



COMPARISON OF ULTRASOUND-GUIDED AND LANDMARK-BASED WALANT TECHNIQUES IN CARPAL TUNNEL SURGERY: A CADAVERIC EVALUATION WITH RADIOLOGICAL IMAGING

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Abstract

Objective: The WALANT (Wide Awake Local Anesthesia No Tourniquet) technique has gained popularity in hand surgery due to its simplicity, cost-effectiveness, and elimination of tourniquet-related discomfort. Despite its widespread use, the anatomical accuracy of anesthetic spread between ultrasound-guided (USG) and landmark-based WALANT injections remains underexplored. This study aims to compare the anatomical distribution and perineural coverage of anesthetic solution delivered via ultrasound-guided versus landmark-based WALANT techniques using computed tomography (CT) and magnetic resonance imaging (MRI) in a cadaveric model.

Methods: WALANT injections were performed on a formalin-fixed female cadaver. The right upper limb received a USG-guided injection, while the left received an injection based on anatomical landmarks. A radiopaque contrast-containing solution was used. CT and 1.5 T MRI scans were acquired to evaluate distribution patterns in axial, coronal, and sagittal planes.

Results: USG-guided injection demonstrated a more compact, deeper, and anatomically precise distribution, particularly with pronounced perineural spread around the median nerve within the carpal tunnel. The landmark-based technique showed broader but less focused spread, extending to superficial planes with less perineural accumulation.

Conclusion: Ultrasound-guided WALANT injection provides superior anatomical targeting and perineural anesthetic coverage compared to the landmark-based technique. Routine use of ultrasound guidance in WALANT procedures is recommended to enhance effectiveness and reduce anatomical variation-related complications.

Keywords: Carpal tunnel, peripheral nerve block, median nerve.

Introduction

In recent years, the importance of minimally invasive techniques that prioritize patient comfort in peripheral extremity surgery has been steadily increasing. In this context, the WALANT (Wide Awake Local Anesthesia No Tourniquet) technique, which utilizes local anesthesia with epinephrine and does not require a hemostatic tourniquet, has become a widely preferred anesthesia method, especially in hand and wrist surgeries.¹ In addition to eliminating the need for sedation, the WALANT technique enables the preservation of the patient's active range of motion during surgery, allowing direct observation of tendon tension, implant placement, and functional outcomes.²

Carpal tunnel syndrome (CTS) is the most commonly encountered peripheral nerve entrapment syndrome in hand surgery, caused by compression of the median nerve within the carpal tunnel. Although conservative approaches are available as treatment options, surgical decompression becomes inevitable in advanced cases. Surgical treatment generally involves the release of the flexor retinaculum to eliminate pressure on the median nerve.³ Open, mini-open, and endoscopic techniques may be employed, and WALANT can be integrated with any of these approaches.²

Traditional WALANT applications are typically performed as blind injections based on anatomical landmarks. However, in recent years, ultrasound-guided (USG) injections have also gained popularity. Ultrasonography can provide significant advantages in terms of safety and effectiveness by allowing for more targeted injection and better visualization of anatomical variations.⁴ Nevertheless, cadaveric-based systematic studies comparing the clinical efficacy, anesthetic distribution, nerve visualization, and injection accuracy between USG-guided and landmark-based WALANT techniques remain limited. This study aims to comparatively analyze the effectiveness of ultrasound-guided and landmark-based WALANT techniques in open carpal tunnel surgery using a cadaver model, with a focus on anatomical distribution assessed through computed tomography and magnetic resonance imaging. The findings are expected to contribute to decision-making processes concerning anesthesia safety and effectiveness in surgical practices.

Methods

This study was conducted on a cadaver of an 89-year-old female. The cadaver was obtained through voluntary donation solely for scientific research and educational purposes and was preserved in a 10% formalin solution. The hand and elbow regions of the cadaver were carefully examined, and no signs of previous surgical intervention or traumatic injury were observed.

A special solution was prepared for injection prior to the procedure. For a total of 40 mL, the mixture consisted of 20 mL of 2% methylene blue, 15 mL of 0.9% saline, 2.5 mL of radiopaque dye (Iohexol, Kopaq 350 mg/1 mL, Koçsel), and 2.5 mL of radiopaque dye (Gadodiamide, Omniscan 287 mg/1 mL, Opakim), yielding a 1% methylene blue-containing solution.

Ultrasound-Guided Block Application

In the ultrasound-assisted group of the study, WALANT injection was performed under ultrasonographic guidance. After the cadaver was placed in the supine position, the upper extremity was positioned on an arm table and antiseptic cleaning was performed. Using a portable ultrasound device

with a high-frequency linear probe, the wrist area was evaluated in both transverse and longitudinal planes. Once the median nerve was clearly visualized proximally, 10 mL of the prepared solution was injected per plane, totaling 20 mL (Figure 1).

