasound image demonstrating the ultrasound-guided infraspinatus-teres minor fascia plane block. (**A**) The fascial plane between the infraspinatus and teres minor was identified before block placement. (**B**) Local anesthetics were administered via a nerve block needle using the interfascial approach, with injections directed from caudal to cranial. The local anesthetic diffused within the interfascial space, partially reaching the surface of the scapula. (**C**) The distribution of local anesthetic post blockade is shown.

Abbreviations: DM, deltoid muscle; IS, infraspinatus muscle; TM, teres minor muscle; S, scapula bone; LA, local anesthetic.

Outcomes

The baseline information, including age, gender, BMI, ASA classification, surgical side, and operation time, was recorded for the two groups of patients. The primary outcome was the area under the curve (AUC) of VAS_{pain} at each time point (0.5, 2, 6, 12, 24, and 48 hours) within 48 hours after surgery. The AUC was calculated using Graphpad Prism software by the trapezoidal method. Specifically, the VAS_{pain} at each time point was directly connected to calculate the total area under the curve. Moreover, in case a VAS_{pain} is missing at a certain time point, the last observed value was carried forward for processing, and a sensitivity analysis was conducted to verify the robustness of the results.

The secondary outcome was VAS_{pain} at each time point, opioid consumption during the operation, postoperative analgesia, the dosage of administered analgesics, the time to the first rescue analgesia request, and recovery quality score, and alterations in diaphragmatic activity. In addition, the anesthesia-related complications included in the study (such as puncture bleeding or infection, postoperative nausea and vomiting, etc.) were also meticulously recorded.

Measurement of diaphragmatic excursion via ultrasound: Prior to and following the patient's surgery, a portable ultrasound diagnostic device equipped with a low-frequency convex array probe (2−5 MHz) was utilized. The patient was placed in a supine position, and the probe was positioned at the affected side of the patient's diaphragm. M-mode ultrasound was utilized to record the diaphragmatic motion curve, and the maximum disparity in diaphragmatic displacement at the end of inspiration and expiration was measured. Three consecutive measurements were conducted, and the mean value was adopted as the final measurement outcome (Figure 2).[15]

Statistics

Sample size calculation was performed using G-Power software (version 3.1, Germany). Based on pre-experimental data, the mean difference (MD) in the AUC of VAS_{pain} between the ITM and Sham groups was $\Delta\mu = 12.8$, pooled standard deviation = 15.46. The calculated Cohen's d effect size was 0.83. An a priori power analysis, conducted with a significance level (α) of 0.05 (two-tailed) and a statistical power of 90%, indicated that a sample of 32 participants per group would be sufficient for an independent samples *t*-test. To accommodate a potential 20% dropout rate, the final sample size was adjusted to 40 participants per group, leading to a total enrollment of 80 patients.

Statistical analyses were performed using SPSS software (version 26.0; IBM, NY, USA). Continuous variables are expressed as mean ± standard deviation (SD) or median (interquartile range), depending on their distribution, while categorical variables are presented as frequencies and percentages. The Shapiro–Wilk test was used to assess the normality of continuous variables. For variables that were normally distributed, the independent samples *t*-test was applied to compare differences between the two groups. In situations where the continuous variables did not exhibit a normal distribution, the Mann–Whitney *U*-test was implemented. Categorical variables were compared using the chi-

