

Navigating scalp nerve blocks: A comparative study of ultrasound vs. landmark methods

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SUMMARY

Objectives: Scalp block is a regional anesthesia technique involving the administration of anesthetic around the scalp nerves for head and neck surgeries and pain management. Two primary methods for performing scalp blocks are ultrasound guidance and anatomical landmarks. This study aimed to compare the success rates of scalp blocks using these two methods, assessing pain absence, anesthesia occurrence during surgery, and complications.

Methods: A total of 50 eligible craniotomy candidates were evaluated at Shohadaye Tajrish Hospital over a 6-month period. Patients were divided into two groups: ultrasound-guided block and landmark-guided block. The ultrasound group received blocks under ultrasound guidance, while the landmark group relied on anatomical landmarks for block administration. Both groups were administered a scalp nerve block with 0.5% ropivacaine prior to surgery.

Results: The overall success rate of scalp blocks was higher with ultrasound guidance compared to anatomical landmarks (ultrasound success rate=72%, landmarks success rate=24%). However, when analyzing success rates for individual nerves, the differences were not statistically significant (supraorbital $p=0.357$, supratrochlear 100% success, zygomaticotemporal $p=0.977$, auriculotemporal $p=0.107$, occipital major $p=0.151$, occipital minor $p=0.199$). No complications were observed in either group.

Conclusion: Ultrasound-guided scalp blocks demonstrated a higher success rate than landmark-guided blocks in craniotomy candidates. Further research is recommended to optimize scalp block methods for each nerve, compare drug consumption, and increase sample sizes.

Keywords: Anatomical landmarks; craniotomy; scalp block; scalp nerves; success rate; ultrasound guidance.

Introduction

Regional anesthesia, a dynamic and rapidly evolving branch of anesthesiology, has gained significant attention and widespread adoption in recent years. The growing recognition of its efficacy, coupled with heightened awareness of systemic side effects associated with traditional anesthetic drugs, has propelled regional anesthesia to the forefront of clinical practice. As our patient population ages and comorbidities become more prevalent, optimizing postoperative pain control and patient satisfaction has become paramount.^[1]

Scalp blocks, specifically cranial nerve blocks, play a pivotal role in achieving these goals. By strategically administering local anesthetic agents at precise points on the scalp, sensory and motor nerve conduction in various areas of the skull can be effectively modulated. Consequently, surgery within the head and skull region can be performed without relying solely on systemic anesthetics. The versatility of scalp blocks extends beyond surgical anesthesia; they are now utilized for acute and chronic pain management, including the treatment of specific headache types such as migraines.^[2]

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Despite significant recent advancements in pharmacological and neuromodulatory therapies for managing migraines, there are still several considerations that may render these treatments suboptimal for certain patients. Coexisting conditions such as cardiovascular or cerebrovascular diseases, renal or hepatic dysfunction, pregnancy, psychiatric comorbidities, or potential drug interactions can limit the suitability of these available treatment options.^[3]

The mechanisms underlying the analgesic effects of peripheral nerve blocks (PNBs) remain incompletely understood. It is suggested that these effects are attributed to the targeted blockade of sensory fibers, preserving motor function, and subsequently eliciting central pain modulation through second-order neurons within the trigeminocervical complex.^[4]

A preoperative scalp nerve block has the potential to mitigate hemodynamic instability and alleviate postoperative pain.^[5] Notably, scalp blocks find particular utility in craniotomy cases, especially during awake craniotomy procedures. Surgeons across diverse medical specialties increasingly embrace this technique, appreciating its benefits in terms of patient outcomes and safety.

