

Patients Prefer Ultrasound to Nerve Conduction Studies for the Diagnosis of Carpal Tunnel Syndrome

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Background: The net promoter score (NPS) allows analysis of patient satisfaction and preference between treatment and/or diagnostic testing. Electrodiagnostic testing (EDX) and ultrasound (US) are commonly used diagnostic tests for carpal tunnel syndrome. Although EDX is reliable for diagnosing carpal tunnel syndrome (CTS), it can be uncomfortable and inconvenient for patients. We aimed to determine whether patients preferred US or EDX studies for the diagnosis of CTS, using the NPS.

Methods: Seventy-five patients presenting to the clinic for evaluation of CTS complaints who had EDX were prospectively studied. US evaluation of the median nerve was then completed at time of evaluation. Patient satisfaction was determined by asking, “how likely are you to recommend this procedure to a friend or relative?” for both EDX and US. Patient demographics, comorbidities, CTS-6 questionnaire (CTS-6), and functionality assessed through patient-reported qDASH were also recorded.

Results: Sixty-five patients were included in the study. Most patients did not have any comorbidities and were nonsmokers. The gender composition was similar, and the average age of the enrolled patients was 58. The NPS for US was significantly higher than EDX ($P < 0.0001$). Patients with diabetes mellitus rated their EDX experience significantly lower than those without diabetes mellitus.

Conclusions: Patients are more likely to recommend US instead of EDX in the evaluation of CTS complaints. This allows for shared decision-making between the patient and provider if ordering diagnostic testing for CTS. (*Plast Reconstr Surg Glob Open* 2023; 11:e5279; doi: [10.1097/GOX.0000000000005279](https://doi.org/10.1097/GOX.0000000000005279); Published online 19 September 2023.)

INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common peripheral nerve entrapment and is diagnosed through history and physical examination. Sears et al. noted that 55% of surveyed hand surgeons “always” or “usually” obtain electrodiagnostic studies (EDX) as part of the workup for a patients with suspected CTS.¹ Numerous studies²⁻⁶ have demonstrated similar or superior diagnostic accuracy of musculoskeletal ultrasound (US) when compared to EDX. US offers the ability to look at dynamic motion; therefore, there are clinically applicable methods in which to observe the motion of the flexor tendons and the median nerve in a patient with CTS because such motion differs in

patients who do not have CTS.⁷⁻⁹ US also offers the advantage of being able to detect anatomic and structural causes contributing to US that can only be detected by imaging methods and would be missed if only using EDX studies. In the setting of similar diagnostic accuracy, other factors such as cost, efficiency, and patient preference should be taken into consideration. Shared decision-making is ever important in the current climate of medicine. Thus, having a better understanding of what patients prefer is extremely useful and can increase patient satisfaction.¹⁰

The net promoter score (NPS) was first introduced in 2003 in the *Harvard Business Review* to evaluate a customer’s loyalty to a company and was used to predict a company’s financial performance.¹¹ On a scale of 1–10, customers answered one simple question, “how likely is it that you would recommend [company X] to a friend or colleague?”¹¹ Scores from 0 to 6 would be labeled as a “detractor,” scores 7 to 8 as “passively satisfied,” and scores

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9 to 10 as “promoter.” The NPS was calculated as the percentage of promoter minus detractors. Therefore, scores range from -100 to 100 with higher positive score being more favorable. Although this score continues to be used in the business world today, it has also become an attractive tool in the healthcare industry.

A variant of the NPS, the friends and family test (FFT), has also been used in healthcare. It asks how likely a patient is to recommend a medical service to a family or friend with the same condition. The NPS or FFT has been used in several orthopedic studies to measure patient satisfaction after a procedure and has been found to be a useful addition to traditional measures of patient satisfaction.^{12–19} According to Stirling et al, the FFT correlated well with postoperative hand surgery functional improvement and patient satisfaction.¹² The benefits of using the NPS in healthcare includes ease of use, high completion rates,¹³ and being well understood by most patients.²⁰ Therefore, the goal of this study is to ask patients how satisfied they were with both US and EDX for the diagnosis of CTS, using the NPS given the usefulness of US as a diagnostic modality for CTS. Our hypothesis is that patients will prefer US over EDX, given the discomfort and inconvenience associated with EDX studies.