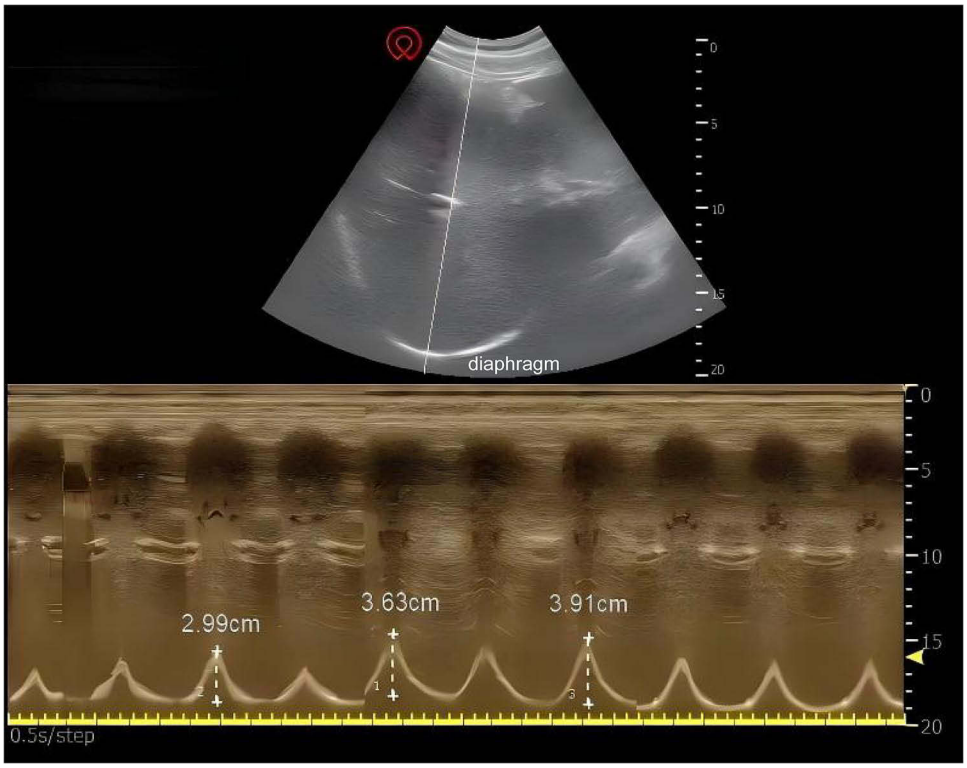

Figure 2 Illustrates the ultrasonic examination method for assessing diaphragmatic mobility. Utilizing M-mode ultrasound, the diaphragmatic motion wave is captured, with the peak height of the wave corresponding to the amplitude of diaphragmatic movement. To ensure accuracy, the average value is derived from three separate measurements.

square test or Fisher's exact test, as appropriate. Additionally, for postoperative pain intensity measured by the VAS_{pain} at different time points, a repeated-measures analysis of variance (ANOVA) was conducted to assess the overall differences between the groups over time. If the sphericity assumption was violated, the Greenhouse-Geisser correction was applied. The Bonferroni correction was applied to adjust for multiple comparisons. Statistical significance was defined as $P < 0.05$ for all analyzes.

Results

A total of 80 patients were enrolled in the study. During the study period, data from three patients were lost due to follow-up discontinuation caused by condition changes (two in Sham group and one in ITM group), four patients failed to complete the full follow-up due to early reoperation (three in Sham groups and one in ITM group), and one patient voluntarily withdrew in Sham group. Ultimately, complete data from 72 patients were included in the statistical analysis (Figure 3).

Baseline characteristics showed no statistically significant differences between the two groups in terms of age, gender, BMI, ASA classification, surgical side, operation time, complication, and preoperative VAS_{pain} score (all $P > 0.05$, Table 1).

The primary results showed that, compared with the Sham group, the AUC of VAS_{pain} within 48 hours post-operatively was significantly reduced in the ITM group (10.95 ± 1.17 vs. 16.41 ± 1.71, $t = 2.687$, $P = 0.009$). The repeated measures two-way ANOVA results indicated that there was a group × time interaction effect on the VAS_{pain} change trend between the two groups ($F_{5,\ 350} = 10.39$, $P < 0.001$). Post-hoc Bonferroni analysis showed that, compared with the Sham group, VAS_{pain} at 0.5 hours, 2 hours, 6 hours, 12 hours, and 24 hours postoperatively were significantly lower in the ITM group (all $P < 0.001$), with MDs being 2.23, 1.07, 1.05, 1.04, and 1.01, respectively. At 48 hours, there was no statistically significant difference in VAS_{pain} between the two groups ($P = 0.232$), with a MD of 0.35 (Figure 4).

