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RESEARCH

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Neurophysiologic evaluation of patients with cervical spondylotic myelopathy

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Abstract

Background: Cervical spondylotic myelopathy (CSM) is a neurodegenerative disease caused by repetitive spinal cord damage that has resulted in significant clinical morbidity. The clinical evaluation of signs and symptoms, as well as neuroimaging and several neurophysiological tests, are used to make the diagnosis.

Objectives: To investigate changes in the cutaneous silent period (CuSP), cortical silent period (CoSP), and H-reflex in CSM patients, and to correlate these tests with the Japanese Orthopedic Association (JOA) score and Nurick's grading, as well as to determine the diagnostic value of each of them.

Methods: Twenty patients (14 males and 6 females) with CSM were clinically diagnosed and documented by magnetic resonance imaging (MRI), and they were paired with another 20 healthy volunteers (13 males and 7 females) as a control group. CuSP, CoSP, and H-reflex tests were performed on both groups.

Results: In CSM patients, CuSP latency and duration are substantially longer and shorter in CSM patients, respectively. The degree of changes in CuSP latency is well correlated with the severity of the disease. Further, CoSP duration is significantly shortened. The H-reflex parameters did not differ significantly between the patient and control groups.

Conclusion: The shortened CoSP's duration and the prolonged CuSP's latency suggest malfunction of the inhibitory and excitatory circuits in the spinal cord. The CuSP is more sensitive and specific than the CoSP in the diagnosis of a patient with CSM.

Keywords: Cervical spondylotic myelopathy, Cutaneous silent period, Cortical silent period, H-reflex

Introduction

Cervical spondylosis is a degenerative disease that affects the vertebrae, intervertebral disks, facets, and related ligaments. Through direct compression of the spinal cord and/or adjacent blood vessels, the degenerative changes cause cervical spondylotic myelopathy (CSM) [1].

CSM is the most prevalent type of spinal cord injury in adults [2], affecting roughly 100% of individuals with more than 60% canal stenosis [3]. Compressive factors on the spine are involved in the pathophysiology of CSM, which is caused by a mixture of static and dynamic stressors [4].

The clinical sequelae of CSM include a wide range of motor and sensory impairments caused by cervical spinal cord dysfunction [5].

CSM is mostly diagnosed through a combination of history and clinical examination [6]. However, sensory–motor deficits and reflex alterations in the upper limbs are not always present, and physical examination findings are not always consistent with disease severity [7]; in these circumstances, CSM can be mistaken with other degenerative diseases.

Nurick's grading scale [8] and the modified Japanese Orthopedic Association (mJOA) scores [9] were used to determine disease severity. However, according to evaluation standards, there are various issues with JOA

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ratings, including the fact that they do not represent the patient's self-evaluation of pain, numbness, and health status and they are evaluated solely from the physician's perspective [10].

In these patients, magnetic resonance imaging (MRI) is usually the study of choice since it can show or rule out spinal cord compression. MRI of the spinal cord can detect signal aberrations at the level of cord compression, however it provides no precise information on cervical cord dysfunction in CSM, as radiological data are inconsistent with clinical status in 50% of cases [11].

On the other hand, neuroimaging is not always totally reliable for determining a diagnosis, and MRI cannot assess the functional involvement of the spinal cord. Thus, neurophysiological evaluation by various types of electrodiagnostic procedures may be regarded as a necessary reconcile between clinical assessment and radiographic investigations [12, 13].

The objectives of this study are to study the cutaneous silent period (CuSP), cortical silent period (CoSP), and H-reflex in patients with CSM, to score the sensory and motor deficits using the mJOA score and Nurick's grading, to correlate the different neurophysiological tests with the mJOA score, and to assess the diagnostic utility of each neurophysiological tests.

Methods

This is a case–control study conducted from January 2021 to November 2021, at the neurophysiology department of Al-Imamian Al-Kadhemian Medical City, Baghdad. The Iraqi Committee of Medical Specialization approved the study (Decision No. 291; Date 21/1/2021). All subjects who took part in this study gave their consent.