The pain associated with craniotomy primarily arises from skin incisions and muscle disruption rather than direct manipulation of the brain parenchyma. The scalp receives its innervation primarily from the trigeminal nerve along with the second and third cervical nerve roots.^[6]

Scalp blocks can be performed in two ways

1. Using Anatomical Landmarks: Traditionally, regional anesthesia methods relied on anatomical and empirical landmarks, and scalp blocks were no exception. Anatomical landmarks are identifiable points based on touch and sight. With their guidance, an anesthesiologist can perform a scalp block without requiring specialized equipment.^[1]
2. Using Ultrasonography: Over time, advances in medical engineering introduced ultrasonography, which found applications in various medical fields. Anesthesiologists increasingly use ultrasonography to perform regional anesthesia procedures, sometimes even surpassing traditional methods based on anatomical landmarks. By us-

ing ultrasonography, precise nerve and vessel locations can be identified, allowing for injections with higher accuracy and reduced risk.^[5]

The aim of this study was to compare the efficacy and success rate of ultrasound-guided scalp nerve blocks versus traditional landmark-based techniques.

Materials and Methods

Study Design and Data Collection

This randomized clinical trial involved 50 eligible patients scheduled for elective craniotomy at Shohadaye Tajrish Hospital. Data were collected through questionnaires and recorded evaluation results and observations.

Sampling Method

Purposive sampling was employed, selecting individuals who could provide the necessary information effectively.

Sample Size Calculation

The sample size was determined based on results from similar studies.

Significance Level

A p-value<0.05 was considered statistically significant.

Patient Eligibility Criteria

Patients eligible for the study were required to exhibit the following characteristics:

1. Scheduled for elective craniotomy
2. Visited Shohadaye Tajrish Hospital

Eligibility Criteria for Study Participants

To ensure the validity and safety of the study, the following eligibility criteria were established:

1. Age Range: Individuals aged 18 to 65 years were eligible. This age range allowed for conscious consent and active participation.
2. No Substance Abuse or Alcohol: Long-term drug and alcohol use can alter anesthetic requirements. Participants with a history of substance abuse had to inform the anesthesiologist to ensure appropriate anesthesia levels.

3. No Allergy to Anesthetic Drugs: Given the inevitable use of local anesthetic drugs in the study, awareness of potential allergies within this drug group was crucial.
4. Absence of Diabetes: Individuals with diabetes have an increased risk of neuropathy and potential complications. Therefore, only participants without diabetes were included.
5. No Coagulation Disorders: Coagulation disorders may elevate the risk of complications related to nerve blocks. Participants with such disorders were excluded from the study.

Exclusion Criteria

To maintain the integrity of the research results, individuals were not included in the study under the following conditions:

1. Patient's Disagreement During the Block: If a patient chose not to continue cooperating with the research during the block procedure, they were excluded from the study.
2. Patient's Non-Cooperation During Block or Evaluation: Patients who did not actively cooperate with the anesthesiologist during the block procedure or its subsequent evaluation were excluded.
3. Surgeon's Disagreement: The participation of each patient in the study was contingent upon the surgeon's consent. If the surgeon did not agree, the case was removed from the study.

Study Methodology

Patient Selection and Consent

Fifty eligible patients scheduled for craniotomy were enrolled. After explaining the scalp block procedure for intraoperative analgesia, written consent was obtained from willing patients. The study was performed in accordance with the Declaration of Helsinki.

The study was approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences.

Group Allocation

Fifty patients were randomly assigned to two groups (landmark, sonography) using a random number table and SPSS software. The group allocation was not blinded to the block provider or patients, but the