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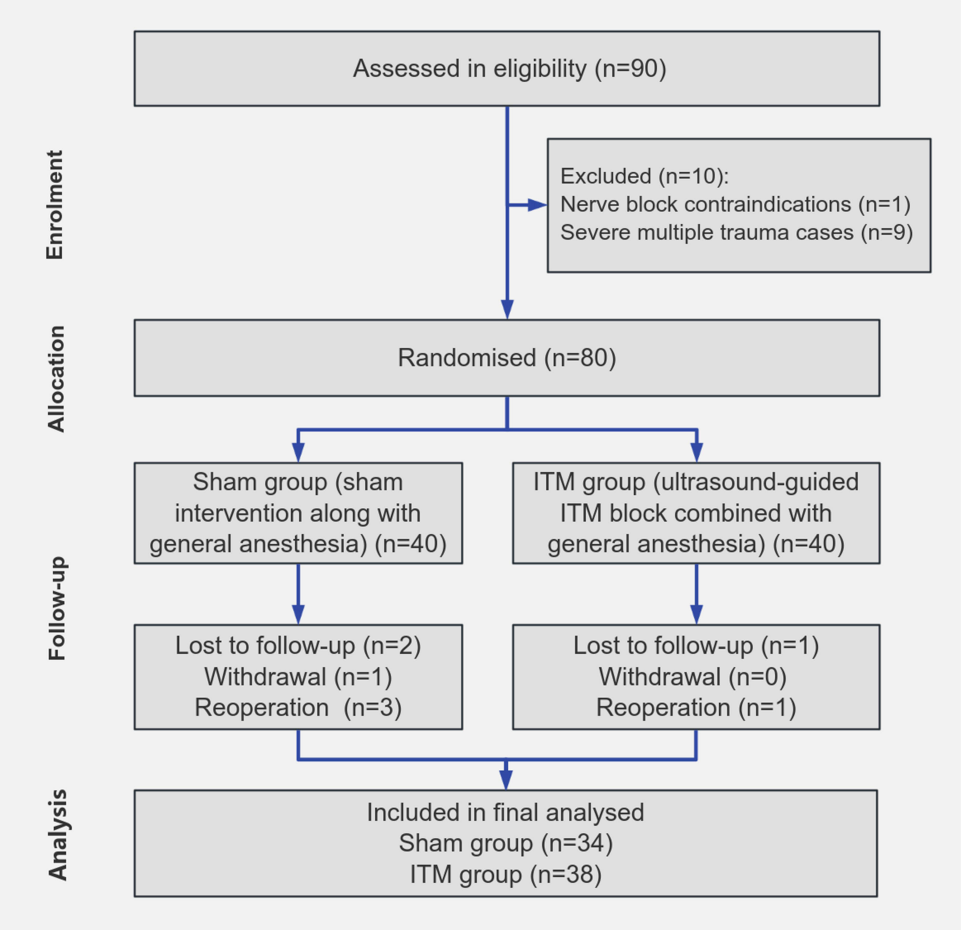

Figure 3 Consort Flowchart.
Abbreviation: ITM, Infraspinatus Teres Minor.

For secondary outcomes, compared with the Sham group, the intraoperative sufentanil consumption was significantly reduced in the ITM group (Welch-corrected $t = 5.005$, $P < 0.001$). Compared with the Sham group, the consumption of rescue analgesic (dezocine) within 24 hours ($t = 2.775$, $P = 0.007$) and 48 hours ($t = 2.588$, $P = 0.012$) postoperatively was significantly decreased in the ITM group. The time to first rescue analgesia demand was prolonged in the ITM group compared with the Sham group (*log−rank, HR* = 1.629, 95% *CI*, 1.104 − 2.583, $P = 0.005$). Compared with the Sham group, the QoR-15 scores at 24 hours ($t = 2.284$, $P = 0.025$) and 48 hours ($t = 3.799$, $P < 0.001$) postoperatively were significantly increased in the ITM group, with MDs being 12.44 and 18.33 (Figure 5).

Table 1 Baseline Characteristics

	Sham (n = 34)	**ITM (n = 38)**	χ^2/t	***P***
Age (years, mean ± SD)	50.53 ± 12.67	50.32 ± 9.44	0.08	0.94
Gender, n (%)			2.85	0.09
Male	31 (91.2)	29 (76.3)		
Female	3 (8.8)	9 (23.7)		
BMI (kg/m^2, mean ± SD)	24.03 ± 3.06	24.54 ± 2.34	0.81	0.42
ASA Classification (I/II/III)	6 / 25 / 3	3 / 34 / 1	3.16	0.21

(*Continued*)

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Table 1 (Continued).

