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ORIGINAL ARTICLE

Evaluation of Bell's Palsy by Electrodiagnosis versus Ultrasonography

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ABSTRACT

Background: The facial nerve, a seventh cranial nerve, is typically assessed using electrodiagnostic tests such as nerve conduction studies, electromyography, and blink reflex. When diagnosing disorders affecting the muscles and peripheral nerves, neuromuscular ultrasonography is quickly becoming an integral part of the process. This study aimed to assess if facial nerve Ultrasonography (US) could be used for better evaluation of Bell's palsy.

Methods: This matched case-control study was conducted on forty patients suffering from unilateral Bell's palsy Detailed history. The facial muscle's function was assessed clinically every visit using the House-Brackman Classification of Facial function .All were subjected to evaluation by electroneurography, blink reflex test, direct facial nerve conduction studies, and Ultrasound imaging. The evaluation was done within 14 days of the onset.

Results: As regards ultrasound cross-sectional area (CSA) among studied groups, there was a high statistical difference in facial nerve thickness between the diseased and healthy group regarding proximal ($p<0.001$), midway ($p<0.001$), and distal ($p<0.001$) sites. The facial CSA area at the proximal site could considered a good discriminator of facial nerve palsy with an area under curve (0.84) with 71% sensitivity 83.9% specificity and a cutoff point of 17 mm. There is a significant correlation between facial nerve CSA at the proximal side and latency of the ipsilateral R2 wave of blink reflex ($r=0.4$, $p=0.02$). There is a significant correlation between facial nerve ultrasound CSA at the proximal site and latency of ipsilateral R2 ($r=0.4$, $p=0.02$)

Conclusion: Establishing normal values of facial nerve nerves may be greatly aided by using ultrasound in conjunction with neural electrophysiology. In the early stages of Bell's palsy, ultrasonography could be useful for evaluating the condition's structural integrity and functional assessment.

Keywords: Bell's palsy, Electroneurography, Blink reflex, House-Brackman scale, Neuromuscular ultrasound.

INTRODUCTION

One of the seven cranial nerves which is considered the master of expression is the facial nerve, or (CN VII). It starts in the brain stem and branches out to both the abducens and vestibulocochlear nerves. After passing through the temporal bone's facial canal and the stylomastoid foramen, it splits into two branches at the back of the parotid gland. [1]. From its origin at the pons-medulla junction, it splits into the intermediate nerve and the main root. The expression muscles of the face are innervated by the bigger main root,

which is called the facial nerve proper. The taste, parasympathetic, and somatic sensor fibers are carried by the smaller intermediate nerve, which is called L. nervus intermedius [2].

Acute idiopathic weakness or paralysis of one or both lower motor neurons in the face, without additional neurological or systemic symptoms, is known as Bell's palsy (BP). In the majority of cases, patients regain some level of function within [3]. Research in several Egyptian governorates has shown an incidence rate of BP ranging from 98.9 to 107 per 100,000 people; the prevalence is higher in male patients than female patients, and it peaks between the ages of 18 and 60, with very low rates at the very young and very old [4].

The electrodiagnostic tests that are usually utilized to evaluate the function of the facial nerve are nerve conduction studies, electromyography (EMG), and blink reflex. These tests may aid in assessing the outcome of a patient who has persistent and severe palsy. An important point to consider is that most of the electromyographic/nerve conduction studies usually do not show an abnormality during the first 3 weeks following nerve injury [5]. Electroneuronography (ENoG) is an electrophysiological test performed to evaluate the functional integrity and the degree of degeneration of the facial nerve [6].

An increasingly common tool for diagnosing abnormalities affecting the muscles and peripheral nerves is neuromuscular ultrasonography (NMUS). Acquired in tandem with electrodiagnostic investigations, it offers structurally based, dynamic information that might hone a diagnosis or reveal a structural cause. Patients suffering from motor neuron illness, muscle problems, polyneuropathy, or mononeuropathy can benefit from NMUS-advanced patient care [7].

Research has shown that neuromuscular ultrasonography can also assess the extent and spread of diseases. We can learn more about the potential of ultrasonography to aid clinical trials and the evaluation of novel, promising treatments for neuromuscular diseases if we incorporate it into current and future studies of therapeutic interventions [8].

