COMPARATIVE EFFICACY OF STEROID PLUS BUPIVACAINE, 5% DEXTROSE AND HYALURONIDASE FOR MEDIAN NERVE BLOCK IN CARPAL TUNNEL SYNDROME: A RANDOMIZED CONTROL TRAIL

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ABSTRACT

Background: Carpal Tunnel Syndrome (CTS) produces three main events including pain and numbness together with functional disability. Multiple physicians have studied individual treatment methods including steroid mixed with bupivacaine and 5% dextrose along with hyaluronidase to treat symptoms, however our study compared the effects of these 3 treatment methods.

Methods: This study involved 90 patients diagnosed with mild to moderate CTS who received three different types of therapy group assignments: Group A therapy included steroid + bupivacaine (30 patients); Group B therapy consisted of 5% dextrose for 30 patients; and 30 patients received Group C therapy of hyaluronidase. The study measured outcomes through Visual Analog Scale (VAS) for pain and Boston Carpal Tunnel Questionnaire (BCTQ) for functional assessment as well as nerve conduction studies (NCS) and median nerve cross-sectional area (CSA) on ultrasound. Analysis was conducted through SPSS version 27.0.

Results: Baseline characteristics were comparable in all groups ($p>0.05$). At 6 months, Group C (hyaluronidase) showed the greatest pain reduction (VAS: 1.5 ± 0.57), followed by Group B (1.8 ± 0.68) and Group A (3.3 ± 1.30); $p<0.001$. Functional improvement was highest in Group C (BCTQ-SSS: 1.53 ± 0.31, BCTQ-FSS: 1.20 ± 0.23) compared to Group B (SSS: 1.63 ± 0.49, FSS: 1.33 ± 0.27) and Group A (SSS: 2.86 ± 0.64, FSS: 2.34 ± 0.48); $p<0.001$. Nerve conduction velocity (NCV) improved most in Group C (43.3 ± 4.58 m/s) compared to Group B (39.8 ± 5.21 m/s) and Group A (33.9 ± 5.78 m/s); $p<0.001$. Median nerve CSA reduction was greatest in Group C (10.8 ± 1.95 mm²) vs. Group B (11.2 ± 1.89 mm²) and Group A (13.5 ± 2.01 mm²); $p<0.001$.

Conclusion: Chronic pain intensity along with functional capacity showed improvement in patients who received any of the three treatment modalities. The application of hyaluronidase produced the leading long-term advantages for pain reduction in combination with nerve function and structural repair. Steroid-bupivacaine created the quickest symptom relief and 5% dextrose provided ongoing but moderate symptom relief.

Keywords: carpal tunnel syndrome, steroid injection, bupivacaine, dextrose 5%, hyaluronidase, nerve conduction studies.

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INTRODUCTION

Carpal Tunnel Syndrome (CTS) represents a common neuropathy which develops from pressure affecting the median nerve in the carpal tunnel of the hand. The symptoms of this condition appear as numbness and tingling sensations along with pain that affects the hand and fingers causing functional impairments.[1] CTS starts from various factors that involve repetitive hand movements along with wrist usage, and medical

conditions which include diabetes mellitus and rheumatoid arthritis.[2] CTS creates important economic challenges because it impairs both workplace performance and individual life satisfaction.[3]

Measures for treating CTS consist of using wrist splints with NSAIDs, physical treatment, corticosteroid injections and non-drug interventions.[4,5] The widespread use of corticosteroid injections stands because of their anti-inflammatory properties which helps decrease perineural inflammation while reducing edema.[6,7] The effectiveness of these typical interventions differs from patient to patient, so alternative intervention methods are needed to reach satisfactory treatment outcomes.

Researches have shown increasing focus on adjuvant substances to strengthen peripheral nerve block effects of local anesthetics throughout the past few years.[8] Doctors often use bupivacaine as their primary drug choice for local anesthesia because of its extended pain-killing properties.[9] Research indicates that Dextrose use shows neuroprotective and anti-inflammatory effects in the nervous system.[10] To improve both distribution and therapeutic efficacy of nerve blocks injected substances are dispersed through the application of hyaluronidase.[11]

Studies exist which examine the direct outcomes and dual applications of these pharmaceutical substances within peripheral neuropathy treatments. A recent study showed that both dexamethasone and triamcinolone, combined with bupivacaine, significantly improved pain and functional outcomes in CTS patients compared to baseline measurements, without significant differences between the two steroid groups.[12] Another study found that 5% dextrose injections were successful for treating patients with mild to moderate CTS by producing positive improvements in nerve conduction and symptom relief.[13] Researches also presented evidence that adding hyaluronidase to local anesthetics during nerve blocks creates more effective pain relief and shorter time to onset.[14]