	Sham (n = 34)	ITM (n = 38)	χ^2/t	*P*
Surgical side, n (%)			0.77	0.38
Left	18 (52.9)	24 (63.2)		
Right	16 (47.1)	14 (36.8)		
Operation time (min, mean ± SD)	80.29 ± 22.49	71.97 ± 18.51	1.72	0.09
Complication, n (%)			1.77	0.65*
Rib fracture	4 (11.8)	3 (7.9)		
Hemothorax/Pneumothorax	2 (5.9)	3 (7.9)		
Pulmonary contusion	3 (8.8)	1 (2.6)		
Preoperative VAS_{pain} score (cm, mean ± SD)	4.4 ± 1.5	4.1 ± 1.4	0.81	0.42

Note: *Fisher's exact test.
Abbreviations: BMI, Body Mass Index; ASA, American Society of Anesthesiologists; SD, standard deviation; ITM, Infraspinatus Teres Minor; VAS, Visual Analogue Scale.

The assessment of the patient's ipsilateral diaphragm revealed that, although diaphragmatic excursion in the Sham group decreased slightly after surgery compared to before, there was no statistically significant difference between the two groups (median 0.89 vs. 0.92, $P = 0.113$) (Figure 6).

During the study period, neither group experienced any study-related adverse events, such as puncture site infection, bleeding, or nerve injury.

Discussion

Recently, various analgesic strategies have been utilized for the management of scapular fractures globally, ranging from systemic pharmacotherapy to regional anesthetic techniques. Traditional approaches include NSAIDs, acetaminophen, and opioid-based analgesia, while ultrasound-guided nerve blocks have gained popularity due to their targeted efficacy and reduced systemic side effects.[3–9] Despite these options, no consensus exists on the optimal analgesic regimen for surgical fixation of scapular fractures, highlighting the need for further investigation.

This study, for the first time, experimentally demonstrates that ultrasound-guided ITM block offers significant analgesic benefits during the early postoperative period. The observed decline in pain intensity within the initial 24 hours post-surgery, coupled with the reduced consumption of opioids and the extended duration until the first rescue analgesia, suggests effective pain management through ITM block. Moreover, this study reveals that the ITM block is

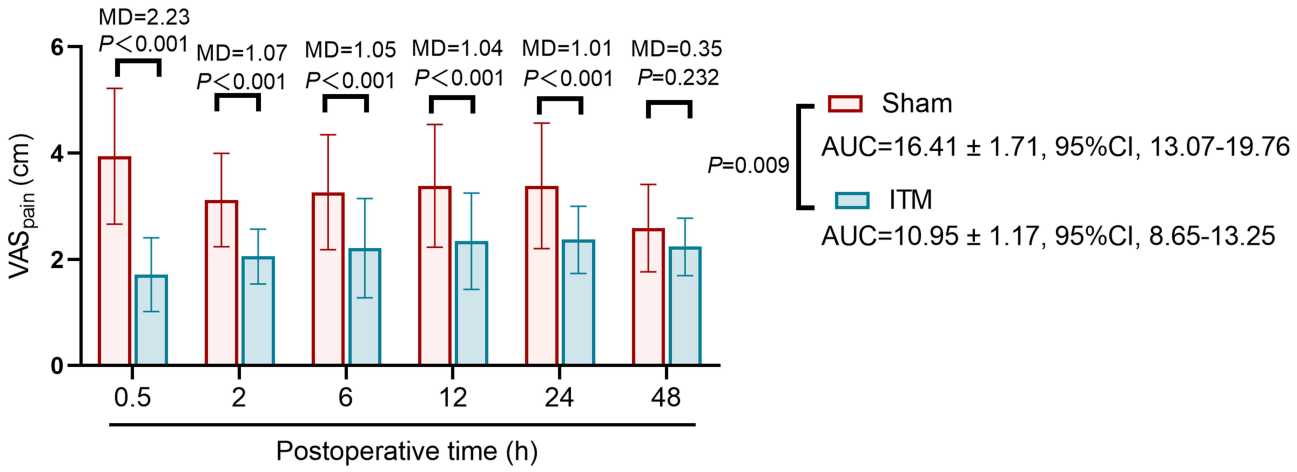

Figure 4 The pain levels in both patient groups at each postoperative time point (0.5 h, 2 h, 6 h, 12 h, 24 h, and 48 h) were assessed using the VAS_{pain}. The area under the VAS_{pain} curve and the individual VAS_{pain} at each time point were compared between the two groups. $P < 0.05$ indicates a statistically significant difference.
Abbreviations: ITM, Infraspinatus Teres Minor; VAS, Visual Analog Scale; MD, Mean Difference; AUC, Area Under the Curve.