The study included 20 patients of either sex aged 40 to 70 years who have CSM, diagnosed by senior neurosurgeon and documented by MRI. An abductor pollicis brevis (APB) muscle power of grade ≥ 4 according to the Medical Research Council (MRC) scale was ensured for all patients prior to their inclusion in the study.

Patients with a history of cervical surgery, peripheral neuropathy, diabetes, spinal cord lesions, pregnancy, central nervous system disorders, restless leg syndrome, motor neuron disease, fibromyalgia, and epilepsy, brain surgery, the presence of a pacemaker, or any metallic foreign body in the body were all excluded from the study.

The control group consists of another 20 sex- and age-matched healthy volunteers.

Clinical evaluation

The Nurick grading scale and the modified scale of the Japanese Orthopedic Association (mJOA) system were used to assess functional neurological state. Nurick's grading [8] is as follow: grade 0 = signs and symptoms of root involvement without spinal cord disease; grade 1 = signs of spinal cord disease without difficulty in walking; grade 2 = slight difficulty in walking that does not prevent full-time employment; grade 3 = difficulty in walking that prevents full-time employment or daily takes without requiring assistance with walking; grade 4 = ability to walk only with assistance; and grade 5 = chair bound or bedridden. The lower grades indicating better walking ability.

For the mJOA [9], it is a questionnaire that assesses six functions: motor dysfunction in the upper and lower extremities (0–4), sensory function in the upper and lower extremities (0–2), sensory function in the trunk (0–2), and bladder function (0–3). The sum of these subscales varies from 0 to 17, with a minimum score of 0 being the lowest and a maximum score of 17 being the highest. CSM cores 15–17 for mild, 12–14 for moderate, and 0–11 for severe cases [14].

Cervical spine imaging

A comprehensive radiological evaluation of the cervical spine was performed, which included X-rays to identify spinal cord compressing pathology in the cervical area and MRI with a Siemens (MAGNETOM Aera 1.5T MRI) MRI machine using T1 and T2 sagittal, T2 axial, coronomyelo, sagitto-myelo sections.

Neurophysiological studies

The CuSP and H-reflex measurements were performed using a four-channel electromyography (EMG) equipment (Medtronic, Denmark). Room temperature was monitored between 25 and 28 °C during test procedures and skin temperature between 32 and 34 °C was ensured using a skin thermometer.

For the CuSP, ring electrodes were applied to stimulate the index finger, and EMG activity was recorded using surface electrodes from the APB with filter setting of 2 Hz–10 kHz.

Participants were asked to make an opposition of the right thumb to obtain a steady maximal contraction, and an EMG audiosignal was used to monitor muscle contraction. A single painful stimulus (80-mA intensity) with a 0.5-ms duration was delivered to the index finger during maximal voluntary contraction until a complete silent period of consistent latency and duration was attained. The experiment was repeated at least ten times until we obtained five ideal recordings demonstrating total silence of the motor unit potential with the longest duration and shortest delay.

We chose the mean value of the five best CuSPs as the final value for CuSP parameters in each subject to reduce any variation in CuSP parameters. The interval between stimulation and the start of the silent period

was characterized as CuSP latency. The time between the start and end of the silent period was specified as CuSP duration. Visual assessment at the start of an abrupt reduction or upon recovery of EMG activity determined the onset and endpoint latencies of each CuSP [15].

To measure H-reflex, participants were sitting comfortably with their forearms on a table in front of them. Surface recording electrodes were used to capture the H-reflex of the flexor carpi radialis. The active electrode was put over the flexor carpi radialis muscle belly, and the reference electrode was placed over the brachioradialis, away from other forearm median-innervated muscles. A bipolar felt pad electrode was used to stimulate the median nerve just proximal to the elbow (cathode proximal, pulse width 0.5 ms). The ground electrode lies between the stimulator and the recording electrode [16].

Responses to median nerve stimulation were identified as H-reflexes if they had latencies between 12 and 25 ms. Five H-responses were analyzed to ensure that they were repeatable. After correcting for height (or limb length), latencies were determined from the onset of stimulus artifact until the start of the reflex response. The amplitudes were measured from the baseline to the highest negative peak and H/M amplitude ratio was calculated.