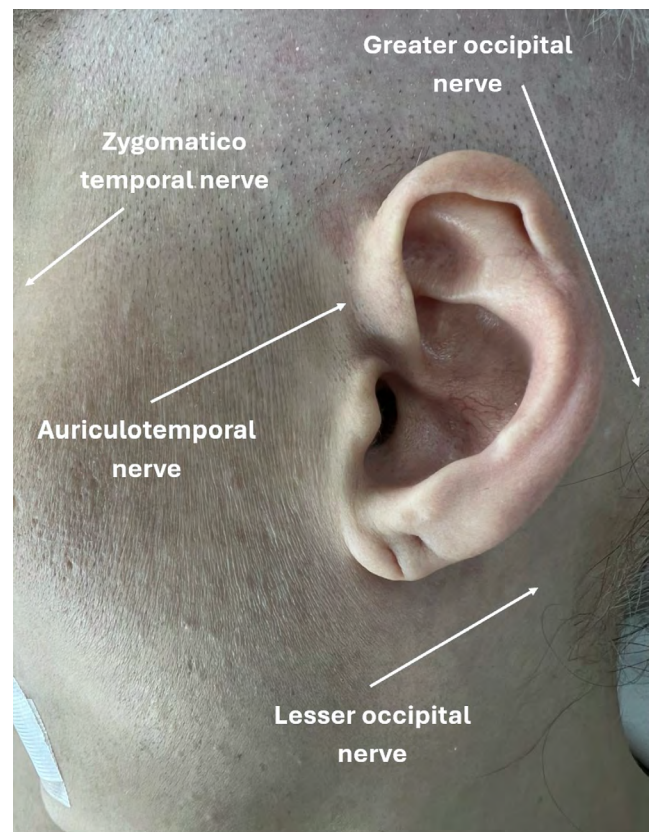


Figure 1. Anatomical landmarks of scalp block.

surgeon, anesthetic providers, and postoperative outcome assessor were blinded.

All patients were positioned on the operating table before anesthesia induction. Patients underwent routine monitoring for oxygen saturation, electrocardiography, and noninvasive blood pressure. Prior to induction into the block groups, patients were premedicated with midazolam, and a series of blocks was then performed by an independent anesthesiologist. The skin was sterilized with 2% chlorhexidine after protecting the patient's eye with gauze. A 0.5% solution of ropivacaine was prepared as the local anesthetic.

Nerve Identification

The surgical team determined the precise incision location for each patient. The anesthesiologist identified the nerves required for the scalp block based on the surgical incision site. Among the 12 known nerves involved in scalp blocks, the specific nerves were targeted.

Anatomical Landmarks (Fig. 1)

1. Superficial Temporal Nerve (STN):

Landmark: 2–3 cm (0.8–1.2 inches) anterior to the tragus (the small flap in front of the ear canal).

Target: The STN is located about 1–2 cm (0.4–0.8 inches) deep to the landmark.

2. Supraorbital Nerve (SON):

Landmark: The midpoint of the eyebrow (supraorbital notch).

Target: The SON is located about 1–2 cm (0.4–0.8 inches) deep to the landmark.

3. Greater Occipital Nerve (GON):

Landmark: 2–3 cm (0.8–1.2 inches) lateral to the external occipital protuberance (a bony landmark at the back of the skull).

Target: The GON is located about 1–2 cm (0.4–0.8 inches) deep to the landmark, just below the superior nuchal line (a bony ridge at the base of the skull).

4. Lesser Occipital Nerve (LON):

Landmark: 2–3 cm (0.8–1.2 inches) lateral to the mastoid process (the bony prominence behind the ear).

Target: The LON is located about 1–2 cm (0.4–0.8 inches) deep to the landmark.

5. Posterior Auricular Nerve (PAN):

Landmark: The posterior aspect of the ear, about 1–2 cm (0.4–0.8 inches) posterior to the tragus.

Target: The PAN is located about 1–2 cm (0.4–0.8 inches) deep to the landmark.

6. Zygomaticotemporal Nerve (ZTN):

Landmark: The posterior aspect of the zygomatic bone (cheekbone), about 1–2 cm (0.4–0.8 inches) anterior to the ear.

Target: The ZTN is located about 1–2 cm (0.4–0.8 inches) deep to the landmark.

Sonographic Landmarks

1. Superficial Temporal Nerve (STN) (Fig. 2):

Sonographic landmark: The temporal artery, which appears as a pulsatile, hypoechoic structure.

Target: The STN is located just superficial to the temporal artery, about 1–2 mm deep to the skin.

Ultrasound appearance: The STN appears as a small, hyperechoic structure (brighter than surrounding tissue).

2. Supraorbital Nerve (SON) (Fig. 3):

Sonographic landmark: The supraorbital notch, which appears as a hypoechoic depression in the frontal bone.

Target: The SON is located just below the supraorbital notch, about 1–2 mm deep to the skin.

Ultrasound appearance: The SON appears as a small, hyperechoic structure.

