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Shear Wave Elastography of the Sural Nerve in Healthy Subjects: A Pilot Study

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Abstract

The goal of this study is to evaluate the potential ability of shear wave elastography (SWE) to evaluate the sural nerve (SN) in healthy subjects.

***Methods and Results*:** Thirty-six SNs were evaluated in 18 healthy adult subjects. Subjects were examined in the prone position with the ankle in the neutral position, and the knees fully extended; a linear transducer was used [L18-4, MHZ] (EPIQ Elite SW 5.0.1, Philips). Nerve conduction studies were performed with the Nihon-Cohden Neuropack device. The mean cross sectional area of the SN at both sides was 4.03±1.16 mm^2. The mean shear elastic modulus of the right SN in the short axis was 24.92±6.08 kPa, while in the long axis it was 26.45±5.66 kPa. The mean shear elastic modulus of the left SN in the short axis was 24.1±4.1 kPa [range 19-33.13], while in the long axis it was 23.9±4.9 kPa [range 16.4-30.77]. The cross sectional area of the SN correlated positively with height (P<0.05), weight (P<0.001), and body mass index (P<0.01).

Conclusion: SWE could play a complementary role in future evaluation of SN pathologies. (**International Journal of Biomedicine. 2022;12(1):34-37.**)

Key Words: sural nerve • shear wave elastography • body mass index

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Abbreviations

BMI, body mass index; **CSA**, cross sectional area; **LA**, long axis; **SA**, short axis; **SN**, sural nerve; **SWE**, shear wave elastography.

Introduction

The sural nerve (SN) is a small sensory nerve, which is formed by a branch of the common fibular nerve (lateral sural cutaneous nerve) and a branch of the tibial nerve (medial sural cutaneous nerve). It supplies the skin of the lateral side of the foot and the lateral and posterior part of the inferior third of the leg.[1-3] Anatomical and topographical variations are common. Union of the SN roots can occur at the proximal part of the calf, although occasionally, more distal fusion can be seen.

During its course, the SN has a close relationship with the short saphenous vein and the Achilles tendon.[1-5] The SN is essential in several clinical situations. In nerve conduction studies, it is used to diagnose polyneuropathies like sciatic and tibial neuropathies, as well as lumbosacral plexopathies.[6-11] Also, the SN biopsy represents the mainstay in the diagnostic workup of some other types of peripheral nerve diseases.[12,13] Nerve graft procedures are another important use of the SN.[1] Ultrasound was used for more than two decades to assess the musculoskeletal system. It is a non-invasive, fast, and dynamic diagnostic technique. These features favor its use over magnetic resonance imaging for a small nerve like the SN. Sonoelastography was first described in the 1990s to detect tissue stiffness. Two main types of elastography are present at the moment. The first is strain elastography, where mild pressure is applied by a probe to estimate the tissue stiffness, resulting in qualitative and semi-quantitative values. The other type is SWE, where the probe induces a pulse that propagates waves in a transverse manner with resultant attenuation by the different target tissues. The amount of stiffness is related to the velocity of wave propagation. SWE is now widely used in evaluating many organs, such as the liver, breast, and thyroid gland. Recently it has been introduced to assess the musculoskeletal and peripheral nervous systems.[14-24] The goal of this study is to evaluate the potential ability of SWE to evaluate the SN in healthy subjects.

Materials and Methods

Thirty-six SNs were evaluated in 18 healthy adult subjects. After obtaining institutional review board approval, subjects were recruited between September 2019 and December 2019, and written consent was obtained. Our inclusion criteria were healthy male or female, age range of 24-46. The following were excluded in each subject: the presence of pain due to neuropathy, limb weakness, trauma to the lower limb. Demographic data were obtained for all subjects.