In their discussion of Bell's palsy, Gupta et al. [9] brought up the fact that ultrasound has been used to forecast facial nerve outcomes. Patients diagnosed with Bell's palsy participated in a prospective, randomized trial that examined the effects of ultrasound 2–7 days following the beginning of paralysis. The stylomastoid foramen was used to measure the facial nerve diameter proximally, the pes anserinus to measure distally, and the midway point between the two was used to measure distally. These three measures were used to compute the average diameter of the facial nerve. The results were compared with research on the blink reflex and nerve conduction. So, this study aimed to assess if facial nerve Ultrasonography (US) could be used for better evaluation of Bell's palsy.

METHODS

This 2024 was referred for the diseased side control, which was the contralateral normal side.

The research ethics board of the Faculty of Medicine at Zagazig University gave its approval to the study, and all participants gave written informed consent. A component of the Code of Ethics for Research Involving Humans, the Declaration of Helsinki ensures that the study was carried out in compliance with its provisions. Before this study could begin, we obtained approval from the Institutional Review Board (IRB#6530).

Patients included in the study were able to physically and mentally participate in the trial, and they were diagnosed with unilateral idiopathic facial palsy (Bell's palsy) at the rheumatology outpatient clinic within the first 7–14 days after symptoms began. Three times weekly, all patients participated in physiotherapy sessions that included face muscle exercises and electrical stimulation.

We excluded all participants with previous attacks of Bell's palsy, secondary facial palsy due to trauma, infection (Ramsay Hunt syndrome), acute otitis media, neoplasia, arachnoid cyst, and congenital causes (Moebius syndrome).

Detailed history, general examinations, central nervous system examinations, and facial nerve examinations were done on all 40 patients. The facial muscle's function was assessed clinically every visit using the House-Brackman Classification of Facial Function and giving a grade for each patient.

All patients were subjected to evaluation by electroneurography (ENOG), blink reflex test (BR), direct facial nerve conduction studies, and ultrasound imaging. The evaluation was done within the 14th day of the onset.

Clinical grading by House-Brackman

The House-Brackmann scale (six-point gross scale) was used for facial nerve function percentage for the specific grade. The scale encompasses the secondary characteristics and runs from 1 (normal) to 6 (complete paralysis) [10]. The observer measured the movement of the patient's paralyzed

side, noting upward and outward movements of the eyebrow midpoint and oral commissure. Each 0.25 cm movement was assigned one point, with a maximum displacement of 1.0 cm for both features. The score ranged from 0 to 8, with the measurement column displaying the actual score and the function column providing the corresponding function percentage. The estimated function column indicates the facial nerve function percentage for the specific grade.

Electrophysiological studies

An electrophysiology test was performed using NIHON KODHEN NEUROPACKS electro-myography equipment (Japan). The electrophysiological studies were performed within the 7th–14th day from the onset.

Electroneurography (ENoG)

The patient lay supine on the examination table or sat comfortably while they were relaxed. Disc electrodes were used to capture the compound muscle action potential (CMAP) from the frontalis, nasalis, and mentalis muscles. By a bipolar surface stimulator, the facial nerve at both sides was stimulated supramaximally on the skin over the stylomastoid foramen, The current intensity begins with 10 mA and 0.2ms duration, then gradually increasing intensity to reach supramaximal stimulation [11].

The active electrode is placed over the nasalis, frontalis, and mentalis muscles. The reference electrode is placed in the same position on the opposite side with a sweep speed of 0.2 ms and sensitivity of 1 mV. The amplitude of the CMAP of the facial nerve was measured in millivolts (mv) from the frontalis and mentalis muscles and compared to the unaffected side. The ENoG degeneration index of nasalis muscle was calculated as {100- (ENoG amplitude affected side / ENoG amplitude unaffected side) ×100}.

Blink reflex (BR)

The location of the stimulation site was identified as a slight depression in the bony ridge above the eyebrow, which was located over the medial supraorbital ridge. The duration of the electrical pulse was 100 ms. To achieve the shortest latency and maximum amplitude potentials, the current was gradually increased from a baseline of 0 mA to supramaximal stimulation, often in increments of 3–5 mA. Low currents were able to easily excite the nerve. To achieve supramaximal stimulation, an amount of 15–25 mA was usually sufficient [11].

