

Effectiveness and Safety of Ultrasound-Guided Nerve Hydrodissection in Pain Management

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Abstract

Objective: To evaluate current evidence on Ultrasound-guided nerve Hydrodissection (US-HD) for pain management. **Methods:** Comprehensive search of PubMed, Embase, Cochrane Library, Google Scholar (last 15 years, English only). Eligible studies included RCTs, cohort studies, case series, and cadaveric investigations. **Results:** 124 records identified; 17 studies met inclusion criteria. Evidence supports US-HD effectiveness for entrapment neuropathies (notably carpal tunnel syndrome, cervical radicular pain). Most studies showed significant pain and functional improvement, with low complication rates. Indirect evidence from anesthesia block studies supports procedural safety. Adverse events were rare and minor. **Conclusion:** The findings suggest that US-HD is a promising and minimally invasive intervention for peripheral and spinal nerve entrapments, particularly carpal tunnel syndrome and cervical radicular pain. Most studies reported significant improvements in pain relief and functional outcomes, with low complication rates. Adverse events were infrequent and generally minor, such as transient discomfort at the injection site. Best practice recommendations are beginning to emerge regarding ultrasound technique, needle approach, and injectate selection, with dextrose and local anaesthetic solutions most frequently described. Real-time ultrasound imaging allows precise needle placement, improved safety, and visualization of tissue planes, though techniques remain heterogeneous across studies. Overall, US-HD appears safe and effective, but current evidence is limited by small study sizes, variable protocols, and short follow-up. Larger randomized controlled trials are required to confirm efficacy, optimize technique, and standardize training.

Keywords

Ultrasound Guided, Hydrodissection, Pain Management, Systematic Review, Best Practice, Regenerative Medicine, Ultrasound Guidance Standardization, Pain

1. Introduction

Ultrasound-guided nerve Hydrodissection (HD) is a minimally invasive technique involving fluid injection to separate tissue planes, particularly around peripheral nerves. In pain medicine, HD is increasingly used to treat neuropathic pain syndromes by mechanically separating entrapped nerves from surrounding tissues, thereby restoring nerve mobility and improving injectate dispersion. Cadaveric work by Evers *et al.* demonstrated that Hydrodissection can reduce peak gliding resistance of the median nerve within the carpal tunnel by approximately 21%, lending biomechanical support to the decompression rationale for this procedure [1]. Clinical evidence has steadily expanded: multiple randomized controlled trials, including those by Wu *et al.*, have shown that perineural injection of 5% dextrose outperforms both saline and corticosteroid for carpal tunnel syndrome in terms of pain relief and functional improvement [2] [3]. Similar benefits have been observed in ulnar neuropathy at the elbow, Chen, and meralgia paresthetica, Shi, indicating the technique's versatility across entrapment syndromes [4] [5].

Beyond symptomatic improvement, HD may play a role in neural regenerative strategies. Trescot and Brown outlined its potential in combination with regenerative injectates such as platelet lysate or stem cell derivatives, aiming not only to decompress but also to enhance neural recovery [6]. Furthermore, optimization of technique—including injectate type and volume—has been explored in trials like Eyvaz, which found that 10 mL of 5% dextrose provided superior outcomes to smaller volumes [7]. The physiological basis for Hydrodissection includes decompression of the *nervi nervorum* and *vasa nervorum*, structures critical for neural feedback and vascular supply. Entrapment of these may contribute to ischemia, stasis, and ongoing nociceptive input, potentially resulting in chronic pain. Although interest is growing, the clinical literature remains fragmented, with variations in technique, injectates, and outcome reporting. This review synthesizes current evidence on the efficacy and safety of Ultrasound-guided Hydrodissection.

2. Objectives

- To evaluate the effectiveness of ultrasound-guided nerve Hydrodissection in the management of pain conditions.
- To assess safety outcomes and complication rates.
- To summarize current procedural techniques and emerging recommendations for ultrasound-guided hydrodissection.

3. Methods

A structured literature search was performed using PubMed, Embase, Cochrane Library, and Google Scholar. Keywords included “ultrasound-guided hydrodissection”, “nerve entrapment”, “cervical facet joint disease”, and “neck pain”. The search focused on studies published in the last 15 years and used Boolean operators to refine results. Eligible studies involved adult populations receiving US-HD

for neuropathic or nociceptive pain, with outcomes including pain reduction, functional improvement, safety, and long-term follow-up. Eligible studies included adult patients undergoing ultrasound-guided nerve hydrodissection for peripheral or spinal nerve entrapments, including but not limited to carpal tunnel syndrome, ulnar neuropathy, meralgia paresthetica, and cervical radicular pain.