3. Greater Occipital Nerve (GON):

Sonographic landmark: The occipital bone, which appears as a hyperechoic (bright) curved line.

Target: The GON is located in the fascial plane between the trapezius muscle and the occiput, about 1–2 cm deep to the skin.

Ultrasound appearance: The GON appears as a small, hyperechoic structure.

4. Lesser Occipital Nerve (LON):

Sonographic landmark: The mastoid process, which appears as a hyperechoic (bright) bony prominence.

Target: The LON is located just posterior to the mastoid process, about 1–2 cm deep to the skin.

Ultrasound appearance: The LON appears as a small, hyperechoic structure.

5. Posterior Auricular Nerve (PAN):

Sonographic landmark: The posterior aspect of the auricle (ear), which appears as a hyperechoic (bright) curved line.

Target: The PAN is located just posterior to the auricle, about 1–2 cm deep to the skin.

Ultrasound appearance: The PAN appears as a small, hyperechoic structure.

Intervention

- Group 1 (Anatomical Landmarks): An injection of 0.5% ropivacaine (1–3 cc) was administered to the identified nerves using anatomical landmarks and a G29 needle. Epinephrine 1:200,000 was

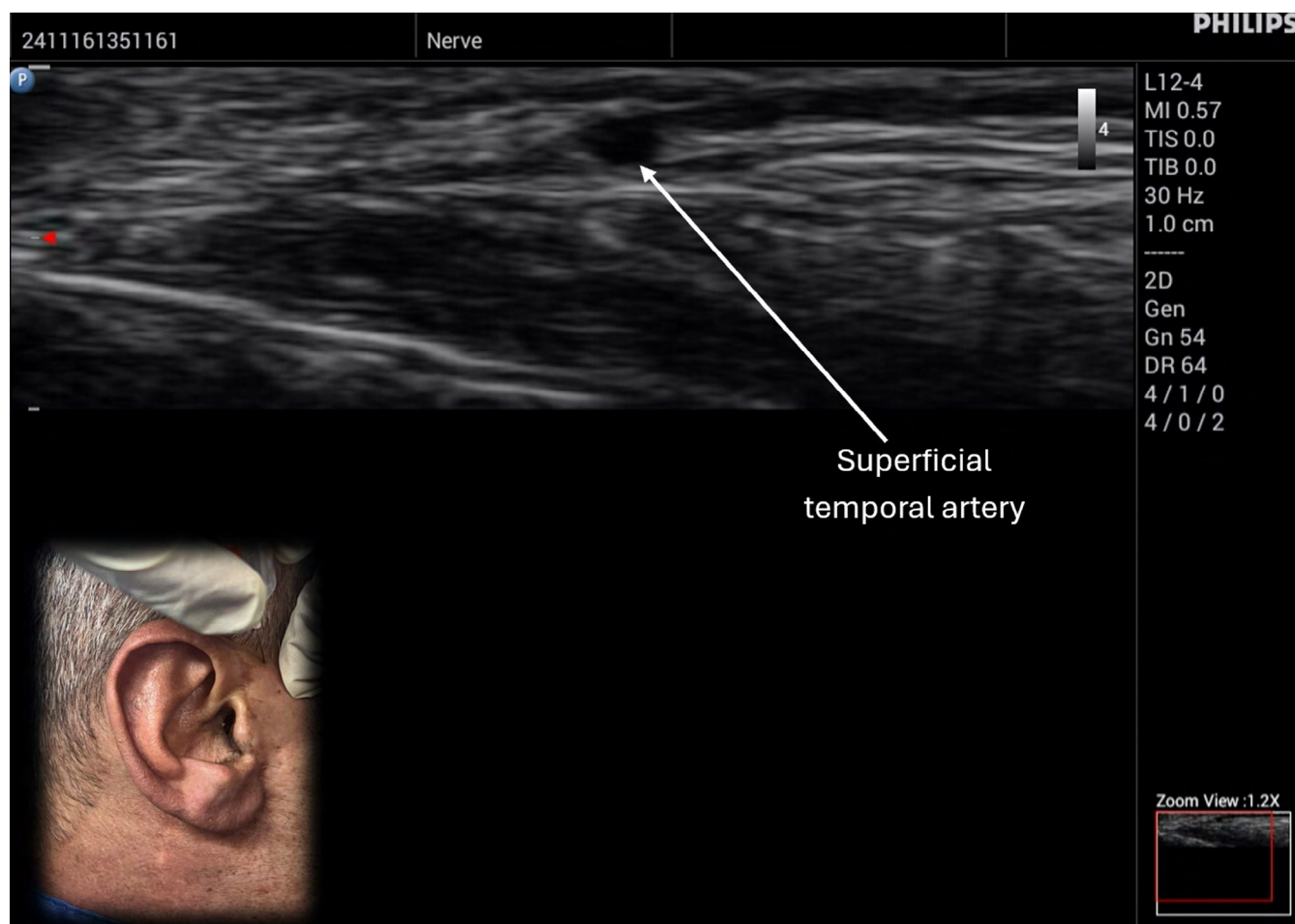


Figure 2. Sonographic vs anatomical landmark of superficial temporal nerve (STN) block.

added to the local anesthetic for patients without cardiovascular conditions such as a history of percutaneous coronary intervention or angina.

- Group 2 (Ultrasound Guidance): The same steps were followed, but drug injection was guided by ultrasound.