An EMG equipment (Micromed, Italy) was used for CoSP. Each participant sat on a comfortable chair. Three brief maximal voluntary isometric contractions (5 s) starting off the test. To avoid exhaustion, maximum efforts were spaced by approximately 60 s of rest. The subjects next performed isometric contractions, which resulted in the firing of one or two single motor units that could be identified.

The appropriate region of the hemisphere for APB muscle was stimulated with a transcranial magnetic stimulator (Magstim 2002, Magstim Co., Whitland, UK) using circular coil electrode with a 90-mm diameter (type 9784, UK). The stimulation site on the head was determined utilizing suprathreshold stimuli around the C3 region, as per the international 10–20 system [17].

During a weak isometric contraction of the contralateral APB muscle, five to ten random (between 4 and 6 s) single pulse transcranial magnetic stimulation at an intensity of roughly 140% of resting motor threshold were applied. The best location was then identified and used throughout the experiment [18].

To reduce variability, the individual was requested to maximally contract the APB muscle against resistance, then a single suprathreshold transcranial magnetic stimulation pulse was given to the motor cortex, followed by at least five repeatable responses. We looked for motor evoked potentials (MEPs) with the shortest latency and maximum amplitude. The duration of CoSP is measured from the start of muscle activity suppression to the return of muscle activity. 30-Hz low filter and 30-kHz high filter settings were employed.

Statistical analysis

For all statistical studies, statistical package of social sciences (SPSS) software version 25.0 was utilized (SPSS, Chicago). Continuous data were expressed as mean ± SD and analyzed with a Student's *t*-test (between two groups) or an analysis of variance with least significant difference as a post hoc pairwise comparison (between more than two groups).

Categorical variables were expressed as numbers and percentages. The receiver operating characteristic curve was used to find out the discriminative value of some parameters to differentiate between patients and controls. The possible association of neurophysiological measures with age, disease duration, arm length, and JOA score was investigated using Pearson's correlation test. When the *p*-value was less than 0.05, the difference was considered statistically significant.

Results

Demographic data

Table 1 shows the demographic data of the study population. There was no significant difference between the patients and the control groups in terms of age, gender, or occupation.

Regarding the patients' clinical characteristics, all of them had progressing myelopathy with varied degrees of decreased sensorimotor function in both the upper and lower extremities, as well as bladder dysfunction. Table 2 shows that the mean disease duration was 20.1 months (range: 6–84 months). According to the mJOA score, seven patients (35%) had mild disabilities, eight (40%)

Table 1 Demographic data of the study population

Characteristics	Patients $N=20$	Controls $N=20$	*p*-value
Age, years			
Mean ± SD	55.25 ± 10.08	51.85 ± 9.17	0.272
Gender			
Male	14(70%)	13(65%)	0.727
Female	6(30%)	7(35%)	
Occupation			
Workers	6(30%)	3(15%)	0.233
Housewives	5(25%)	9(45%)	
Officers	4(20%)	1(5%)	
Others	5(25%)	7(35%)	
Arm length, cm			
Mean ± SD	89.1 ± 5.12	88.33 ± 6.05	0.664
Range	82–98	80–102	

Table 2 Clinical characteristics of the patients

Characteristic	
Disease duration, months	
Mean ± SD	22.1 ± 26.3
Range	6–84
Disability by mJOA score	
Mean ± SD	13.15 ± 1.9
Range	9–16
Mild	7(35%)
Moderate	8(40%)
Severe	5(25%)
Nurick grade	
Grade 1	2(10%)
Grade 2	10(50%)
Grade 3	7(35%)
Grade 4	1(5%)
MRI lesion	
C3–C4	4(20%)
C4–C5	4(20%)
C5–C6	9(45%)
C6–C7	3(15%)

mJOA modified Japanese Orthopedic Association, *MRI* magnetic resonance imaging

had moderate disabilities, and five (25%) had severe disabilities. According to Nurick's grading, 2% of the patients were in grade 1, 10% in grade II, 7% in grade III, and the remaining 5% in grade IV.