However, available research does not contain full-scale investigations which compare bupivacaine along with dextrose and hyaluronidase for CTS treatment effectiveness. Research currently examines agent effects alone along with corticosteroid mixtures while neglecting direct comparisons between these elements. The current insufficient research leads to problems in finding the optimal therapy from the available choices. Multiple limitations in existing studies including inadequate sample sizes along with short follow-up times and inconsistent outcome assessment decrease the usefulness of their findings for general application. Therefore, our study compared the efficacy of steroid plus bupivacaine, 5% dextrose, and hyaluronidase in the treatment of CTS through a median nerve block approach.

METHODS

Study Design: The study implemented a randomized controlled trial (RCT) format with single-blinded design.

Study Population: Patients were selected who met every inclusion requirement and no exclusion requirement. The research included adults within the 18–70 age range who had mild to moderate CTS which was confirmed by conducting both nerve conduction studies (NCS) evaluations and showing clinical symptoms. The research included participants who tested positive using at least one clinical screening method including Tinel's sign or Phalen's test or Reverse Phalen's test. Patient candidates required both chronic symptoms lasting 6 months and willingness toward consenting after being fully informed about the procedure.

The research excluded patients who needed surgery for severe CTS and also excluded those who received injections or surgical treatments within 6 months and those who had polyneuropathy or radiculopathy or systemic disorders including rheumatoid arthritis and severe diabetic neuropathy. The study excluded pregnant and lactating women together with individuals who had allergies or any known contraindications to the study medications.

Sample Size and Randomization: Out of 90 participants who met the selection standards researchers split them uniformly into three equal subsets of 30 patients per group through a computerized randomization list. Sealed envelopes provided the mechanism to protect allocation concealment during the process. To protect the trial from bias the participants remained unaware of their treatment groups but the investigator administering the injections knew their allocation details.

Intervention Protocol: Ultrasound-assisted median nerve block procedures were performed at their wrist location under sterile conditions. The clinical procedure required the use of a high-frequency linear ultrasound probe (7–12 MHz) which showed the median nerve and a 22-gauge needle was inserted under real-time guidance to precisely deliver the assigned treatment. Patients in each group received a 5 mL injection although solution components differed among the groups.

Group A (Steroid + Bupivacaine): Received 2 mL bupivacaine (0.5%), 1 mL dexamethasone (4 mg/mL), and 2 mL normal saline, totaling 5 mL. Group B (5% Dextrose): Received 5 mL of 5% dextrose in sterile water.

Group C (Hyaluronidase): Received 1500 IU of hyaluronidase dissolved in 5 mL normal saline.

All injections were injected under strict aseptic techniques to reduce the risk of infection or complications.

Outcome Measures: The primary outcome of the study was pain relief, measured using the Visual Analog Scale (VAS) at baseline, 1 week, 1 month, 3 months, and 6 months post-injection. Another primary outcome included functional and symptomatic improvements,

assessed via the Boston Carpal Tunnel Questionnaire (BCTQ), which consists of the Symptom Severity Scale (SSS) and the Functional Status Scale (FSS). Secondary outcomes included nerve conduction studies (NCS) to evaluate nerve conduction velocity (NCV), distal motor latency (DML), and sensory latency and median nerve cross-sectional area (CSA) measured using ultrasound at baseline and 6 months to assess structural changes.

Follow-up and Data Collection: Participants were followed up at 1 week, 1 month, 3 months, and 6 months after the procedure. Pain scores, functional status, and electrophysiological parameters were recorded at each visit. Data collection was performed using standardized assessment tools, and all evaluations were conducted by trained clinicians to maintain consistency and reduce bias.

Ethical Considerations: The study was conducted following Good Clinical Practice (GCP) guidelines, ensuring patient safety and adherence to ethical standards. Participants had the right to withdraw from the study at any time without affecting their medical care. Any adverse events related to the procedure or medications were monitored, documented, and managed accordingly. Data confidentiality was maintained, and only authorized personnel had access to patient information.

Statistical analysis: The collected data were analyzed using IBM SPSS, version 27.0. Normality was assessed by skewness, kurtosis, Q–Q plots and Shapiro Wilk's test. Categorical variables were presented as frequency and percentage and compared by Chi square test and Fisher exact test. Continuous variables are expressed as mean and standard deviation (SD). Continuous parametric variables were compared by One-way ANOVA (between groups), and paired samples t-test (within the group), nonparametric variables compared by the Kruskal-Walli's test (between groups), and by the Wilcoxon rank-sum test (within the group). Level of significance was set at 5% and $p<0.05$ (at 95% CI) was considered significant.