After the intervention was concluded, the sensory blockade in the forehead, upper neck, and occipital regions was evaluated. Block success was determined by the absence of sensation to cold stimuli at all sites.

General anesthesia was induced using propofol (effect-site target-controlled infusion (TCI) of 5 µg/mL) and remifentanyl (effect-site TCI of 3 ng/mL). Following loss of consciousness, 0.6–0.8 mg/kg of atracurium was administered intravenously, and the patient was manually ventilated with 100% oxygen. Tracheal intubation was performed after 2 minutes using a 7.5 mm (internal diameter) endotracheal tube (ETT) for women and an 8.0 mm ETT for men.

With the use of a hand pressure gauge, cuff pressure was 20–25 mmH₂O. End-tidal carbon dioxide (EtCO₂) and invasive arterial blood pressure through a radial artery catheter were measured.

Anesthesia was maintained with effect-site TCI of propofol and remifentanyl to keep blood pressure and heart rate within 20% of their baseline values. Hypotension (baseline mean arterial pressure <20%) was managed with 5 mg of ephedrine, bradycardia (baseline heart rate <20%) with 0.5 mg of atropine, and hypertension (baseline mean arterial pressure >20%) with 250 µg of nitroglycerine IV administration. Mechanical ventilation was sustained with a tidal volume of 8 mL/kg, and ventilator frequency was adjusted to maintain EtCO₂=35–40 mmHg.

The neuromuscular block was reversed by IV administration of neostigmine (0.03–0.07 mg/kg) and atropine (15 µg/kg). The patient was extubated and transferred to the intensive care unit (ICU). All procedures were identical between the two groups.