MATERIALS AND METHODS

Following institutional review board approval, 75 patients who presented to a tertiary-care hand clinic were enrolled into the study between March 2021 and November 2021. The patients were clinically diagnosed with CTS and evaluated in the outpatient setting. The patients were at least 18 years of age. Inclusion criteria included prior upper extremity EDX within the last 3 years, which was confirmed through the electronic health record. After obtaining written consent, the median nerve cross-sectional area was measured by a trained hand fellow or attending hand surgeon using a standard protocol.²¹ After performing the US, patients were asked their willingness to recommend their procedure to a friend or family member on a scale of 0 to 100, with 100 representing full support for the procedure and 0 representing no support. The same question was then asked for EDX based on the patient’s prior experience. Each rating was used to calculate the NPS.

Demographic data including age, gender, race, and ethnicity were collected from the patients. History of comorbidities including diabetes mellitus (DM), thyroid disorders, heart disease, rheumatoid arthritis, osteoarthritis, and smoking status was also collected. Patient-reported severity measures, Quick-DASH (qDASH) and CTS-6, were also calculated. Patients without prior nerve conduction studies (EDX) or whose EDX occurred more than 3 years before their visit were excluded from the study. Patients with incomplete qDASH questionnaires were also excluded.

The NPS for US and EDX was calculated by determining the number of promoters (90–100), passives (70–80), and detractors (≤ 60). The NPS was then determined to be the percentage difference between promoters and detractors. A Wilcoxon matched-paired signed rank test was used to determine significance between the EDX and US NPS for each patient. Mann-Whitney tests were

Takeaways

Question: Do patients prefer ultrasound or nerve conduction studies for carpal tunnel syndrome diagnosis?

Findings: Patients prefer ultrasound to diagnose carpal tunnel syndrome.

Meaning: Knowing patient preference allows for shared decision-making between patient and provider when ordering diagnostic testing for carpal tunnel syndrome.

used to compare values for data that was unpaired (eg, DM diagnosis). Kruskal-Wallis tests was used to compare multiple values (eg, current smoker, nonsmoker, former smoker). Linear regression was used to assess trends (eg, qDASH and CTS-6 scores). *P* values less than 0.05 were determined to be statistically significant.

RESULTS

A total of 75 patients with CTS were enrolled in this study, but only 65 met the inclusion and exclusion criteria. Most patients did not have any comorbidities and were nonsmokers. The gender composition was similar (53.8% male) and the average age of the enrolled patients was 58.1 (Table 1).

The percentage of promoters, passives, and detractors for US was 95%, 3%, and 1.5%, respectively. For EDX, it was 17%, 8%, and 75%, respectively. Overall, the US NPS was 93.8 and EDX NPS was -58.5 (Fig. 1, $P < 0.0001$). To determine what factors may have prompted patients to rate EDX lower than US when recommending the procedure to another, each severity measure and comorbidity was compared against the EDX rating. CTS-6 and qDASH were not statistically different. (See appendix, Supplemental Digital Content 1, which shows that CTS-6 and qDASH scores were not statistically significant with respect to EDX NPS, <http://links.lww.com/PRSGO/C775>.) Moreover, EDX ratings among positive CTS-6 scores (≥ 12.5) and negative scores (< 12.5) were not different. (See appendix, Supplemental Digital Content 2, which shows that all EDX scores with respect to the comorbidities were not significant, <http://links.lww.com/PRSGO/C776>.) All EDX scores with respect to the comorbidities were not significant (Supplemental Digital Content 2, <http://links.lww.com/PRSGO/C776>), except for whether the patients had diabetes and if they were former smokers. Patients with DM rated their EDX significantly lower than those without DM (patients with DM, 13 and without DM, 52; $P = 0.04$) (Fig. 2). Patients who were former smokers rated their EDX significantly lower than nonsmokers (former smokers, 19 and nonsmokers, 39; $P = 0.003$). Despite the significance, this analysis was not included in the main findings of the paper given the small sample size.