Responses were defined as normal values when R1 latency was 8-13 ms, R2 ipsilateral latency 29-41 ms, and R2 contralateral latency ≤ 44 ms. Ipsilateral R1 with latency > 13ms, R2> 41ms, and R2 contralateral > 44ms are classified as delayed type, and those with no response are classified as absent type.

Ultrasound imaging

Ultrasound examination was conducted with a Siemens Acuson x300 (GE Company, New York, USA) machine. A high-frequency linear transducer (>12 MHz) was used, and depth was usually adjusted to 2–3 cm.

All patients were placed in the supine posture with their heads turned to the opposite side from the side that was being scanned to scan the facial nerves on both sides. In the mastoid region, specifically the sternomastoid foramen, the probe was inserted somewhat below the ear lobule. To acquire a longitudinal picture of the facial nerve within the parotid gland, the transducer is positioned transversely right beneath the ear lobule. Located midway between the parotid gland's superficial and deep portions, the nerve seemed like a thin linear tubular-like structure with a hypoechoic core and a hyperechoic periphery [13] (Figure 1).

After that, we angled the probe perpendicular to get the facial nerve's cross-sectional area at the proximal and distal parts we could see, as well as midway in between. There was a linear fascicular look to the normal nerve in this plane, with an oval hypoechoic structure and the spot echo around the hyperechoic film strip in the transverse sonogram. The sheath was comparatively hyperechoic compared to the muscles around it. Contrarily, the abnormal facial nerve frequently exhibited swelling, decreased echo, hyperechoic sheath, and an unclear fascicular pattern [14]. Figure (2).

STATISTICAL ANALYSIS

Software from SPSS Inc., Chicago, IL, USA, known as IBM SPSS 23.0 for Windows, and the Jamovi project (2022) (Version 2.3) were used to code, enter, and analyze the obtained data. Data from neurophysiological assessments are presented as mean standard deviation or median (interquartile range [IQR]), as appropriate. For correlation between two quantitative variables, Pearson's correlation is used for parametric, normally distributed quantitative data, and Spearman's rank correlation test is used for ordinal data or if the assumptions of normality of data are not satisfied. Mann-Whitney U test is used to compare outcomes between two independent groups as comparing the medians between two populations. Cutoff values of the cross-sectional area of ultrasound were

investigated using receiver operating characteristic (ROC). P-value ≤ 0.05 indicates a statistically significant difference.

RESULTS

days,The disease duration with mean ±SD was (36.3±14.26) years and (11.3±5.23) days respectively. Regarding the gender of the patients, half of the patients (50%) were males, and the other half were females. Five patients (12.5%) had a positive family history of Bell's palsy (Table 1).

In our patients, results of degeneration ratio >50% by ENOG were detected in (55%) of the patients in the frontalis muscle, (52.5%) in the nasalis muscle, and (59%) in orbicularis oris muscle.

As regards ultrasound CSA among studied groups, there was a high statistical difference in facial nerve thickness between diseased and healthy groups regarding proximal (p<0.001), midway (p<0.001), and distal (p<0.001) sites (Table 2).

On conducting Receiver Operating Curve (ROC) analysis, it was shown that facial nerve CSA at the proximal site had the highest area under the curve (0.84) with 71% sensitivity and 83.9% specificity at the cut-off point of 17 mm, so the facial CSA area at the proximal site could be considered as a good discriminator of facial nerve palsy (Figure S1A)

A highly statistically significant difference was revealed between the 2 sides as regards ipsilateral R1, ipsilateral R2, and contralateral R2 (p<0.001). In the diseased side, the median of ipsilateral R1 latency was 17 ms (14.9-21.5), ipsilateral R2 latency was 41 ms (37.8-46) and contralateral R2 was 35.2 ms (31.1-41.9), while the normal side ipsilateral R1 latency was 11.4 ms (10.5-13.2), ipsilateral R2 latency was 35 ms (31.4-39.4) and contralateral R2 was 41.4 ms (37.7-52.6).

According to our study, we found that there is no significant correlation between facial nerve ultrasound CSA and House-Brackmann scale grading (p > 0.05). (Table 3).