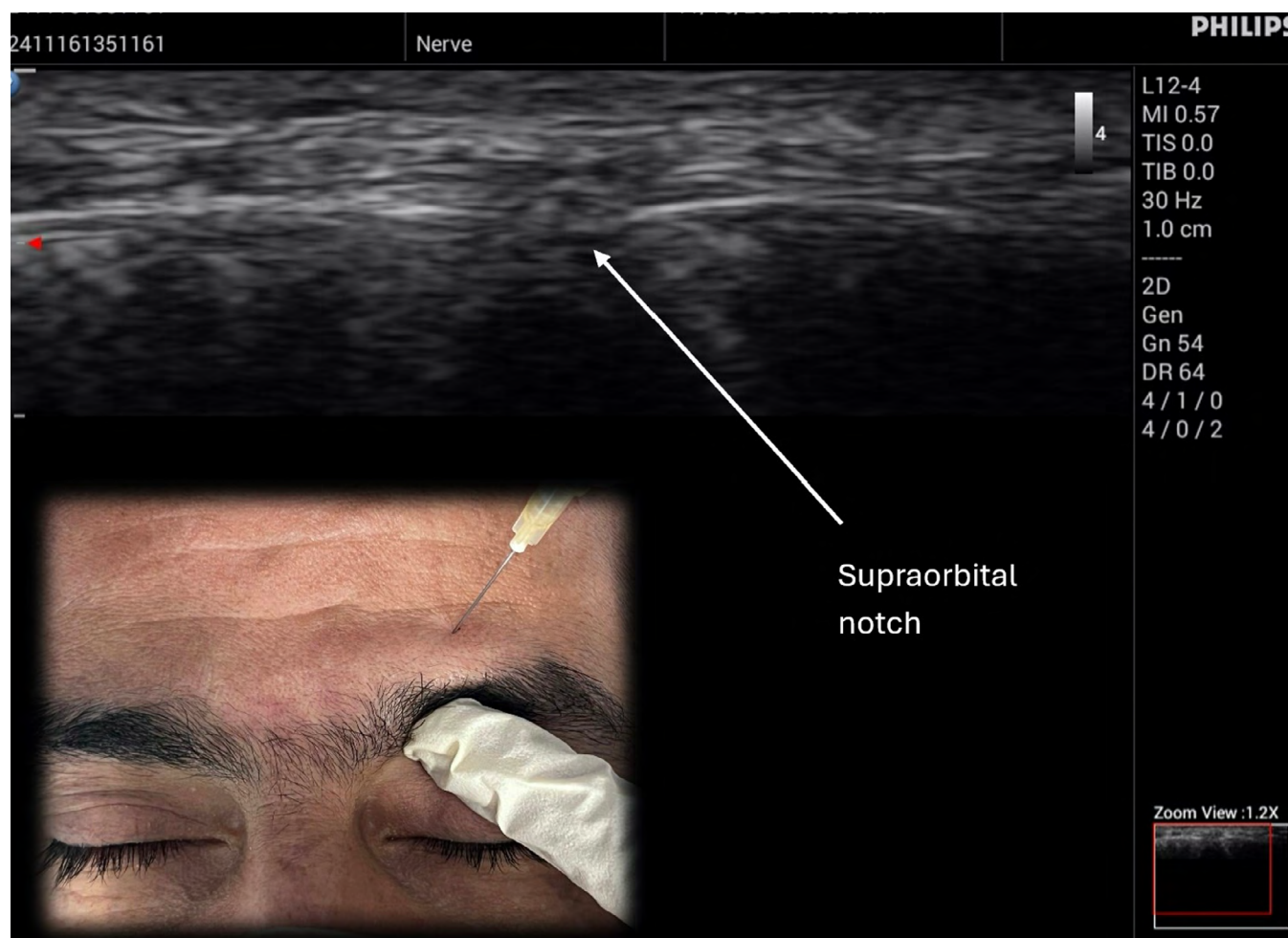


Figure 3. Sonographic vs anatomical landmark of supraorbital nerve block.

Data Collection

- Each blocked nerve's name and injected drug volume were recorded.
- Block success was evaluated by an anesthesiologist blinded to the method.
- In case of unsuccessful blocks, repeat injections were performed for adequate analgesia.
- Unintended block-related complications (such as bleeding, hematoma, or nerve injury) were promptly assessed and documented for up to 12 hours post-block.

Statistical Analysis

SPSS software was used for statistical analysis. Qualitative data were compared using the chi-square test, while quantitative data were analyzed using the t-test. Data were analyzed by a blinded statistical analyst, and results were reported.

Results

This randomized, comparative, prospective study was conducted on 50 patients aged between 18–65 years scheduled for craniotomy to compare conventional and ultrasound-guided scalp block in terms of sensory blockade in the forehead, upper neck, and occipital regions. Block success was determined by the absence of sensation to cold stimuli at all sites. There were no clinical or statistically significant differences in the demographic profile of patients in either group (Table 1, 2).

The results of the chi-square test showed that the two groups did not differ in terms of the gender variable ($p=0.774$). No significant sex predominance was seen in either group (Table 1).