DISCUSSION

The NPS for US and EDX was 93.8 and -58.5, respectively. Given that NPS ranges from -100 to 100, it suggests that nearly all patients would recommend getting US for

Table 1. Demographic Data for All Patients (n = 65)

Demographics	
Age, y (mean ± SD)	58.1 ± 13.2
Sex (%)	
Male	53.8
Female	46.2
Race (%)	
American Indian/Native	1.54
Asian	1.54
Black/African American	10.8
White	86.1
Ethnicity (%)	
Hispanic	6.15
Non-Hispanic	92.31
Other	1.54
DM (%)	
Yes	20.0
No	80.0
Thyroid disorder (%)	
Yes	13.8
No	86.2
Heart disease (%)	
Yes	10.8
No	89.2
Rheumatoid arthritis (%)	
Yes	7.69
No	92.3
Osteoarthritis (%)	
Yes	43.1
No	56.9
Smoking status (%)	
Current smoker	10.8
Former smoker	29.2
Never smoked	60.0

Most patients did not have any comorbidities and were nonsmokers. The gender composition was similar (53.8% male), and the average age of the enrolled patients was 58.1.

detection of CTS to family or friends. In contrast, most patients would not recommend an EDX for the diagnosis of CTS. Moreover, neither CTS-6 nor qDASH scores correlated with EDX NPS ratings, which implies EDX is disliked as a diagnostic tool regardless of the patient’s CTS severity. Similar findings were found in other studies that used NPS to determine patient preference after

different orthopedic procedures, which found no significance among NPS with respect to qDASH.^{12,13} Patients with thyroid disorders, heart disease, rheumatoid arthritis, osteoarthritis, and who were current smokers did not significantly rate their experience with EDX significantly different from those without the comorbidity. Again, this suggests that EDX is overall less favored compared to US for CTS diagnosis; patients would recommend US over EDX to family and friends if given the option. These findings are likely because EDX is an uncomfortable, painful, and lengthy procedure that may require a separate appointment. In contrast, US offers a painless, quick, and portable bedside diagnostic tool that can be completed when patients present to the clinic for the first time with CTS symptoms.

Patients with DM rated EDX significantly lower than patients without DM. This may suggest having DM predisposes patients toward having more pain during EDX, or perhaps, more testing is needed given their underlying diagnosis. Although prior studies suggest that patients with DM may be more averse to EDX because they often require higher stimulus intensity.²² Our study did not control for the stimulus intensity or needles used during EDX, which could have skewed these results. However, EDX needle size was not shown to significantly influence pain experienced during EDX.²³

There were several limitations with this study. The first is that the study assumed that US and EDX provide the same diagnostic capabilities, and patients were told to base their ratings on this assumption. However, it is unknown whether the use of US is indeed comparable to EDX. Several studies have already been conducted on this topic and suggest they are comparable.²⁻⁶ Nevertheless, more research is needed on the wider scale. Additionally, all comorbidities were patient reported and thus had subjective interpretation by the patient. Patients were asked directly after receiving US about their willingness to recommend the procedure to family or friends; however, they had to recall their experiences from the EDX to answer the same question. We tried to minimize the recall bias by only including patients who had their EDX within the last 3 years. The sample size was also small for patients with diabetes, which increases the variability we observed in this groups. However, given that the NPS magnitude for