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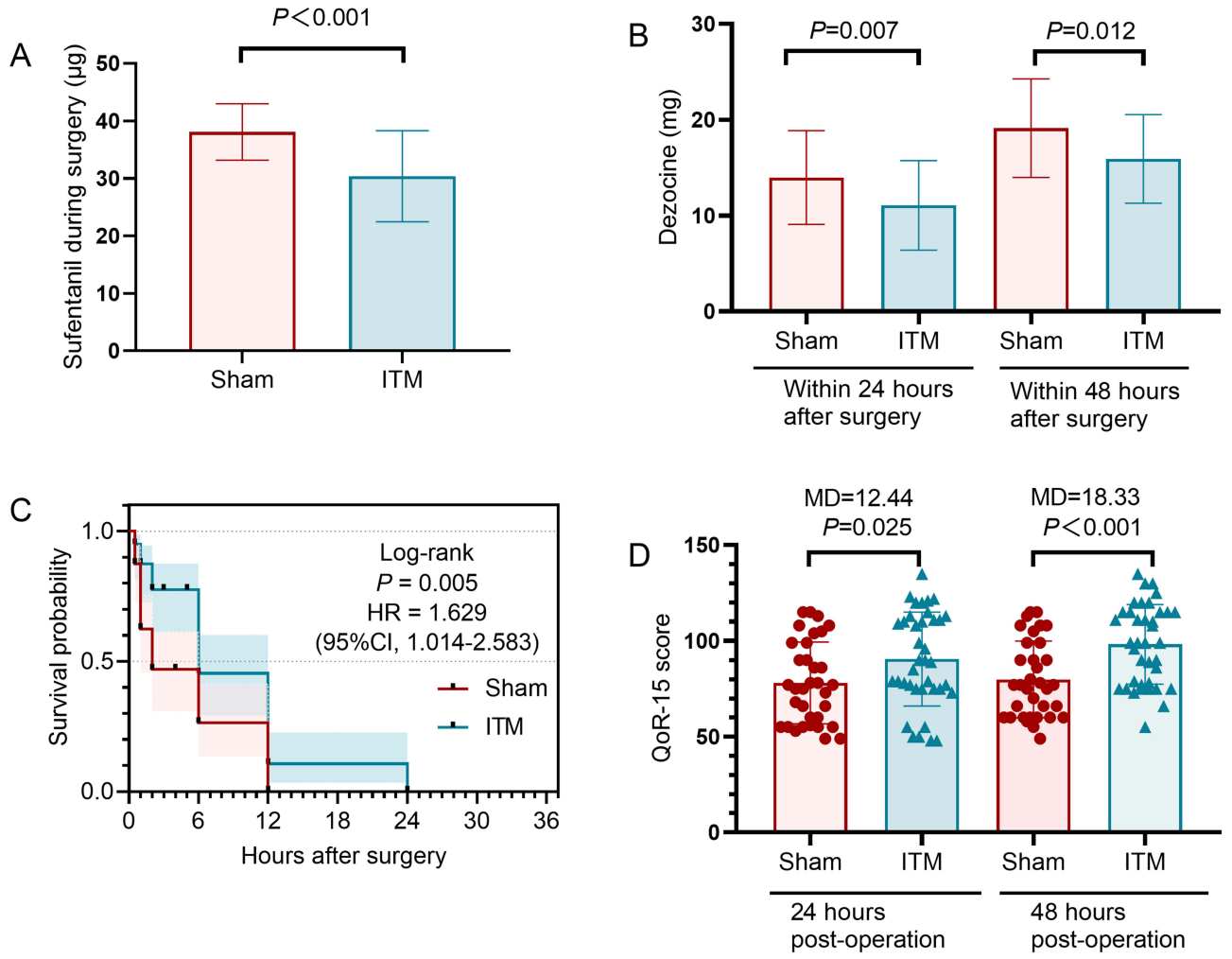

Figure 5 Secondary outcomes. (**A**) Comparison of sufentanil usage during surgery between the two groups of patients. (**B**) Comparison of rescue analgesic drug usage within 24 hours and 48 hours after surgery between the two groups of patients. (**C**) Survival curve analysis of the time when the two groups of patients first sought rescue analgesia. (**D**) Comparison of recovery quality 24 hours and 48 hours after surgery between the two groups of patients.
Abbreviations: ITM, Infraspinatus Teres Minor; MD, Mean Difference; QoR, Quality of Recovery.

advantageous for the early postoperative recovery of patients undergoing scapular fracture surgery, has no impact on diaphragmatic movement, and exhibits high safety.