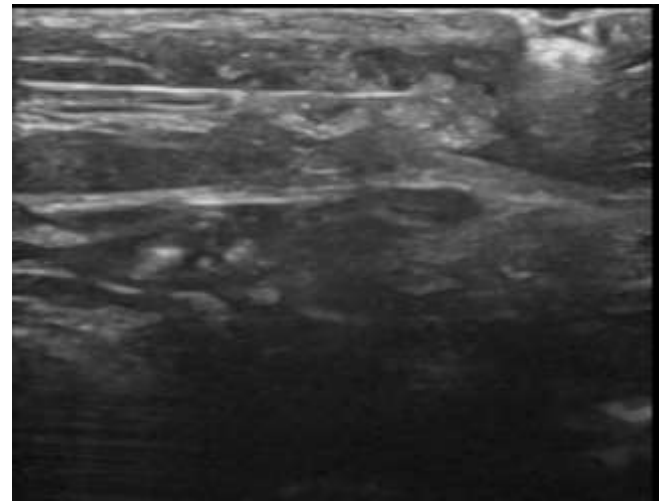


Figure 1: Ultrasound image demonstrating real-time application of USG-guided WALANT injection with needle tip visible near the median nerve.

Injections were administered to ensure perineural spread, and the needle tip was monitored in real-time on the ultrasound screen. Aspiration was performed to avoid vascular structures before completing the injection. This technique provided both peripheral nerve blockade and ensured anatomical distribution of the solution in the targeted area.

WALANT Application Without Ultrasound (Anatomical landmark-based Technique)

In the other arm of the study, the WALANT technique was applied based on anatomical surface landmarks without ultrasound guidance. A total of 10 mL of the solution was injected at approximately 0.5 cm proximal to the flexor crease of the wrist, between the palmaris longus muscle and its tendon. An additional 10 mL was administered along the planned surgical incision line.

Computed Tomography Imaging

Following the WALANT injection, the cadaver was positioned in the supine position and scanned using a 640-slice multidetector computed tomography system (Aquilion One, Canon, Japan). Imaging was performed in helical mode with a tube voltage of 120 kV and a rotation time of 0.5 seconds. Acquired data were analyzed using the Vital Vitrea software (Canon Group, Minnetonka, MN, USA) with a soft tissue window setting (window level: 40; window width: 400). A radiologist evaluated the images in axial, coronal, and sagittal planes to determine the distribution of the contrast agent.

Magnetic Resonance Imaging (MRI) Protocol

After the injection, MRI scans were obtained using a 1.5 Tesla scanner (Achieva, Philips Healthcare, the Netherlands). Based on pilot study parameters, T2-weighted fast spin echo sequences were acquired in axial, coronal, and sagittal planes (TR: 9800 ms; TE: 100 ms; slice thickness: 4 mm; matrix size: 128×256; field of view: 32×24 cm). The MRI scans were interpreted by a radiologist, with specific attention given to the neurovascular structures and the dispersion pattern of the contrast agent, especially in the axial and coronal sections.

Results

In this study, WALANT injection was applied under ultrasound guidance to the right upper extremity and using anatomical landmarks to the left upper extremity. Following both procedures, computed tomography (CT) and magnetic resonance imaging (MRI) were performed. The distribution of the contrast-containing solution within anatomical structures was comparatively evaluated.

Radiological evaluation of contrast agent distribution in both upper extremities revealed effective anesthetic spread in both sides. In the right upper extremity, both CT and MRI showed a deeper, more compact distribution pattern with clear perineural spread adjacent to the median nerve and flexor muscle groups (Figure 2). In the left upper extremity, the anesthetic spread also reached deep anatomical structures, especially along the volar compartment. However, the distribution was broader and more diffuse, with extension into superficial regions (Figure 3). These findings indicate that both injections were effective in reaching target anatomy, although the right side demonstrated a more focused and anatomically optimal distribution pattern.

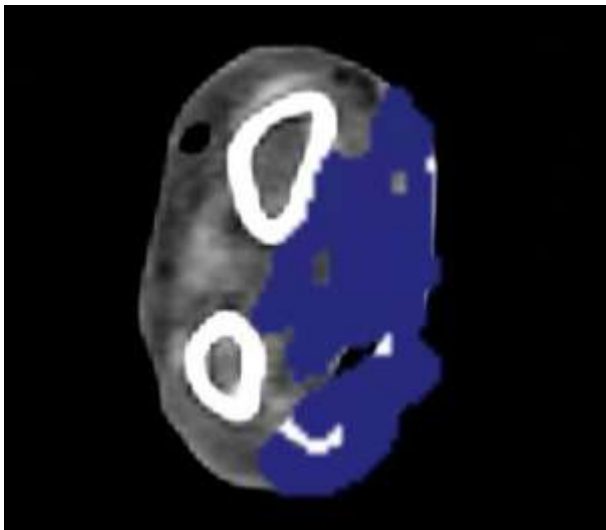


Figure 2: Axial CT image of the right forearm following ultrasound-guided WALANT injection showing compact contrast accumulation around the median nerve.