All 20 individuals had pathologic abnormalities on their cervical MRIs. C3–C4 compression was seen in four (20%) patients, C4–C5 compression in four (20%) patients, C5–C6 compression in nine (45%) patients, and C6–C7 compression in three (15%) patients.

Neurophysiological data

Three patients, one with severe disability (mJOA score = 0–11), and two with moderate disability (mJOA = 12–14), had absent H-reflex. The neurophysiological data of the study population are shown in Table 3. CuSP onset in the CSM group was 82.9 ± 15.45 mesc which is considerably longer than 77.04 ± 8.27 ms of the control group ($p = 0.008$). CuSP on the other hand, has a duration of 32.72 ± 7.27 ms which is significantly less than 46.37 ± 5.43 ms of the control group ($p < 0.001$).

Moreover, the duration of CoSP of the patient group equals 53.28 ± 14.35 ms which was also shorter than 86.13 ± 20.79 ms of the control group ($p < 0.001$). The onset of CoSP, on the other hand, did not differ among the groups studied ($p = 0.953$). Likewise, there was no difference in H-reflex latency or H/M amplitude ratio between the two groups ($p = 0.075$; $p = 0.154$), respectively.

Table 3 Comparison of neurophysiological data in the study population

Characteristics	Patients *N* = 20 Mean ± SD	Controls *N* = 20 Mean ± SD	*p*-value
H-reflex latency, ms	17.87 ± 2.17	16.69 ± 1.76	0.075
H/M amplitude ratio	0.32 ± 0.2	0.25 ± 0.11	0.154
CuSP onset, ms	82.9 ± 15.45	77.04 ± 8.27	**0.008***
CuSP duration, ms	32.72 ± 7.27	46.37 ± 5.43	**< 0.001***
CoSP onset, ms	53.82 ± 8.54	54.0 ± 10.92	0.953
CoSP duration, ms	53.28 ± 14.35	86.13 ± 20.79	**< 0.001***

CuSP cutaneous silent period, *CoSP* cortical silent period, *Statistically significant at ≤ 0.05

As indicated in Table 4, no significant correlation was found between the various neurophysiological variables and any of the different parameters of patients (such as age, disease duration, arm length, and mJOA score).

Table 5 shows that gender was significantly associated with the H/M amplitude ratio being higher in males than females ($p = 0.046$) when testing for a possible association between the dichotomous factors and neurophysiological parameters (if any) within the patient group. In addition, the onset of CuSP was correlated with Nurick grade IV ($p = 0.011$). Furthermore, the CuSP duration was shown to be associated with the C6-7 MRI lesion site ($p = 0.037$).

The diagnostic values of CuSP onset, CuSP duration, and CoSP duration in the context of discrimination between patients and controls were determined using the receiver operating characteristic curve. The area under the curve (AUC) for CuSP onset was 0.754, 95% CI 0.597–0.911, $p = 0.006$. At a cut-off value of CuSP onset = 73.9 ms, the test's sensitivity and specificity were 75% and 65%, respectively, as shown in Fig. 1.

The AUC for CuSP duration was 0.943, 95% CI 0.856–1.0, $p < 0.001$. At a cut-off value of CuSP duration = 40.4 ms, the test's sensitivity and specificity were 80% and 90%, respectively. The AUC for CoSP duration was 0.903, 95% CI 0.813–0.992, $p < 0.001$. At a cut-off value of CoSP duration = 69.5 ms, the test's sensitivity and specificity were both 80% as shown in Fig. 2.

Discussion

The natural course of CSM is quite variable. Although myelopathic signs are an integral component of clinical diagnosis of CSM, however, they are not very sensitive and may be absent in about 20% of myelopathic patients. Thus, signal changes on MRI and some

Table 4 Correlation of neurophysiological tests with other variables in the patient group