The average age was 53.60 ± 10 years in group LM and 55.96 ± 12.01 years in group US. The results of the independent t-test showed that the two groups did not differ in terms of age and body mass index ($p>0.05$) (Table 2).

Table 1. Gender distribution (p=0.774)

	Groups	
	Landmark	Sonography
Gender		
Man		
Count	10	11
Percent	40	44
Woman		
Count	15	14
Percent	60	56
Total		
Count	25	25
Percent	100	100

Table 2. Distribution of age and BMI

Group	Count	Average	SD	p
Age				0.454
Landmark	25	53.60	10	
Sonography	25	55.96	12.01	
BMI				0.740
Landmark	25	25.67	3.24	
Sonography	25	25.97	3.28	

SD: Standard deviation; BMI: Body mass index.

Table 3. Supraorbital nerve block success rate in two methods using ultrasound and anatomical landmarks (p=0.357)

	Groups	
	Landmark	Sonography
Supraorbital		
Successful		
Count	32	35
Percent	91.4	97.2
Unsuccessful		
Count	3	1
Percent	8.6	2.8
Total		
Count	35	36
Percent	100	100

The results of Fisher's test showed that there was no significant difference between the percentage

Table 4. Supratrochlear nerve block success rate in two methods using ultrasound and anatomical landmarks (p=NA)

	Groups	
	Landmark	Sonography
Supratrochlear		
Successful		
Count	35	36
Percent	100	100
Total		
Count	35	36
Percent	100	100

Table 5. Zygomaticotemporal nerve block success rate in two methods using ultrasound and anatomical landmarks (p=0.977)

	Groups	
	Landmark	Sonography
Zygomaticotemporal		
Successful		
Count	33	34
Percent	94.3	94.4
Unsuccessful		
Count	2	2
Percent	5.7	5.6
Total		
Count	35	36
Percent	100	100

of success in supraorbital block between the two groups (p=0.357) (Table 3).

Supratrochlear block success rate was 100% in both groups (Table 4).

In terms of zygomaticotemporal sensory block, the results of Fisher's test showed no significant difference between the two groups (p=0.977) (Table 5).

No significant differences in the percentage of success were seen between the two groups in auriculotemporal block, lesser occipital block, and greater occipital block (p=0.107, p=0.199, p=0.155, respectively) (Table 6–8).

Table 6. Success rate of Auriculotemporal nerve block in two methods using ultrasound and anatomical landmarks (p=0.107)

	Groups	
	Landmark	Sonography
Auriculotemporal		
Successful		
Count	30	35
Percent	85.7	97.2
Unsuccessful		
Count	5	1
Percent	14.3	2.8
Total		
Count	35	36
Percent	100	100

Table 7. The success rate of Lesser Occipital nerve block in two methods using ultrasound and anatomical landmarks (p=0.199)

	Groups	
	Landmark	Sonography
Lesser occipital		
Successful		
Count	31	35
Percent	88.6	97.2
Unsuccessful		
Count	4	1
Percent	11.4	2.8
Total		
Count	35	36
Percent	100	100

Even a single failure in either the sonographic or landmark block was considered indicative of an unsuccessful attempt. Therefore, the success rates in each group were as follows: ultrasound success rate=72%, landmark success rate=24%. There was a statistically significant difference between the success rates of the two groups (p=0.02) (Table 9).

Discussion

The research, investigation, and statistical analysis conducted on cranial blocks reveal that utilizing ultrasonography for performing blocks yields a high-

Table 8. Greater Occipital nerve block success rate in two methods using ultrasound and anatomical landmarks (p=0.155)

	Groups	
	Landmark	Sonography
Greater occipital		
Successful		
Count	29	34
Percent	82.8	94.4
Unsuccessful		
Count	6	2
Percent	17.2	5.6
Total		
Count	35	36
Percent	100	100

Table 9. Ultrasound success rate vs landmarks success rate. (p=0.02)