We found that midway facial nerve ultrasound measurements were significantly higher among patients with >50% degeneration ratio detected by ENoG at the frontalis muscle (P = 0.04). However, there was no statistically significant difference between the facial nerve cross-sectional area and the percent of degeneration in the nasalis muscle and orbicularis oris muscle (p >0.05). (Table 4).

A significant correlation was found between facial nerve CSA at the proximal side and latency of the ipsilateral R2 wave of the blink reflex (r = 0.4, p = 0.02); also, a significant correlation was revealed between facial nerve ultrasound CSA at the proximal site and latency of R2 *(r = 0.4, p = 0.02)* (Table 5).

At a cut of 15 mm2, the facial nerve midway CSA had a sensitivity of 55.6% and a specificity of 50% to predict improvement (Table 8). The variation in examination times among patients and the presence of fatty infiltration on the parotid gland in certain cases could be the cause of low sensitivity and specificity., Midway fascial nerve CSA at a cut-off point of 15 mm2 had 55.6% sensitivity and 50% specificity, with an AUC of 0.42 to predict complete improvement (Figure S1B).

Table 1: Demographic and clinical data between studied patients

Variable	**Patients (n=40)**
Age (years) *mean±SD*	36.3±14.26
Sex *n.%* Male Female	20 (50%) 20
Disease duration (days) *mean±SD*	11.3±3.23
Family history *n%* Present Absent	5 (12.5%) 35 (87.5%)

Table 2: Facial nerve ultrasound CSA between two sides

	Diseased side Mm2	**Healthy side Mm2**	**MD**	**p-value**
Proximal *Median (IQR)*	19 (15.2-20)	12 (10.2-16)	5	**<0.001**
Mid-way *Median (IQR)*	15 (10.2-17.8)	10 (9-15)	3	**<0.001**
Distal *Median (IQR)*	14 (11.2-18)	11 (9-12.8)	4	**<0.001**

*Mann-Whitney test, P-value >0.05 non-significant; ≤ 0.05 Significant. MD: mean difference.

Table 3: Correlation between facial nerve ultrasound CSA and Hausmann scale grading

	House-Brakmann scale	
	r	**P**
Proximal facial nerve CSA	-0.08	0.682
Mid-way facial nerve CSA	-0.16	0.393
Distal facial nerve CSA	-0.12	0.513

*Spearman's rho correlation coefficient

Table 4: Relation between facial nerve ultrasound CSA and percent of degeneration in frontalis, Nasalis, and Orb. Oris muscle

	ENoG data of frontalis muscle		p-value	ENoG data of Nasalis muscle		p-value	ENoG data of Orb. Oris's muscle		p-value
	≤50% degeneration ratio (n=15)	>50% degeneration ratio (n=16)		≤50% degeneration ratio (n=15)	>50% degeneration ratio (n = 16)		≤50% degeneration ratio (n=12)	>50% degeneration ratio (n=18)	
Proximal *Median (IQR)*	19 (12.2 – 20)	18.5 (17 – 20)	0.5	19 (17 – 20)	18.5 (13 – 20)	0.6	19 (15.8-20)	18.5 (15.8 – 20)	0.85
Mid-way *Median (IQR)*	12 (10 – 16.8)	16.5 (12 – 20)	0.04	15 (10.2 – 17)	16 (10.4 – 18)	0.7	14.5 (10.4 – 18.8)	16 (10.9 – 18)	0.82
Distal *Median (IQR)*	14 (10.2 – 17.5)	15 (12.4 – 18.6)	0.2	14 (12 – 17.5)	15.5 (10.4 – 18)	0.9	15 (12 – 18.6)	14 (11 – 18)	0.69

Table 5: Correlation between facial nerve ultrasound CSA and blink reflex findings

Variable	Proximal		Mid-way		Distal	
	r	P	r	p	R	p
Ipsilateral R1	0.2	0.3	0.3	0.1	0.02	0.9
Ipsilateral R2	0.4	0.02	0.07	0.7	0.12	0.6
Contralateral R2	0.33	0.1	0.27	0.2	0.28	0.1

*Pearson correlation coefficient, P-value >0.05 Non-Significant; ≤ 0.05 Significant