These findings are consistent with prior studies emphasizing the effectiveness of regional anesthesia techniques in providing perioperative pain relief.[16,17] Regional block, by blocking the conduction pathway of specific nerves, effectively alleviates pain sensation in the surgical area. Compared with intravenous analgesia and other methods, it has definite therapeutic effects, a long duration of action, fewer side effects, and facilitates patients' postoperative recovery and early mobilization.[16]

The efficacy of the ultrasound-guided ITM block can be ascribed to its distinctive mechanism of action. The sensation in the scapular surface and associated skin areas is primarily mediated by four nerves: the suprascapular, dorsal scapular, posterior medial branch of the thoracic, and axillary nerves.[3,18] The ITM block aims at the suprascapular nerve and axillary nerves that innervate the scapular area, which play a vital role in transmitting pain signals from the surgical site.[3,12,19] By obstructing these nerves, the ITM block can effectively disrupt the pain pathway, resulting in a diminished pain perception. Furthermore, this study found that during the injection process, local anesthetic agents may diffuse through the surface gap of the scapula to reach the fracture sites and produce a local anesthetic effect. This mechanism may extend the scope of the ITM block beyond the innervation area of the suprascapular nerve and axillary nerve,

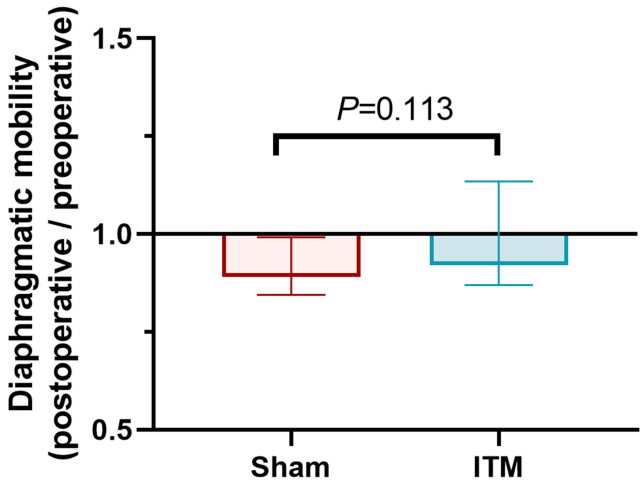

Figure 6 Comparison of the changes in the movement amplitude of the affected diaphragm before and after surgery between the two groups of patients. $P < 0.05$ indicates a statistically significant difference.
Abbreviation: ITM, Infraspinatus Teres Minor.

augmenting its efficacy, while simultaneously elevating the risk of infection. Consequently, greater attention should be paid to aseptic manipulation.

Similar to other efficacious regional blocks, the diminution in opioid consumption also represents a notable advantage of the ITM block.[20] In the comparison between the ITM group and the Sham group, the significant reduction in intraoperative sufentanil consumption is a remarkable finding. Sufentanil is a potent opioid analgesic, and its reduced use not only implies a lower risk of opioid-related side effects, such as respiratory depression, nausea, and vomiting, but also helps to avoid potential opioid tolerance and addiction issues.[21] Similarly, the reduced postoperative consumption of rescue analgesics further validates the long-lasting analgesic effect of the ITM block. The extended time to the first rescue analgesia further supports the efficacy of the ITM block. This indicates that the block can sustain pain control over a longer period, reducing the frequency of additional analgesic use and potentially enhancing patient comfort.[22]

However, this study reveals that 48 hours after the operation, there was no significant difference in pain scores between the two groups. This suggests that the effect of a single ITM block is limited to the early postoperative period. As time progresses, its analgesic effect gradually fades. This also suggests that, in clinical practice, for patients undergoing scapular fracture surgery who require longer-lasting analgesia, it may be necessary to consider continuous block or combination with other analgesic methods.[23] Previous studies have explored the feasibility of continuous ITM block, but further clinical verification is still needed.[12]

In clinical research, the minimal clinically important difference (MCID) is of great significance as it helps clinicians determine whether the treatment effect has actual clinical value.[24] This study found that at each time point within 24 hours post-operation, the MD of VAS_{pain} scores between the two groups of patients exceeded 1.0, which is above the MCID for VAS_{pain} scores.[20,24] This shows that ITM block not only has statistical significance in reducing patient pain but also has actual clinical significance.