RESULTS

A total of 90 patients were enrolled in the study and randomly assigned to three groups: Group A (n=30) received a combination of bupivacaine 0.5% and dexamethasone, Group B (n=30) received 5% dextrose in sterile water, and Group C (n=30) received hyaluronidase dissolved in saline solution.

The gender distribution was similar across the groups (p=0.358), with females constituting the majority in all groups. The mean age of participants was comparable among the three groups (Group A: 54.7 ± 10.14 years, Group B: 54.7 ± 12.81 years, Group C: 55.5 ± 9.23 years; p=0.949). However, there was a significant difference in mean height, with Group A participant's being taller than those in Groups B and C ($p<0.001$). No significant differences were observed in weight (p=0.466) or BMI (p=0.428) among the three groups.

All patients in the study presented with paresthesia and tingling/numbness. Other symptoms such as weakness (p=0.266), forearm pain (p=0.792), positive Tinel's sign (p=0.530), and positive Phalen's test (p=0.627) were comparable among the groups. However, a significant difference was observed in the positive Reverse Phalen test, with fewer patients in Group B showing positivity compared to Groups A and C (p=0.005). The mean duration of disease was significantly shorter in Group B (18.2 ± 4.50 months) compared to Groups A and C (22.5 ± 5.82 months and 21.4 ± 6.32 months, respectively; p=0.009).

The distribution of lesion site (right or left) was not significantly different among the groups (p=0.411). The severity of carpal tunnel syndrome (CTS) based on the Padua classification showed no significant differences, with most cases being of moderate severity across all groups (p=0.366). The prevalence of diabetes mellitus (p=0.667) and hypertension (p=0.447) was also similar among the three groups (Table 1).

Table 1. Clinical characteristics of study participants.

	Group A (n=30)		Group B (n=30)		Group C (n=30)		p value
	n	%	n	%	n	%	
Sign and symptoms							
Paresthesia	30	100.0 %	30	100.0 %	30	100.0 %	-
Weakness	16	53.3%	18	60.0%	22	73.3%	0.266
Tingling and numbness	30	100.0 %	30	100.0 %	29	96.7%	1.000
Forearm pain	23	76.7%	23	76.7%	21	70.0%	0.792
Positive Tinel sign	21	70.0%	23	76.7%	19	63.3%	0.530
Positive Phalen test	22	73.3%	24	80.0%	25	83.3%	0.627
Positive Reverse Phalen test	19	63.3%	8	26.7%	19	63.3%	0.005
Duration of disease (months), mean ± SD	22.5 ± 5.82		18.2 ± 4.50		21.4 ± 6.32		0.009
Lesion site							
Right	18	60.0%	21	70.0%	16	53.3%	0.411
Left	12	40.0%	9	30.0%	14	46.7%	
Degree of CTS (Padua)							
Mild	12	40.0%	13	43.3%	8	26.7%	0.366
Moderate	18	60.0%	17	56.7%	22	73.3%	
Co-morbidities							
Diabetes mellitus	5	16.7%	3	10.0%	6	20.0%	0.667
Hypertension	9	30.0%	14	46.7%	11	36.7%	0.447

Abbreviations: CTS: Carpal tunnel syndrome

The mean Visual Analogue Scale (VAS) scores at baseline were comparable among the groups (Group A: 7.8 ± 0.82, Group B: 7.7 ± 1.06, Group C: 7.9 ± 0.58; p=0.472). Significant reductions in VAS scores were observed at each follow-up within all groups. At one week, Group C had the lowest VAS score (4.8 ± 1.06) compared to Group A (5.5 ± 1.36) and Group B (5.0 ± 1.00), with a significant intergroup difference (p=0.040). By six months, Group C continued to show the greatest pain reduction (1.5 ± 0.57), followed by Group B (1.8 ± 0.68) and Group A (3.3 ± 1.30), with a statistically significant difference (p<0.001) as shown in table 2.

Table 2. Changes in visual analogue scale (VAS) scores over time in different treatment groups.