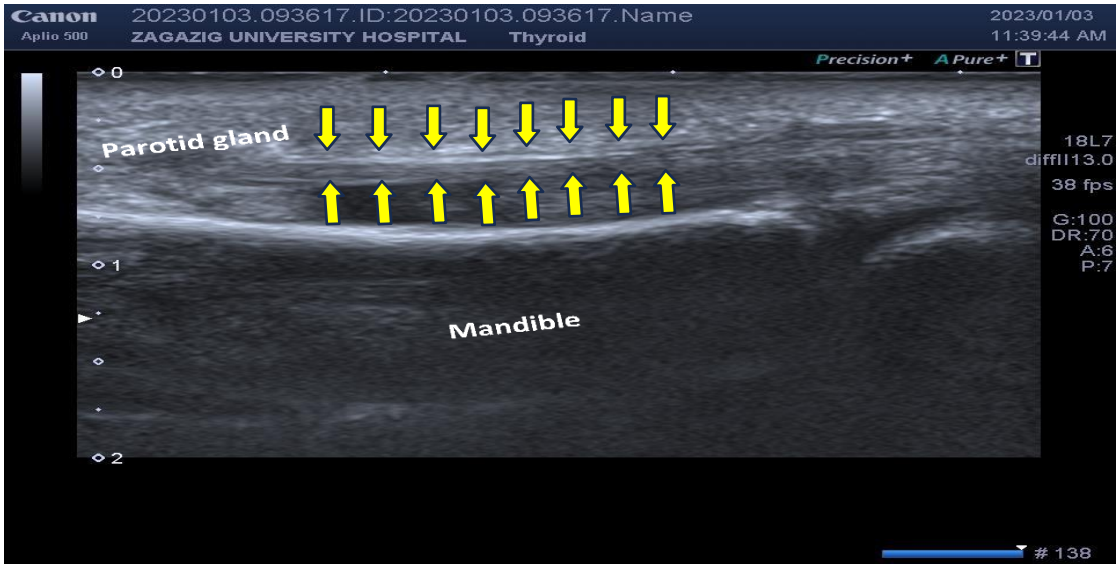

Figure 1: The longitudinal course of the facial nerve.