Variables	Age (years)		Disease Duration (month)		Arm length (cm)		mJOA score	
	r	*p*	*R*	*p*	*R*	*p*	*R*	*p*
H-reflex latency (ms)	0.183	0.481	0.145	0.579	0.122	0.642	− 0.093	0.724
H/M amplitude ratio	− 0.188	0.470	− 0.188	0.471	0.271	0.292	0.291	0.257
CuSP (ms)								
Onset	− 0.112	0.639	− 0.413	0.071	− 0.183	0.439	0.107	0.652
Duration	0.116	0.627	0.244	0.300	0.133	0.575	0.314	0.178
CoSP (ms)								
Onset	0.260	0.268	0.038	0.874	-0.056	0.814	− 0.035	0.884
Duration	0.140	0.557	0.385	0.093	0.177	0.454	0.051	0.830
JOA	− 0.035	0.883	0.035	0.884	− 0.180	0.447	1.0	0.724

CuSP cutaneous silent period, *CoSP* cortical silent period, *mJOA* Japanese Orthopedic Association

Table 5 Association of neurophysiological tests with dichotomous variables in the patient group

Variables	H-reflex		Cutaneous silent period (ms)		Cortical silent period (ms)	
	latency, (ms)	H/M AR	Onset	Duration	Onset	Duration
Gender						
Male	18.03 ± 2.28	0.38 ± 0.18	82.71 ± 17.06	33.48 ± 8.06	55.47 ± 9.0	53.93 ± 15.21
Female	17.5 ± 2.06	0.2 ± 0.08	83.42 ± 12.45	30.91 ± 5.14	49.97 ± 6.4	53.28 ± 14.35
p-value	0.664	**0.046***	0.928	0.484	0.194	0.764
Occupation						
Workers	19.1 ± 2.98	0.32 ± 0.11^{ab}	75.1 ± 19.33	34.58 ± 9.87	52.5 ± 10.85	51.17 ± 16.74
Housewives	17.88 ± 2.17	0.15 ± 0.06^{b}	88.1 ± 4.80	30.90 ± 5.75	48.76 ± 6.35	52.1 ± 14.84
Officers	17.43 ± 0.51	0.47 ± 0.40^{a}	93.88 ± 15.32	29.58 ± 6.25	57.68 ± 3.31	62.7 ± 16.23
Others	16.9 ± 1.75	0.38 ± 0.84^{ab}	78.36 ± 14.03	34.8 ± 6.5	57.38 ± 9.24	49.46 ± 9.74
p-value	0.473	0.153	0.212	0.636	0.328	0.558
Nurick grade						
1	18.0 ± 2.83	0.30 ± 0.14	81.50 ± 9.90^{a}	33.0 ± 8.48	51.65 ± 7.27	42.55 ± 3.61
2	17.38 ± 1.62	0.36 ± 0.26	89.62 ± 11.62^{a}	33.15 ± 6.5	51.65 ± 11.95	56.67 ± 14.33
3	17.85 ± 2.55	0.28 ± 0.13	70.17 ± 12.94^{b}	33.3 ± 8.83	52.53 ± 9.54	52.69 ± 16.51
4	21.7 ± 0.00	0.30 ± 0.0	108.0 ± 0.0^{c}	23.7 ± 0.00	60.1 ± 0.0	45.0 ± 0.0
p-value	0.339	0.912	**0.011***	0.689	0.850	0.603
MRI lesion						
C3–C4	18.95 ± 3.08	0.40 ± 0.11	71.02 ± 17.46^{a}	40.2 ± 8.17^{a}	50.6 ± 12.47	56.75 ± 19.38
C4–C5	16.0 ± 0.0	0.23 ± 0.11	75.12 ± 11.84^{a}	27.8 ± 3.31^{b}	56.95 ± 9.62	53.15 ± 13.78
C5–C6	18.09 ± 2.11	0.27 ± 0.12	86.78 ± 11.59^{ab}	33.31 ± 6.13^{ab}	52.07 ± 7.23	48.38 ± 10.33
C6–C7	17.65 ± 0.5	0.5 ± 0.56	97.6 ± 16.39^{b}	27.5 ± 5.73^{b}	59.2 ± 1.56	63.53 ± 19.77
p-value	0.372	0.362	0.069	**0.037***	0.475	0.450

Different small letters indicate significant differences, *Statistically significant at ≤ 0.05

AR amplitude ratio

electrophysiological tests are valuable adjuncts to diagnosis. In general, our study demonstrates significant changes in the CuSP latency and duration and CoSP duration, whereas, the H-reflex parameters did not differ between the patient and control groups.