Visual analogue scale	Group A (n=30)	Group B (n=30)	Group C (n=30)	p value
	Mean ± SD	Mean ± SD	Mean ± SD	
Baseline	7.8 ± 0.82	7.7 ± 1.06	7.9 ± 0.58	0.472
1 week	5.5 ± 1.36*	5.0 ± 1.00*	4.8 ± 1.06*	0.040
1 month	4.2 ± 0.65*	3.5 ± 0.82*	2.9 ± 1.17*	< 0.001
3 months	3.0 ± 1.00*	2.2 ± 1.21*	2.0 ± 0.81*	< 0.001
6 months	3.3 ± 1.30*	1.8 ± 0.68*	1.5 ± 0.57*	< 0.001

(*) significant difference in comparison to basal value within the same group.

Table 3. Comparison of Boston Carpal Tunnel Syndrome Questionnaire (BCTQ) scores over time among treatment groups.

	Group A (n=30)	Group B (n=30)	Group C (n=30)	p value
	Mean ± SD	Mean ± SD	Mean ± SD	
Symptom Severity Scale (SSS)				
Baseline	3.63 ± 0.61	3.47 ± 0.46	3.72 ± 0.48	0.195
1 week	2.97 ± 0.62*	2.94 ± 0.45*	2.80 ± 0.41*	0.358
1 month	2.83 ± 0.43*	2.20 ± 0.55*	2.03 ± 0.45*	< 0.001
3 months	2.57 ± 0.46*	1.90 ± 0.35*	1.80 ± 0.38*	< 0.001
6 months	2.86 ± 0.64*	1.63 ± 0.49*	1.53 ± 0.31*	< 0.001
Functional Status Scale (FSS)				
Baseline	3.02 ± 0.43	2.87 ± 0.28	3.06 ± 0.46	0.145
1 week	2.53 ± 0.62*	2.39 ± 0.36*	2.31 ± 0.41*	0.211
1 month	2.29 ± 0.38*	1.86 ± 0.42*	1.78 ± 0.30*	< 0.001
3 months	2.12 ± 0.46*	1.59 ± 0.26*	1.50 ± 0.29*	< 0.001
6 months	2.34 ± 0.48*	1.33 ± 0.27*	1.20 ± 0.23*	< 0.001

(*) significant difference in comparison to basal value within the same group.

The Symptom Severity Scale (SSS) and Functional Status Scale (FSS) scores improved significantly over time in all groups. At six months, Group C exhibited the greatest improvement in both SSS (1.53 ± 0.31) and FSS (1.20 ± 0.23) scores compared to Group B (SSS: 1.63 ± 0.49, FSS: 1.33 ± 0.27) and Group A (SSS: 2.86 ± 0.64, FSS: 2.34 ± 0.48), with statistically significant differences (p<0.001 for all comparisons).

At baseline, nerve conduction velocity, distal motor latency, and sensory latency were comparable among the groups (p>0.05). However, at six months, Group C demonstrated the highest improvement in nerve conduction velocity (43.3 ± 4.58 m/s) compared to Group B (39.8 ± 5.21 m/s) and Group A (33.9 ± 5.78 m/s), with a significant difference (p<0.001). Similarly, distal motor latency and sensory latency showed the greatest improvements in Group C (p<0.001 and p=0.004, respectively).

Table 4. Comparison of electrophysiological parameters at baseline and 6 months among treatment groups.

	Group A (n=30)	**Group B (n=30)**	**Group C (n=30)**	**p value**
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	
Nerve conduction velocity (m/s)				
Baseline	30.3 ± 3.81	31.2 ± 5.46	29.84 ± 5.5	0.575
6 months	33.9 ± 5.78*	39.8 ± 5.21*	43.3 ± 4.5*	< 0.001
Distal motor latency (ms)				
Baseline	4.8 ± 0.52	4.7 ± 0.50	5.0 ± 0.75	0.345
6 months	4.3 ± 0.52*	3.4 ± 0.41*	3.2 ± 0.25*	< 0.001
Sensory latency (ms)				
Baseline	3.5 ± 0.54	3.4 ± 0.41	3.6 ± 0.62	0.398
6 months	3.2 ± 0.72*	2.9 ± 0.56*	2.8 ± 0.32*	0.004

(*) significant difference in comparison to basal value within the same group.

Baseline cross-sectional area measurements were similar among groups (p=0.703). At six months, all groups showed a significant reduction in median nerve cross-sectional area, with Group C exhibiting the most substantial decrease (10.8 ± 1.95 mm²), followed by Group B (11.2 ± 1.89 mm²) and Group A (13.5 ± 2.01 mm²), with a significant intergroup difference (p<0.001).

DISCUSSION

CTS is a frequent condition characterized by median nerve compression inside the carpal tunnel that makes patients experience hand and finger numbness alongside pain and tingling sensations. Our research investigated how combining steroid with bupivacaine, 5% dextrose and hyaluronidase would affect CTS symptom management.