The improvement in the QoR-15 scores in the ITM group also indicates that patients in this group experienced a better quality of recovery.[25] This includes aspects such as physical comfort, psychological well-being, and the ability to resume normal activities.[25] A higher quality of recovery is associated with shorter hospital stays, lower healthcare costs, and greater patient satisfaction.[26] This study found that the quality of recovery of patients in the ITM group was higher at both 24 and 48 hours after surgery, with the difference being more pronounced at 48 hours. This suggests that, after a certain period of recovery, the benefits of ITM block become more evident, likely because its early analgesic effect provides favorable conditions for the body's recovery and minimizes the interference of pain in the recovery process.[27–31] A lower pain level allows patients to perform necessary limb movements more easily, thereby promoting blood circulation and metabolism, which is beneficial for the healing of the fracture site and the recovery of muscle function.

https://doi.org/10.2147/JPR.S605358

The reduced use of opioids effectively reduces related complications such as drowsiness, nausea, and vomiting, further facilitating patient recovery.[27–31] At the same time, psychological comfort is enhanced, and patients no longer experience anxiety and irritability due to pain, allowing them to face the postoperative recovery process with a more positive attitude, which is crucial for psychological adjustment and rehabilitation. The study also found that the MD of QoR-15 scores in both groups was greater than its MCID (8.0), indicating that this advantage has clinical significance.[20,27–31]

Compared to other traditional blockade methods, the ITM block demonstrates a comparable analgesic effect in scapular fracture surgery, providing a similar degree of pain relief. A significant advantage of the ITM block over direct suprascapular nerve block and dorsal scapular nerve block is its wider coverage, which can more comprehensively block the transmission of pain signals.[8] In addition, the incidence of nerve injury with ITM block is relatively low, reducing potential nerve damage during the operation. However, this block method also exhibits certain drawbacks, primarily reflected in the requirement for a greater volume of local anesthetic. In comparison to brachial plexus block, ITM block demonstrates a higher success rate in blocking the suprascapular nerve and more effectively intercepts the pain signals transmitted by this nerve. Meanwhile, ITM block circumvents the potential impact on diaphragmatic function caused by brachial plexus block, thereby reducing the risk of postoperative respiratory complications, which is of great significance for patients' postoperative recovery.[8] Compared with epidural analgesia and thoracic paravertebral block, ITM block presents less difficulty and is associated with fewer complications.[32–34] Finally, in comparison with rhomboid muscle block and erector spinae plane block, the coverage area of ITM block does not conflict with those of these two block methods; instead, it can produce a complementary effect.[6,18,33–37] In actual clinical applications, these block methods can be flexibly selected or used in combination according to the specific conditions of patients and surgical requirements, so as to achieve the best analgesic effect and the least side effects.[7]

The absence of diaphragmatic movement in the ITM block constitutes a critical safety advantage. This study revealed that postoperative diaphragmatic mobility in both patient groups showed a slight decrease compared to preoperative levels. This may be attributed to changes in respiratory rhythm resulting from surgical trauma and pain, or potentially residual anesthetic effects.[38] Notably, this reduction was minor and probably not clinically significant. No diaphragmatic movement differences were observed between the ITM and Sham groups, confirming that ITM block has no effect on diaphragmatic function.[15,38] Diaphragmatic function is essential for normal breathing, and any impairment can lead to respiratory complications, especially in patients who are already in a vulnerable post-operative state.[15] The high safety profile of the ITM block, with no study-related adverse events, makes it a reliable option for clinical use, especially compared to the commonly used brachial plexus block.[8]