The failure to record a significant difference in H-reflex parameters between patients with CSM and controls could be due to the fact that nearly half of the patients tested had MRI lesions above the C5 spinal segment. Cervical radiculopathies, which affect the C7, C6, C8, and C5 nerve roots, are thought to account for

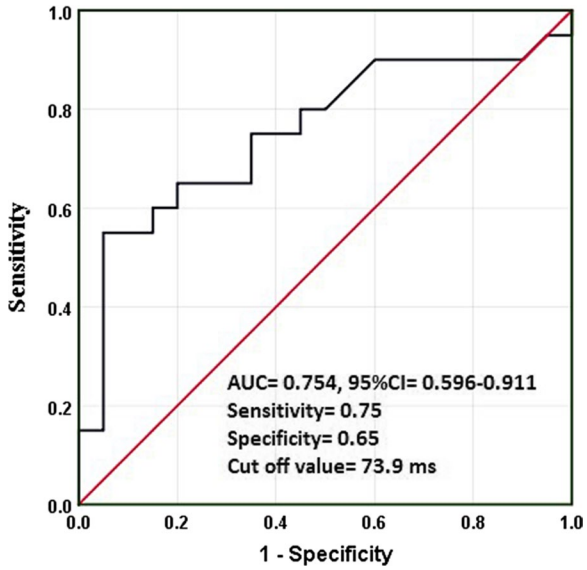

Fig. 1 Receiver operating characteristic curve for CuSP onset in the context of discrimination between patients and controls

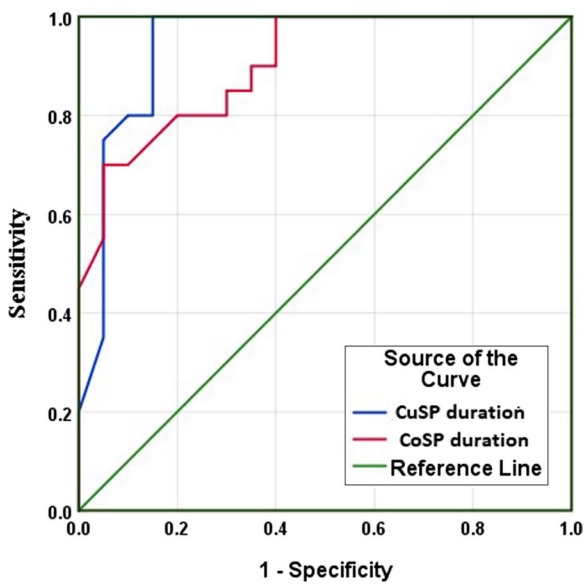

Fig. 2 Receiver operating characteristic curve for CuSP duration and CoSP duration in the context of discrimination between patients and controls

only 5–10% of all spinal nerve root disorders [19, 20]. For patients with C6/7 [21, 22] or C7 [23], an upper extremity H-reflex study (mediated through C6/C7 levels through the median nerve measured across the flexor carpi radialis muscle) is recommended.

Men had higher H/M values than women in this study, which could indicate that women had lower motoneuron excitability during H-reflex evaluations. Mendonca and his colleagues came to a similar conclusion [24]. Other literatures on the issue found discrepancies in the interaction between sex and the H/M ratio [25–28].

Dissimilarities at this level may be related to methodological concerns, despite the fact that the exact mechanisms are unknown. Because of its modulation by various well-known factors [29, 30] or sex-related changes in brain maturation [31], as well as differential activation of cortical areas during motor tasks [31, 32], H-reflex recordings require very precise and constrained conditions.

MRI is beneficial for identifying SC compression and intramedullary signal alterations, although morphological abnormalities do not always correspond to clinical signs and symptoms [33]. As a result, the CuSP was used in this study since its anomaly indicates intramedullary pathology such CSM and syringomyelia [34, 35]. Furthermore, even if the aberration is mild, it is said to be able to detect CSM [36].