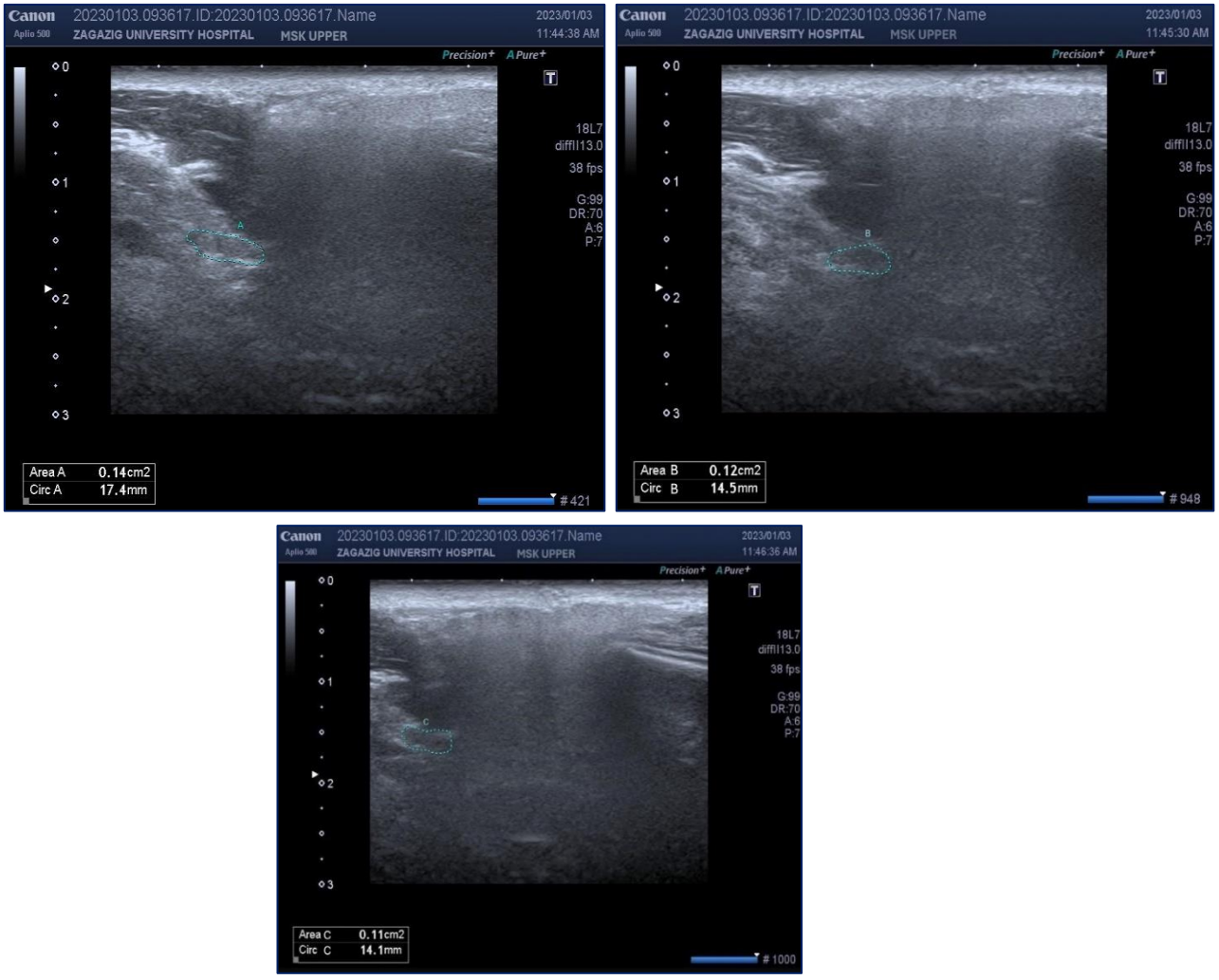

Figure 2: Cross-Sectional Area Measurements of the right facial nerve (diseased side): (A) Proximal Area= (14 mm2), (B) Midway Area = (12 mm2), (C) Distal Area = (11 mm2)

DISCUSSION

The purpose of this study was to use facial nerve ultrasound for better evaluation and assessment of Bell's palsy compared to the results of electrophysiological studies. Forty patients with unilateral Bell's palsy were included in this study. The unaffected side of each patient was examined and used as the control group. Patients were clinically evaluated by the House-Brackman score. Electrophysiological evaluation included direct facial conduction studies (NCS), electroneuronography (ENOG), and the blink reflex (BR). We obtained the cross-section area of the facial nerve at the most proximal and distal visualized portions, as well as midway between these two points.

The mean ±SD for age and disease duration of all patients were (36.3±14.26) years and (11.3±5.23) days, respectively. Regarding the gender of the patients, half of the patients (50%) were males and the other half were females. Five patients (12.5%) had a positive family history of Bell's palsy; this came with the Peitersen et al. [11] study, which reported that both males and females were affected equally, against Abdeelal et al. [12], who reported that although there was a little female preponderance, no association was found between the patient's sex and recovery. Seventy percent of their patients were female, and thirty percent were males.

As regards the ultrasound cross-sectional area between the two sides, there was a high statistical difference in facial nerve thickness between diseased and healthy groups regarding proximal ($p<0.001$), midway ($p<0.001$), and distal ($p<0.001$) sites. This was similar to the findings of LI et al. [13], who found significant differences between the two sides. Also, according to LI et al. [13], the mean normal facial nerve cross-sectional area (CSA) was 0.05±0.01 cm2.

On conducting Receiver Operating Curve (ROC) analysis, it was shown that the facial nerve cross-sectional area at the proximal site had the highest area under the curve (0.84) with 71% sensitivity and 83.9% specificity at the cutoff point of 17 mm, so the facial nerve cross-sectional area at the proximal site could be considered as a good discriminator of facial nerve palsy.

This was in accordance with the findings of Baek et al. [8], who discovered that the damaged side had a much greater diameter with the sheath at the proximal section compared to the unaffected side. Also noticeably bigger than the unaffected sides was the diameter of the affected side with the sheath at the distal end.

Another two studies conducted by Zaki et al. [14] and Lo et al. [15] found that there were highly significant variations in the mean between the affected and healthy sides, as well as a noticeable difference in the diameter of the facial nerves on the affected side compared to the healthy controls.