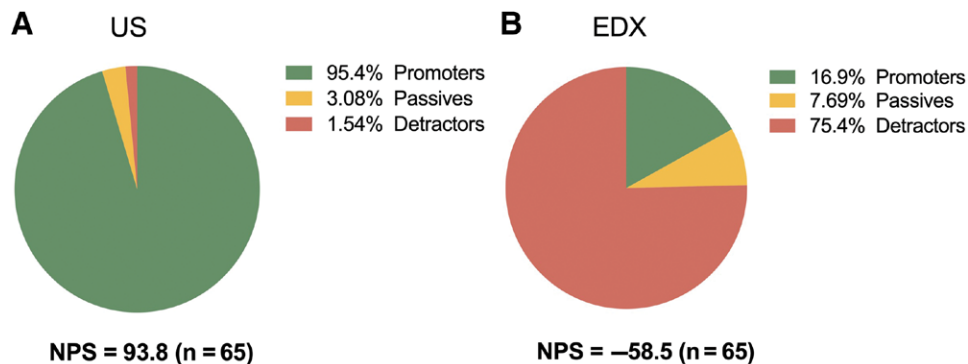


Fig. 1. The number of promoters, passives, and detractors for US (A) vs EDX (B). The NPS for US and EDX was 93.8 and -58.5, respectively.

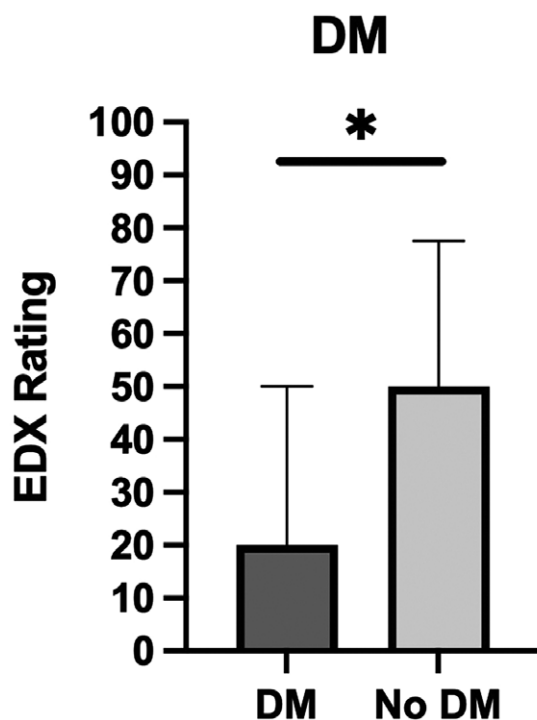


Fig. 2. Patients with DM rated their EDX significantly lower than those without DM ($P = 0.0383$, where $*P \leq 0.05$). Patients with DM and without DM had $n = 13$ and 52 , respectively. Median with interquartile range.

US and EDX were vastly different, this result can be determined to be statistically significant even in the presence of this variability.

Future work includes calculating the NPS in patients who received ultrasound that was not diagnostic first and were then referred for EDX. The NPS between EDX and US may not be as starkly different in this scenario, as EDX was necessary for diagnosis after failed US. Future studies should also aim to include a larger sample size of patients with objective measurements of comorbidities. In summary, this study clearly demonstrates that patients prefer US over EDX for the diagnosis of CTS. This knowledge allows for shared decision-making between patient and provider when ordering diagnostic testing.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

PATIENT CONSENT

Informed consent was obtained from all individual participants included in the study.

DECLARATION OF HELSINKI

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Declaration of Helsinki of 1975, as revised in 2008.