Subjects were examined in the prone position with the ankle in the neutral position, and the knees fully extended; a linear transducer was used [L18-4, MHZ] (EPIQ Elite SW 5.0.1, Philips). An experienced radiologist performed all studies; images were reviewed by a neurologist. The SN was first scanned in the axial scan above the level of the lateral malleolus and lateral to the lesser saphenous vein, and then the CSA was measured. For the SWE measurements, each subject was scanned three separate times. A confidence map was used to increase the reliability of the study. After axial scanning and the SWE measurements were taken, the transducer was rotated 90º for longitudinal SWE measurements. When the nerve was identified, the transducer was held stationary for 4 seconds with the region of interest diameter measuring 2mm and placed within the hyperechoic epineurium. Average, median, and maximum elasticity were recorded in kPa. The color scale was set at a 0 to 200 kPa. The blue color was set for soft tissues and red for stiff tissues (Figures 1 and 2).

Nerve conduction studies were performed with the Nihon-Cohden Neuropack device. An expert neurologist performed electrodiagnostic studies. All studies were performed at optimal room temperature.

Statistical analysis was performed using the standard Statistical Package for the Social Sciences (IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp). Inter-observer agreement was measured using Cohen's kappa (k) statistic. Continuous variables were presented as mean±standard deviation (SD). For data with normal distribution, inter-group comparisons were performed using Student's t-test. The frequencies of categorical variables were compared using Pearson's chi-squared test A probability value of P<0.05 was considered statistically significant.

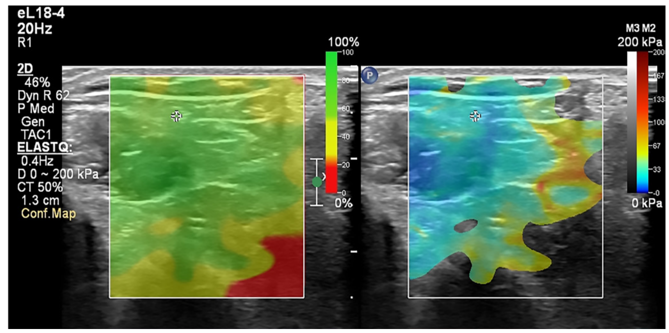

Fig. 1. Axial scan view of the sural nerve shear wave elastography with stiffness measurement in kPa.

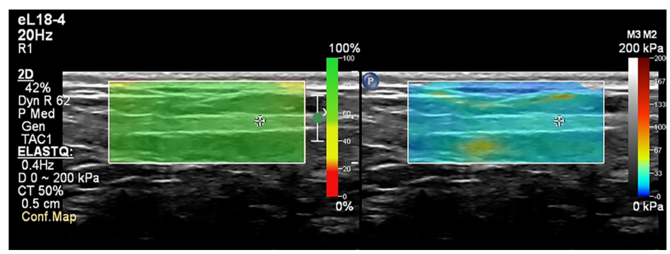

Fig. 2. Longitudinal view of the sural nerve shear wave elastography with stiffness measurement in kPa.

Results

Our study included 18 healthy adult subjects, with a mean age of 32.67±7.07 years [range 24-46], mean height - 157.89±8.29 cm [range 144-177], mean weight - 60.67±9.15 kg [range 43-84], mean BMI - 4.27±2.58 kg/m^2 [range 20.7-30.9]. Table 1 shows CSA and stiffness estimates of the SN. Table 2 shows descriptive statistics used in our study. The intra-observer reliability calculations resulted in an overall intra-class correlation coefficient of 0.80. The mean CSA of the SN at both sides was 4.03±1.16 mm^2 [range 2-7]. The mean CSA area of the right SN was 4±1.3 mm^2 [range 2-7]. The mean shear elastic modulus of the right SN in the SA was 24.92±6.08 kPa [range 14.3-34.9], while in the LA it was 26.45±5.66 kPa [range 11-34.5]. The mean CSA of the left SN was 4.04±1.03 mm^2 [range 2.3-6.1]. The mean shear elastic modulus of the left SN in the SA was 24.1±4.1 kPa [range 19-33.13], while in the LA it was 23.9±4.9 kPa [range 16.4-30.77]. No statistical differences were noted between the right and left sides regarding the CSA (*P*=0.955), shear wave elastic modulus of the SN in the SA (*P*=0.635), and shear wave elastic modulus of the SN in the LA (*P*=0.152). The CSA of the SN correlated positively with height (*P*<0.05), weight (*P*<0.001), and BMI (*P*<0.01). No correlation was noted between CSA and age in our study. No statistical relation could be noted between elasticity measurements in long and short axes. The SN elastic modulus also showed no correlation with CSA in the LA nor SA. Height, weight, and BMI showed no correlation with SN elastic modulus in short or long axes. Only age showed a negative correlation with LA measurements.