According to our study, we found that there is no significant correlation between facial nerve ultrasound CSA and House-Brackmann scale grading ($p > 0.05$). This was in accordance with the findings of Lo et al. [15], who discovered no significant correlation between US diameter and severity grading. In contrast, Zaki et al. [14] discovered a statistically significant positive correlation between clinical grading scale and US diameter.

The distal VII segment becomes implicated and slows down the healing process in Bell's palsy because it is too far away to get cell body nutrition, which would exacerbate the swelling and damage. Even if regeneration had finished in the unseen proximal nerve segments, an anomaly in the visible distal segments of the nerve might still prohibit adequate transmission to the innervated facial muscles [16].

We found that midway facial nerve ultrasound measurements were significantly higher among patients with >50% degeneration ratio detected by ENoG at the frontalis muscle ($P = 0.04$). However, there was no statistically significant difference between the facial nerve cross-sectional area and the percent of degeneration in the nasalis muscle and orbicularis oris muscle ($p< 0.05$).

We found a significant correlation between the facial nerve cross-sectional area at the proximal side and the latency of the ipsilateral R2 wave of the blink reflex ($r = 0.4$, $p = 0.02$). (Table 5). This came against the results of Lo et al. [15], who discovered no connection between the blink reflex and US examination diameter.

The lack of correlation of US with VII NCS and blink reflex suggests that US measurement of nerve diameter may not specifically point to demyelination or axon loss processes independently. The pathophysiology of nerve

swelling and thickening is complex and may involve endoneural edema, demyelination, axonal degeneration, and fibrosis [17].

A larger level of facial nerve CSA was observed on the affected side of Bell's palsy patients compared to the normal side, suggesting that NMUS, when combined with nerve conduction investigations and needle electromyography, can enhance the diagnostic capacities of clinicians. Ipsilateral R2 latency was strongly linked with it [18].

At a cutoff of 15 mm2, the facial nerve midway CSA had a sensitivity of 55.6% and a specificity of 50% to predict improvement. The variation in examination times among patients and the presence of fatty infiltration on the parotid gland in certain cases could be the cause of low sensitivity and specificity.

Limitations of this study must be taken into account; ultrasonography relies on human operators, which could lead to inaccurate results. The second restriction was that a control group was not included. The present study's reliability may have been unaffected by the absence of a separate healthy group, as comparing sides in a single patient decreases interindividual confounding factors. Third, this study did not use magnetic resonance imaging (MRI) to diagnose Bell's palsy, as it is not commonly used in clinical practice.

CONCLUSION

Establishing normal values of facial nerve nerves may be greatly aided by using ultrasound in conjunction with neural electrophysiology. In the early stages of Bell's palsy, ultrasonography could be useful for evaluating the condition's structural integrity and functional assessment.