REFERENCES

- Sears ED, Lu Y-T, Wood SM, et al. Diagnostic testing requested before surgical evaluation for carpal tunnel syndrome. *J Hand Surg Am.* 2017;42:623–629.e1.
- Ashraf AR, Jali R, Moghtaderi AR, et al. The diagnostic value of ultrasonography in patients with electrophysiologically confirmed carpal tunnel syndrome. *Electromyogr Clin Neurophysiol.* 2009;49:3–8.
- El Miedany YM, Aty SA, Ashour S. Ultrasonography versus nerve conduction study in patients with carpal tunnel syndrome: substantive or complementary tests? *Rheumatology.* 2004;43:887–895.
- Kwon BC, Jung KI, Baek GH. Comparison of sonography and electrodiagnostic testing in the diagnosis of carpal tunnel syndrome. *J Hand Surg Am.* 2008;33:65–71.
- Moran L, Perez M, Esteban A, et al. Sonographic measurement of cross-sectional area of the median nerve in the diagnosis of carpal tunnel syndrome: Correlation with nerve conduction studies. *J Clin Ultrasound.* 2009;37:125–131.
- Visser LH, Smidt MH, Lee ML. High-resolution sonography versus EMG in the diagnosis of carpal tunnel syndrome. *J Neurol Neurosurg Psychiatry.* 2008;79:63–67.
- Erel E, Dilley A, Greening J, et al. Longitudinal sliding of the median nerve in patients with carpal tunnel syndrome. *J Hand Surg Am.* 2003;28:439–443.
- Greening J, Lynn B, Leary R, et al. The use of ultrasound imaging to demonstrate reduced movement of the median nerve during wrist flexion in patients with non-specific arm pain. *J Hand Surg Am.* 2001;26:401–406; discussion 407.
- Yoshii Y, Villarraga HR, Henderson J, et al. Ultrasound assessment of the displacement and deformation of the median nerve in the human carpal tunnel with active finger motion. *J Bone Joint Surg Am.* 2009;91:2922–2930.
- Milky G, Thomas J. Shared decision making, satisfaction with care and medication adherence among patients with diabetes. *Patient Educ Couns.* 2020;103:661–669.
- Grisaffe DB. Questions about the ultimate question: conceptual considerations in evaluating Reichheld's net promoter score. *J Consum Satisf Dissatisfaction Complain Behav.* 2007;20:36–53.
- Stirling P, Jenkins PJ, Clement ND, et al. The net promoter scores with friends and family test after four hand surgery procedures. *J Hand Surg Eur Vol.* 2019;44:290–295.
- Hamilton DF, Lane JV, Gaston P, et al. Assessing treatment outcomes using a single question. *Bone Joint J.* 2014;96-B:622–628.
- Kohli R, Gupta A. A cross-sectional study to assess quality of care and patient satisfaction using TheraNow telerehabilitation program post-THR and TKR surgeries. *J Sci Res Med Biol Sci.* 2022;3:28–33.
- Stirling PHC, Oliver WM, Ng N, et al. Distal radius malunion: outcomes following an ulnar shortening osteotomy. *Eur J Orthop Surg Traumatol.* 2022;33:1635–1640.
- Stirling PHC, Yeoman TFM, Duckworth AD, et al. Decompression for recurrent carpal tunnel syndrome provides significant functional improvement and patient satisfaction. *J Hand Surg Eur Vol.* 2020;45:250–254.
- Nicholson JA, Searle HKC, MacDonald D, et al. Cost-effectiveness and satisfaction following arthroscopic rotator cuff repair. *Bone Joint J.* 2019;101-B:860–866.
- Hoorntje A, Koenraadt KLM, Boevé MG, et al. Outpatient unicompartmental knee arthroplasty: who is afraid of

- outpatient surgery? *Knee Surg Sport Traumatol Arthrosc.* 2017;25:759–766.
19. Maempel JF, Ting JZ, Gaston P. Assessing the outcome of hip arthroscopy for labral tears in femoroacetabular impingement using the minimum dataset of the British non-arthroplasty hip register: a single-surgeon experience. *Arthrosc J Arthrosc Relat Surg.* 2018;34:2131–2139.
 20. Koladycz R, Fernandez G, Gray K, et al. The net promoter score (NPS) for insight into client experiences in sexual and reproductive health clinics. *Glob Heal Sci Pract.* 2018;6:413–424.
 21. Fowler JR, Munsch M, Tosti R, et al. Comparison of ultrasound and electrodiagnostic testing for diagnosis of carpal tunnel syndrome: study using a validated clinical tool as the reference standard. *J Bone Joint Surg Am.* 2014;96:e148.
 22. Jerath NU, Strader SB, Reddy CG, et al. Factors influencing aversion to specific electrodiagnostic studies. *Brain Behav.* 2014;4:698–702.
 23. Wee AS, Boyne RL, Abernathy SD, et al. Pain perception to nerve conduction and needle electromyographic procedures. *J Miss State Med Assoc.* 2004;45:327–330.