Table 1.
CSA and shear elastic modulus of the sural nerve

	Right	Left	P-value
CSA Mean ±SD Minimum / Maximum	4±1.3 2 / 7	4±1.0 2.3 / 6.1	0.955
SA Mean ±SD Minimum / Maximum	24.9± 6.08 14.3 / 34.9	24.1±4.1 19 / 33.1	0.635
LA Mean ±SD Minimum / Maximum	26.5±5.66 11 / 34.5	23.9±4.9 16.4 / 30.8	0.152

CSA in mm^2; LA- Long axis stiffness in kPa; SA- Short axis stiffness in kPa

Table 2.
Correlations between age, weight, height, and BMI, with CSA, and elastic modulus of the SN in long and short axis

		Sural CSA	Sural SA	Sural LA
Age	Pearson Correlation	.127	-.216	-.402
	Sig. (2-tailed)	.460	.205	.015
	n	36	36	36
Height	Pearson Correlation	.331	.171	.095
	Sig. (2-tailed)	.049	.318	.581
	n	36	36	36
Weight	Pearson Correlation	.573	.268	.197
	Sig. (2-tailed)	.000	.114	.248
	n	36	36	36
BMI	Pearson Correlation	.491	.201	.179
	Sig. (2-tailed)	.002	.240	.297
	n	36	36	36
Sural CSA	Pearson Correlation	1	.196	.186
	Sig. (2-tailed)		.252	.277
	n	36	36	36
Sural SA	Pearson Correlation	.196	1	.192
	Sig. (2-tailed)	.252		.263
	n	36	36	36
Sural LA	Pearson Correlation	.186	.192	1
	Sig. (2-tailed)	.277	.263	
	n	36	36	36

Discussion

In the last decade, several studies considered major peripheral nerves by SWE. Kantraci et al. [25] studied the median nerve SWE proximal to the carpal tunnel and revealed a mean stiffness of 32 kPa. Paluch et al. studied the ulnar nerve at different levels of the arm and forearm, with mean stiffness of 33 kPa [range 19-52].[26,27] He et al.[28] studied the median nerve at the forearm with a mean stiffness of 35 kPa, as well as the tibial nerve, which showed a mean stiffness value of 36.5 kPa. These values are comparable to the mean stiffness of the SN in our study [SA=24.5 kPa, LA=25.2 kPa], especially when we consider the small size of the SN. Several obstacles were reported when scanning the peripheral nerves with SWE. For example, nerve stiffness can vary substantially with different limb positions and different magnitudes in the upper or lower limb.[29] Another important factor is the position of the nerve and proximity to the bone, with the possibility of repetitive compression.[30] Some authors reported the importance of probe orientation, whether it is only in SA or both long and short axes. In the study done by Aslan et al.,[31] the elastography values were higher when taken on LA than on SA. No difference in the stiffness values between long and short axes was noted in our study. We believe that we cannot generalize this fact and apply it to other nerves that are in close proximity to bone, like the radial nerve in the spiral groove or the common fibular nerve in relation to the fibular neck. In these sites, we expect higher values on LA views. Limitations of this study include the following: First, small sample size limits generalization of our results; second, the female gender dominated and the age range was narrow; third, the SN was scanned at a single location; fourth, the study included healthy subjects. Further larger caliber studies, including variable pathologies of the SN, including mononeuropathy and polyneuropathies, are encouraged.

In conclusion, we believe that SWE could play a complementary role in future evaluation of SN pathologies.

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Competing Interests

The authors declare that they have no competing interests.

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