This study ultimately verified that no complications related to ITM block were found during the process. This indicates that it is very safe. There are fewer large blood vessels on the puncture path of ITM block, so the probability of bleeding and hematoma is very low.[3] Owing to the obstruction by the scapula, the likelihood of pneumothorax is also relatively low. And because it does not directly puncture the nerve, the risk of nerve injury is relatively low. The only concern is the infection at the puncture site, as the puncture point is close to the surgical incision, and the local anesthetic may spread to deeper layers. In this study, no infection cases were identified, suggesting that the infection risk can be controlled with standardized operation.[39] In addition, effective and opioid-independent analgesia may reduce anesthesia-related complications such as nausea and vomiting. However, this study did not conduct a more in-depth comparison in this regard. Future research can further explore the specific effects and advantages of ITM block in reducing anesthesia-related complications.[21]

Regarding the improvement of the blocking technique, there is still room for further exploration of the specific operation methods and drug dosages of ITM block at present. The differences in the effects of local anesthetics with different concentrations and volumes in ITM block can be studied to identify the most optimized drug administration plan, ensuring the analgesic effect while further enhancing safety.[40] It is also possible to explore the possibility of combining with other new drugs or technologies to enhance the analgesic effect and prolong the duration of ITM block.[40]

Several limitations of this study should be acknowledged. Firstly, this study is a single-center research with a sample size from a single source, which may have certain biases.[41] Secondly, the follow-up duration of this study is relatively short and lacks comprehensiveness. The long-term effects of ITM block beyond 48 hours remain unexplored. Subsequent studies could investigate whether the analgesic efficacy and the beneficial effects on functional recovery endure over the

long term. Thirdly, this study did not conduct detailed analyses of subgroups, including different age groups, genders, preoperative analgesic drugs, and individuals with underlying diseases. Further subgroup analysis can aid in clarifying the advantages and limitations of ITM block within specific populations, thereby promoting precision medicine. In addition, in this study, since the intraoperative opioid consumption in the ITM block group was significantly lower than that in the control group, this might have caused the anesthesiologists in charge of intraoperative management to deduce the group allocation, thus potentially introducing performance bias. This is an inherent challenge of the sham-controlled trial design. Finally, although this study confirmed the safety and effectiveness of ITM block, the research on its mechanism of action is not deep enough. In-depth investigations into the mechanism of action of ITM block can help better understand its clinical effects and provide theoretical support for further optimizing block techniques and drug selection. Future research may concentrate on these aspects to progressively enhance the comprehension and application of ITM block.

Conclusion

This study provides preliminary evidence supporting the efficacy and safety of ultrasound-guided ITM blocks in scapular fracture surgery. Ultrasound-guided ITM block can effectively reduce intraoperative anesthetic dosage, decrease post-operative pain scores, prolong the time to first request for remedial analgesia, and has a low incidence of related complications, which is worthy of further clinical promotion and research. Further comprehensive research is warranted to fully elucidate their clinical potential and optimize implementation strategies.

Previous Presentation in Conferences

Some of the results from this study were briefly presented at the 25th Anesthesiology Academic Conference of the Chinese Medical Association in 2025.

Abbreviations

SFs, Scapular fractures; ITM, Infraspinatus Teres Minor; NSAIDs, non-steroidal anti-inflammatory drugs; TSSA, thoracic segmental spinal anesthesia; ASA, American Society of Anesthesiologists; VAS, Visual Analog Scale; HR, Heart Rate; MAP, Mean Arterial Pressure; SpO_2, Peripheral Oxygen Saturation; SD, Standard Deviation; ANOVA, Analysis of Variance; MD, Mean Difference; AUC, Area Under the Curve; QoR, Quality of Recovery.

Data Sharing Statement

The datasets generated and analyzed during the current study are not publicly available owing to privacy and ethical restrictions; however, they are available from the corresponding author upon reasonable request, subject to approval by the institutional review board.

Ethics Approval and Consent to Participate

The study was conducted in accordance with the Declaration of Helsinki. The study was approved by the Ethics Committee of Ningbo No. 6 Hospital on June 6, 2024 (Approval No. 2024-47). All patients provided written informed consent before enrollment.

Consent for Publication

Not applicable, as patients' data were analyzed anonymously.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This study was financially supported by the Agricultural and Social Development Project in Yinzhou District, Ningbo City, Zhejiang Province (No. 2024AS036), Ningbo Clinical Research Center for Orthopedics, Sports Medicine & Rehabilitation(2024L004), and Zhejiang Provincial Medical and Health Science and Technology Project (No. 2025HY0880, 2025HY1076, and 2025HY1078).

Disclosure

No potential conflict of interest relevant to this article was reported.

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