Database queries included full Boolean strings (PubMed: “ultrasound-guided hydrodissection” AND “nerve entrapment” etc.). Searches performed up to March 2024, English-language only.

Inclusion criteria:

- Adult patients with neuropathic or nociceptive pain due to peripheral or spinal nerve entrapment (e.g., carpal tunnel syndrome, ulnar neuropathy, meralgia paresthetica, cervical radicular pain).
- Intervention: ultrasound-guided hydrodissection using any injectate (e.g., saline, dextrose, steroid).
- Reported outcomes: pain relief, function, complications, or follow-up.
- Study designs: RCTs, prospective cohorts, case series.

Exclusion criteria:

- Non-ultrasound-guided interventions.
- Non-Hydrodissection techniques.
- Paediatric or animal studies.
- Editorials, narrative reviews, or duplicate publications.

After applying eligibility criteria, 17 studies were selected for in-depth analysis. A PRISMA flow diagram is provided to illustrate the selection process(see **Figure 1**).

4. Results

4.1. Effectiveness

The studies reviewed consistently support the effectiveness of Ultrasound-guided Hydrodissection (US-HD) in treating nerve entrapment syndromes. Buntra-gulpoontawee reviewed 10 studies and found consistent clinical improvements in CTS patients using a variety of injectates [8]. Sveva evaluated outcomes from over 900 patients and observed durable symptom relief, especially with dextrose and PRP [9]. Lee conducted a network meta-analysis showing 5 cc of dextrose provided superior symptom relief, while PRP was most effective for improving nerve conduction [10]. Lin broadened the application of US-HD to include cervical radiculopathy, achieving successful results across patients with both mild and severe stenosis [11].

4.2. Safety and Complication Rates

Across all studies, US-HD showed a consistently low complication profile. Buntra-gulpoontawee noted no serious adverse events [8]. Common short-term side effects included soreness at the treatment site and occasional dizziness. Tranchitella reported no complications in ulnar nerve applications [12]. Fuchs emphasized procedural risks such as nerve trauma, hematoma, or infection but highlighted that

proper technique and ultrasound visualization significantly mitigate these risks [13]. The fact that US-HD can be performed on an outpatient basis without the need for general anesthesia contributes significantly to its clinical appeal.