Patients with CSM had significantly different CuSP parameters than the control group in this study. These findings are also consistent with what other study groups have found [34–38]. CuSP abnormalities could be explained by structural alterations in neurons and axons caused by aberrant signal processing in the spinal cord [39]. CuSP is mediated by a spinal inhibitory reflex that is subject to supraspinal descending control, which supports this theory [39, 40].

Leis and coworkers [41] found that cervical radiculopathy is not associated with the absence or delay of the CuSP, claiming that the smaller, slower conducting A-delta fibers are relatively less affected by injury or disease that may significantly impair conduction along large afferent fibers, which is supported by previous findings that indicate differential involvement of small versus large fibers in several related peripheral NS conditions.

CuSP duration was considerably shorter in patients with C6-7 compression site compared to other compression sites (as shown in Tables 3, 4). This is because the APB muscle and the index fingertip were thought to represent the cervical 6 and 7 dermatomes, as well as the cervical 8 and thoracic 1 myotome [42]. Tadokoro and colleagues also detected significant involvement of the lower and middle cervical regions [38]. This is corroborated by the findings of Stetkarova and colleagues [35] who found normal CuSP in patients with CSM at the C3–C4 intervertebral disc level and by the findings of Kofler and colleagues [40] who found normal CuSP in patients with thoracic myelopathy.

Furthermore, Tables 3, 4 show that there is an association between disease severity as measured by the Nurick's classification and CuSP latency prolongation. Patients who are allowed to progress to Nurick grade 4 are unlikely to make a complete recovery and are unlikely to improve with surgical intervention [43]. This indicated that the more structural abnormalities in the spinal cord, the worse the functional impairment and the longer the CuSP onset latency. Patients with more severe cases of CSM (including gait alterations) exhibit more significant CuSP abnormalities, according to Lo and colleagues [36].

In this study's CoSP, the duration but not the latency was altered in patients with CSM. Suyama and coworkers [44] and Nicotra and associates [45] both found similar findings. Increased cortical or spinal segmental excitability could be the cause of this shortening [46]. The decreased activity of GABAergic inhibitory interneurons that moderate corticomotoneuronal output is likely to be responsible for the increased intracortical excitability [47].

In comparison to CuSP onset latency and CoSP duration, CuSP duration has the highest sensitivity and specificity. To the best of our knowledge, no comparable findings were present in the literature. CuSP parameters were considerably altered in CSM patients, which is consistent with findings from earlier studies [35–38, 48]. Studies have demonstrated that measuring the CuSP can provide information beyond that obtained from MEPs induced with TMS in cervical cord lesions due to its relevance in SC lesions. CuSP, mediated by spinal reflexes with supraspinal descending control, may address a larger anatomical circuit or area comprising afferent, efferent, and supraspinal inputs, as evidenced in CSM lesions as a result of disc protrusion and anterior cord indentation [36, 37].

The CuSP was not tested following corrective surgery to further assess its validity in patients with CSM, which is one of the study's limitations plus the small sample size.

Conclusion

Our study concludes that CuSP is an effective quick and noninvasive tool for evaluating CSM. CuSP and CoSP electrophysiological changes point to a dysfunction with the inhibitory and excitatory circuits at a spinal level. In the diagnosis of a patient with CSM, CuSP is more sensitive and specific than CoSP.

Abbreviations

APB: Abductor pollicis brevis; AUC: Area under the curve; CoSP: Cortical silent period; CSM: Cervical spondylotic myelopathy; CuSP: Cutaneous silent period; EMG: Electromyography; mJOA: Modified Japanese Orthopedic Association; MRI: Magnetic resonance imaging.

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Author contributions

All the authors have directly participated in the preparation of this manuscript and have approved the final version submitted. 'IN' clinically examined and referring patients with cervical spondylotic myelopathy. 'ZJ' and 'FH' did the electrodiagnostic tests. 'FH' and 'ZJ' drafted the manuscript. 'ZJ', 'IN', and 'FH' conceived the study and participated in its design and interpretation. All the authors have read and approved the final manuscript.

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Availability of data and materials

All data generated or analyzed during this study are included in this published article. The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study was approved by the Iraqi Board for Medical Specialization (Decision No. 291; Date 21/1/2021). Written consent for participation from all subjects was ensured.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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