	Groups	
	Landmark	Sonography
Successful		
Count	6	18
Percent	24	72
Total		
Count	25	25
Percent	100	100

er success rate compared to relying on anatomical landmarks. Therefore, the importance of ultrasonography lies in its ability to provide real-time imaging and precise distribution of the anesthetic substance around the nerve, resulting in a significant statistical advantage. An essential aspect of the research is assessing the success rates of cranial nerve blocks using ultrasonography and anatomical landmarks separately. Notably, the study highlighted the success rate of the zygomaticotemporal block, which, contrary to previous beliefs of its complexity, demonstrated a success rate comparable to blocks in other areas using both methods.^[2]

Sato et al.^[7] revealed that the failure rate for zygomaticotemporal nerve blocks was found to be higher compared to other nerve blocks. The zygo-

maticotemporal nerve is located deep beneath the skin surface and may exhibit anomalies,^[7–9] making it challenging to anesthetize using the anatomical landmark approach. Patients frequently experience headaches during awake craniotomy, and the zygomaticotemporal nerve, responsible for sensation in the temple region,^[8] could potentially contribute to temporal pain during awake craniotomy.

However, as regional techniques gain popularity and evolve, the expertise of physicians in performing these blocks plays a crucial role in achieving successful outcomes. While no specific complications were reported among the study participants, the use of ultrasonography may offer additional reassurance in this aspect. Furthermore, the study revealed a significant reduction in the amount of drug used for nerve blocks with ultrasonography compared to anatomical landmarks, suggesting the need for further investigation into this aspect in future studies.^[5]

Scalp blocks are typically carried out using bony or superficial landmarks as a guide. However, various studies have highlighted significant variations in the position or number of foramina, as well as the course of nerves. These variations can sometimes make blind placement of these blocks risky.^[10]

The scalp sensory nerves present a challenge due to their thin nature and limited visibility on ultrasonography. Accurate identification of these nerves necessitates ultrasound-assisted localization of anatomical landmarks such as bone and blood vessels. Ultrasound-guided scalp nerve blocks for precise anatomical localization have been shown to be beneficial in reducing surgery-induced stress and optimizing local anesthetic dosage in pediatric patients with craniosynostosis undergoing cranial suture reconstruction.^[5]

The results of Paule's study^[10] were consistent with our findings. It revealed that employing ultrasound guidance for scalp nerve blocks is a straightforward technique that can enhance patient safety by minimizing the total amount of local anesthetic used. This is achieved by blocking the nerves with small volumes (2–3 mL for each nerve) and reducing the risk of vascular puncture through the visualization of arteries near the nerves using color Doppler. Ad-

ditionally, given the numerous variations in nerve foramina or courses that have been documented, ultrasound guidance may offer a more accurate localization of nerves.^[10] Thallaj et al.^[11] found no failures when using only 0.1 mL of 1% mepivacaine for blocking the greater auricular nerve. When blocking the greater occipital nerve, Flamer et al.^[12] did not report any instances of block failure. Furthermore, USG helps to avoid an unintended block to another nerve running close, such as the facial nerve, when blocking the greater auricular nerve.^[13] In contrast, Pingree et al.^[14] reported a success rate of 86% for their blocks.

The limitations of our study were as follows

1. The study had a small sample size, which may limit the generalizability of the findings and the statistical power to detect differences between the two methods.
2. Assessment of the sensation absence to cold stimuli and subjective outcomes may vary between patients, making it challenging to draw definitive conclusions.
3. The patients were awake and could not be blinded to their block status because we had to confirm that the block was completely performed. The block was thus performed before general anesthesia induction for the wound area and pin placement during surgical manipulation.

Conclusion

In summary, ultrasound-guided scalp blocks demonstrated a higher success rate than landmark-guided blocks in craniotomy candidates. Further research is recommended to optimize scalp block methods for each nerve, compare drug consumption, and increase sample sizes.

Ethics Committee Approval: The study was approved by Shahid Beheshti University of Medical Sciences Ethics Committee (date: 02.05.2023, number: IR.SBMU.MSP.REC.1402.012).

Informed Consent: Written consent was obtained from willing patients.

Conflict of Interest: The authors declare that there is no conflict of interest.

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