The steroid-bupivacaine mixture led to substantial pain reduction for participants based on VAS measurements from all follow-up time points compared to initial assessment results. Past research proves that corticosteroid injections

effectively treat CTS symptoms for a short period. For example, a recent study by Khalil et al. (2024) demonstrated local corticosteroid injections resulted in improved symptoms at up to 3 months follow-up in patients with mild-to-moderate CTS compared to placebo, indicating superior symptom relief. High doses showed better long-term improvement beyond 3 months.[6] This shows that, steroid injections remain an important short-term solution for CTS but may require repeated administration for sustained benefits.[15]

The subjects who received 5% dextrose injections demonstrated important improvements in their pain levels and functional abilities. Previous researchers have suggested using dextrose prolonged therapy for treating tissue disorders because it enhances tissue repair and controls inflammation. Study by Nitya et al., shown Dextrose injections success in reducing pain, with a statistically significant reduction in VAS scores in 74% of cases.[13] Another study indicates that 5% dextrose injections are effective in reducing pain and improving function in patients with mild to moderate CTS.[16] This shows the role of dextrose as a non-steroidal alternative for long-term symptom control.[17]

The patients receiving hyaluronidase injections experienced both improved symptoms along with functional recovery. The dispersion of injected solutions through hyaluronidase treatment might maximize therapeutic benefits of other medications. The combination therapy of hyaluronidase with corticosteroids proved superior to corticosteroids alone for symptom management in patients with carpal tunnel syndrome according to Alsaeid et al. (2019).[18] This proves that hyaluronidase enhances drug distribution and could be a key factor in CTS treatments, probably by degrading hyaluronic acid in the extracellular matrix, creating channels for deeper drug penetration.[19]

The combination of steroid with bupivacaine generated the early symptom relief yet the dextrose together with hyaluronidase treatment produced gradual symptom changes over time. Prior researches indicate that corticosteroid combinations produce quick symptom reduction yet dextrose and hyaluronidase therapies lead to extended advantages. The study results matched those of Bracken (2022) who reported better pain relief from corticosteroid injections compared to other traditional treatments.[20] This shows that treatment selection should be according to patient needs, with steroids for rapid relief and dextrose/hyaluronidase for sustained improvement.[21]

Each treatment method has beneficial results but health practitioners should evaluate their adverse side effects. Corticosteroid injections deliver effective results but can also lead to serious risks including damage to tendons. The injection of dextrose poses minimal safety risks and it sometimes leads to short-term pain sensation from the injection area. During the treatment process Hyaluronidase demonstrates good tolerance levels yet very infrequent allergic reactions do happen. Study by Zhou et al., argues that proper evaluation must be made to balance both benefits and risks of CTS injection treatment.[22]

Our research strengths include using a randomized controlled approach and thorough follow-up measurements that drive validity into the analysis results. However, limitations are also present. The study utilized a small participant number that might reduce generalizing the research findings. The lack of an included placebo group in this study made it impossible to measure potential placebo effects on the study findings. Further research needs to confirm these results through studies with bigger participant samples as well as detailed placebos. Additional investigation must investigate both safety aspects and long-term benefits of these treatments while identifying appropriate medication dosages.

CONCLUSION

Patients with CTS achieved pain reduction along with functional improvements through the application of three methods which included steroid injection plus bupivacaine, 5% dextrose and hyaluronidase. The combination of steroid and bupivacaine offered patients the quickest symptom relief although 5% dextrose and hyaluronidase demonstrated enduring and continuous therapeutic benefits across time. Hyaluronidase provided the most effective reduction in sustained pain symptoms and nerve function improvement which makes it a promising therapeutic solution. Multiple factors such as patient requirements and symptoms intensity together with therapeutic objectives, help clinicians to make treatment decisions for each patient. Future research with bigger patient samples accompanied by extended observation periods should be conducted to determine best practices and prove the safety along with effectiveness of these medical approaches for CTS treatment.

ETHICAL APPROVAL

Ethical approval was granted by the Ethical Review Committee of PAF Hospital Mushaf, Sargodha, vide reference No MSF(H)/308/3/1/TRG dated: 01/06/2024.

CONFLICT OF INTEREST

Authors declare no conflict of interest.

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AUTHOR'S CONTRIBUTIONS

YH: Concept, manuscript writing, data collection
SMA, SE: Manuscript writing, literature review
HS, SB: Data collection, data analysis, critical review
All Authors: Approval of the final version of the manuscript to be published

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