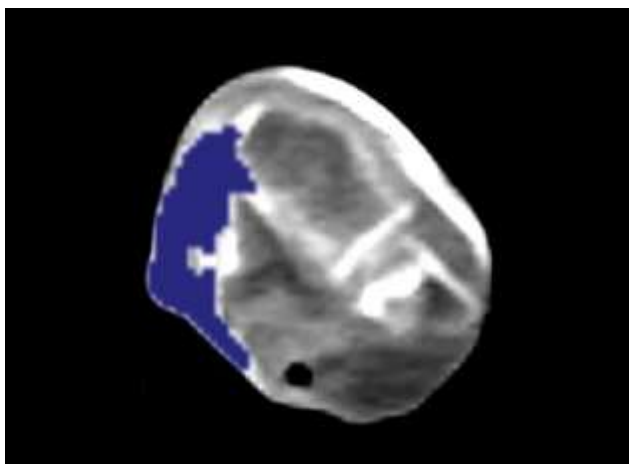


Figure 3: Axial CT image of the left forearm following landmark-based WALANT injection with diffuse contrast spread into superficial tissues.

CT slices demonstrated contrast accumulation among the flexor digitorum superficialis and profundus muscles, with evident enhancement surrounding the median nerve. The distribution was focused and deep, consistent with a successful perineural injection. In the left forearm, contrast distribution was more diffuse, but extended into the deep volar compartment. There was moderate enhancement near the median nerve and surrounding tendinous structures, indicating an effective anesthetic spread.

Axial MRI demonstrated signal intensity consistent with contrast agent presence extending beyond the superficial fascia into the deep anterior compartment, adjacent to the median nerve. The signal was dense and compact, suggesting anatomically accurate delivery. MRI demonstrated hyperintense signal along the volar compartment, indicating that the anesthetic reached deep tissues. However, the distribution was broader and extended into more superficial planes compared to that on the right side.

Discussion

In this study, the effectiveness of WALANT technique applied with and without ultrasound guidance in carpal tunnel surgery was compared based on anatomical distribution using CT, MRI. The findings indicate that ultrasound-guided injection (right arm) provided more accurate anatomical targeting, broader distribution, and more effective perineural coverage.

Ultrasound guidance allows the needle tip to be directed precisely around the target structure, the median nerve, thereby enhancing perineural distribution, reducing the risk of complications, and increasing the success of the block.^{5,6} In our study, ultrasound-guided injections showed homogeneous spread within the carpal tunnel and prominent contrast accumulation around the nerve. These results are consistent with the high accuracy rates reported in the literature.⁷

In contrast, the anatomical landmark-based injection technique in the left arm demonstrated more localized, superficial, and irregular spread. The limited contrast penetration into deep tissues and the carpal tunnel supports the idea that injections based solely on anatomical landmarks carry a higher risk of being off-target due to anatomical variations.⁸

WALANT applications with lidocaine and epinephrine are widely recommended in the literature for enabling tourniquet-free surgeries.⁹ In our study, the use of contrast-containing solution enabled direct visualization of anesthetic spread, allowing for a precise assessment of the anatomical effectiveness of each technique.

Previous studies have shown that WALANT increases patient comfort^{10,11}, reduces postoperative pain, shortens operative time, and decreases costs.^{12,13} However, cadaver-based studies directly visualizing anatomical distribution through imaging and dissection remain limited. Our study contributes significant data to fill this gap.

Conclusion

This cadaveric comparative study demonstrated that ultrasound-guided WALANT injection provides superior anatomical distribution and perineural block effectiveness compared to the anatomical landmark-based injection technique. Especially at the carpal tunnel level, more homogeneous spread, prominent perineural contrast uptake,

and deeper tissue access support the routine use of ultrasound guidance in clinical settings.

Based on these findings, it is recommended that WALANT be performed under ultrasound guidance to maximize both safety and effectiveness, and to minimize risks related to anatomical variation and nerve injury.

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Conflict of Interest

The authors declare that there is no conflict of interest.

Compliance of Ethical Statement

This study was conducted in accordance with the protocols approved by the Non-Interventional Clinical Research Ethics Committee of Kocaeli University Faculty of Medicine (Approval No: GOKAEK-2025/03/18). This study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

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Author Contributions

A.Ö., U.H.Y., C.A., V.A.: Conception; A.Ö., U.H.Y., C.A., V.A.: Design; Ö.Ç., U.H.Y., C.A.: Supervision; Ö.Ç., A.K., T.C.: Data Collection; A.Ö., Ö.Ç., V.A.: Data Analysis and Interpretation; S.D., V.A., C.A.: Literature Review; A.Ö., U.H.Y., S.D.: Manuscript Drafting; A.K., T.C., S.D.: Critical Revision

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