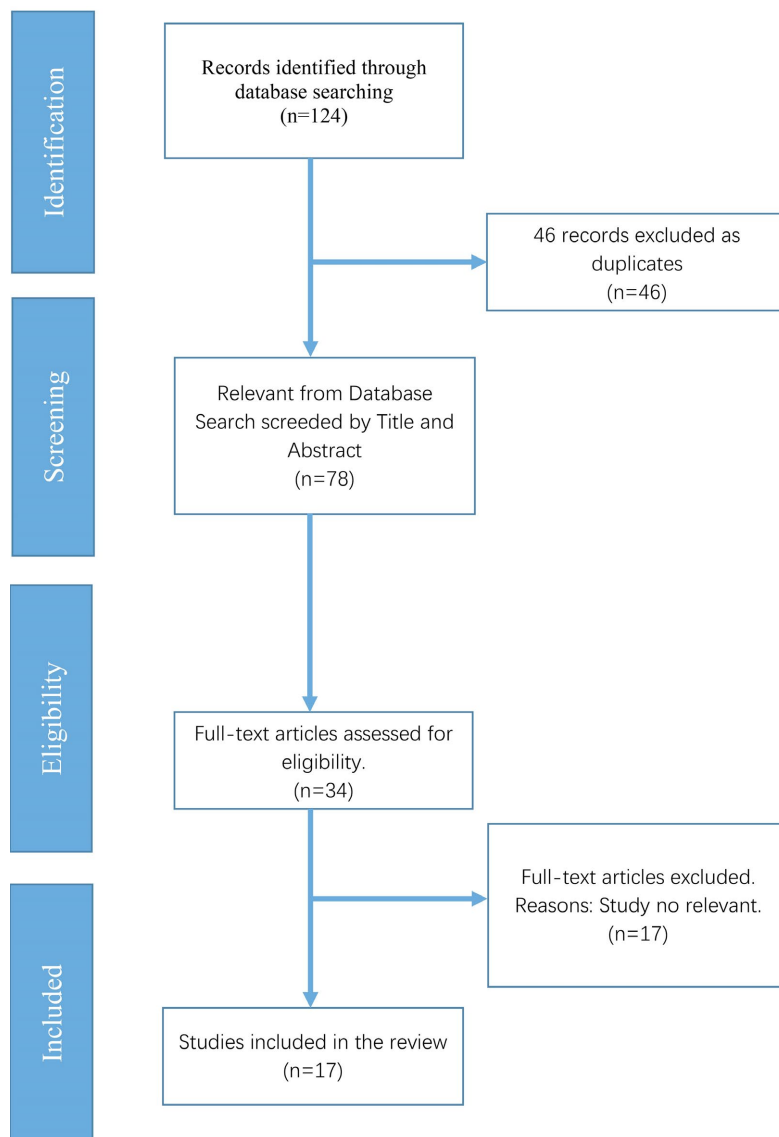


Figure 1. PRISMA diagram.

Recent studies support the safety of using real-time ultrasound for regional anesthesia. Liu showed it helps avoid risky nerve injections [14]. Brull found serious nerve issues in fewer than 3% of cases, confirming overall safety [15]. Bigeleisen reported no long-term nerve damage after axillary blocks [16]. Russon and Blanco presented a safe nerve injection on video, underscoring the importance of both technique and target location [17].

Note: While several studies focused directly on Hydrodissection, others (e.g., Brull [15], Bigeleisen [16]) represent indirect safety evidence from regional anesthesia. These were included as supportive evidence, not direct HD trials.

4.3. Technique and Image Guidance

Technical variations across studies included differences in needle orientation (in-plane vs. out-of-plane), injection approach (radial vs. ulnar), injectate composition, and procedural endpoints. Fouda reviewed these aspects and suggested that in-plane approaches allow for greater needle control [18] [19]. Lam provided cadaveric evidence showing hydrodissection improves nerve gliding and reduces fascial tethering, supporting its use as a biomechanical intervention [20]. Sabbini emphasized the importance of real-time verification during nerve release and recommended standardization of injectate volume and composition [21]. Despite these advancements, variability in technique continues to pose a significant challenge in the evaluation and comparison of study outcomes.

5. Discussion

This review highlights ultrasound-guided nerve hydrodissection as a clinically effective, safe, and scalable intervention for a range of nerve entrapment syndromes. For Carpal Tunnel Syndrome (CTS), US-HD provides outcomes similar to surgery but with lower associated morbidity [8] [22]. Evidence for cervical radicular pain, remains limited [11]. Safety data are consistent across studies, with very low rates of serious complications [12] [15] [16]. The success of the technique appears to depend on operator skill, image quality, and injectate choice [14]. However, inconsistencies in methods, injectates, and outcome reporting limit the ability to generalize findings [19] [21]. Clinical standardization, along with rigorous randomized trials and long-term outcome tracking, is urgently needed to establish US-HD as a first-line intervention [16]. Research has proposed that dextrose may modulate TRPV1 receptor activity, potentially reducing nociceptive signaling in neuropathic pain. In addition, the chronic constriction injury model supports the concept of mechanical decompression to relieve fascicular swelling. These physiological insights enhance our understanding of HD's multifactorial benefits. Overall, this review cites 24 references, of which 17 are primary included studies.

6. Limitations

This review has several limitations. The included studies demonstrate substantial variability in injectates, volumes, and procedural techniques, limiting direct comparison. Many studies had small sample sizes and heterogeneous outcome measures. A formal meta-analysis was not possible due to methodological differences. Only English-language studies were included, introducing potential language bias. Additionally, publication bias cannot be excluded, as studies with negative results may be underrepresented. These limitations should be considered when interpreting the findings.

7. Conclusion

Ultrasound-guided nerve Hydrodissection (US-HD) is a minimally invasive and safe procedure that has shown effectiveness in treating nerve entrapment-related

pain. It consistently yields positive results in conditions such as carpal tunnel syndrome and cervical radiculopathy, with a low risk of complications. As imaging technology and procedural methods continue to advance, US-HD is emerging as a promising non-surgical option, particularly in outpatient settings. Ongoing research should aim to optimize injectate formulations, enhance ultrasound techniques, and conduct large-scale comparative studies to better define its role in pain management.

Future Directions

Future research should aim to standardize the type of fluid used, injection volume, and frequency. Direct comparisons through head-to-head randomized trials between Hydrodissection and other interventional techniques are needed. Additionally, long-term follow-up—including recurrence rates and cost-effectiveness analyses—will be essential to assess the durability and sustainability of clinical outcomes.

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Conflicts of Interest

The authors declare no conflicts of interest.

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Appendix: Comparison of Key Studies

Table S1 summarizes the characteristics of the included studies.

The table below provides a comparative overview of the seventeen key studies included in this review. It summarizes their design, strengths, limitations, and key contributions to the field of ultrasound-guided nerve Hydrodissection.

Table S1. Summary of Ultrasound-Guided Hydrodissection studies.

Study	Design	Strengths	Limitations	Key Contribution
Buntragulpontawee <i>et al.</i> (2021)	Systematic Review	Wide scope, safety data	Small sample sizes, heterogeneity	Supports effectiveness and safety in CTS
Sveva <i>et al.</i> (2024)	Systematic Review	Validated tools, large sample	CTS-specific, lacks injectate comparisons	Strong support for HD in CTS
Lee <i>et al.</i> (2025)	Network Meta-Analysis	Comparative injectate data	Limited group data, no severity stratification	Informs injectate and volume choices
Lin <i>et al.</i> (2023)	Retrospective Cohort	Expands HD use to spine pain	No control group, retrospective design	Supports HD in cervical radicular pain
Fouda <i>et al.</i> (2025)	RCT	Direct comparison with surgery	Single center, short follow-up	Viable alternative to CTS surgery
Tranchitella <i>et al.</i> (2024)	Case Series	Safety in ulnar neuropathy	Small sample, descriptive only	Builds HD safety profile beyond CTS
Lam <i>et al.</i> (2020)	Cadaveric Study	Anatomical mechanism validation	No live patient outcomes	Supports mechanistic rationale for HD
Fouda (2023)	Narrative Review	Detailed technique guidance	No primary data	Useful for planning and technique choices
Sabbineni <i>et al.</i> (2025)	Clinical Study	Symptom improvement, low adverse events	No controls, non-specific	Promotes best practices in HD
Malone <i>et al.</i> (2022)	Case Series	Long-term follow-up	No control, variable outcomes	Validates HD as mid-level CTS option
Liu <i>et al.</i> (2021)	Observational Cohort	Large sample, video review	Not HD-specific	Reinforces procedural safety importance
Brull <i>et al.</i> (2020)	Systematic Review	Low neuropathy rate	Not HD-specific, underreporting risk	Supports guided injection safety
Russon & Blanco (2021)	Case Report	Video confirmation, no harm	Single case, anecdotal	Suggests benign intraneural events with good technique
Bigeleisen (2020)	Observational Study	Functional neuro follow-up	Small sample, not HD-focused	Low long-term nerve damage risk
Fuchs <i>et al.</i> (2024)	Case series	Novel, feasible “2 in 1” hydrodissection technique	Small sample, Short follow-up	First reported ED application of Hydrodissection
Tien-Lee Hsieh <i>et al.</i> (2022)	Case report	Therapeutic and diagnostic MSK ultrasound use	Single patient case, no long term data	First reported case of 5% dextrose for SAN entrapement for post-op adhesion scar
Townsley <i>et al.</i> (2011)	Case report	Demonstrates single short and continuous perineural catheter infusion approaches	Single patient case, short follow-up	Novel diagnostic and therapeutic tool for trapezius myofascial pain

Several studies expanded the application of US-HD beyond carpal tunnel syndrome to include ulnar nerve entrapment, piriformis syndrome, and sciatic neuropathy. Malone *et al.* described a technique involving fluid dissection beneath the flexor retinaculum for the median nerve, with variable long-term outcomes over a 24-month follow-up. Imaging guidance has improved procedural safety and accuracy, although inadvertent nerve injection remains a concern [15]. Observed a 17% rate of unintentional intraneural injection using ultrasound during shoulder blocks; however, no lasting neurological complications were reported. Brull's systematic review estimated neuropathy rates under 3 in 100 cases, reinforcing the favourable safety profile of peripheral nerve blocks, including HD [16].