Conflict of Interest: No

Financial disclosure: No

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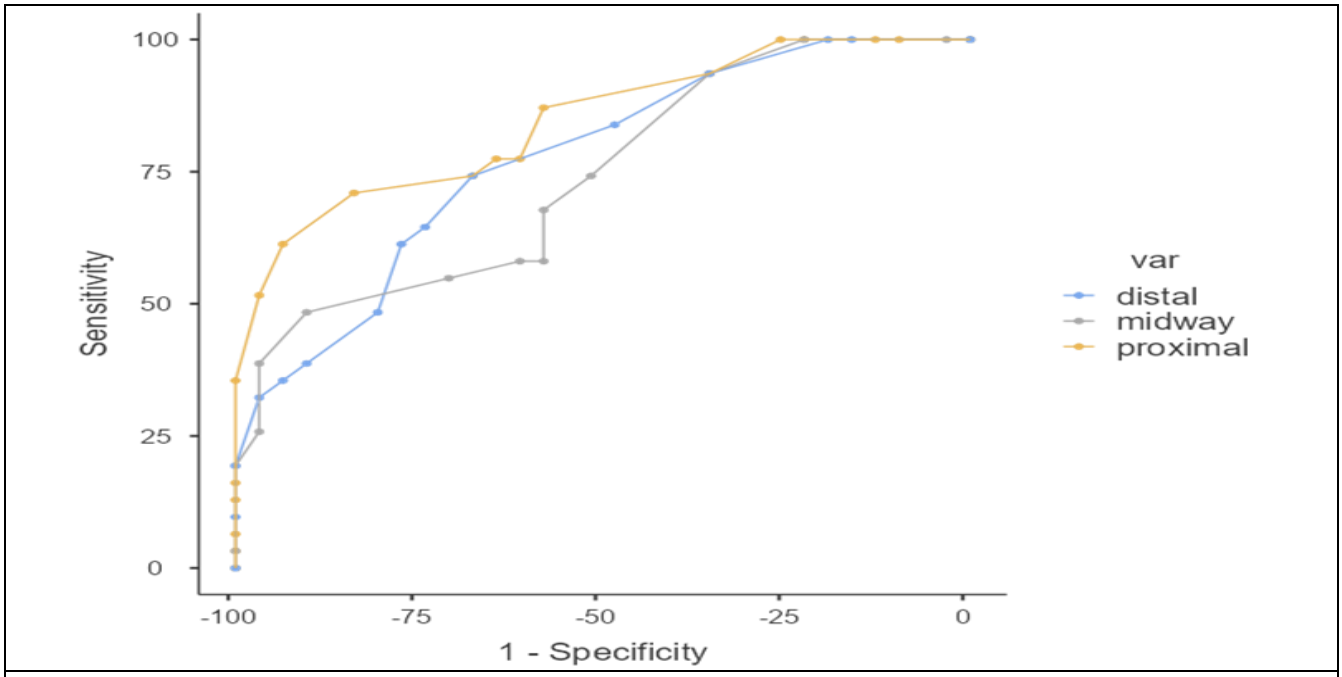
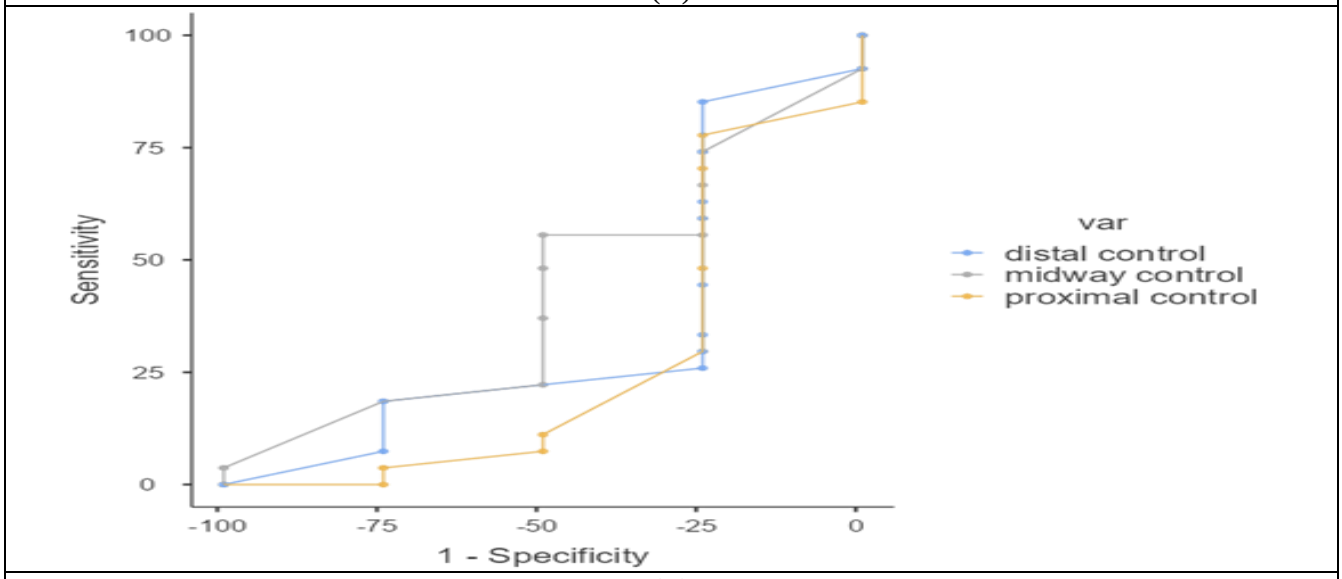


(A)



(B)

Figure S1: (**A**) ROC curve analysis of facial nerve ultrasound CSA to discriminate between diseased and healthy sides; (**B**) ROC curve analysis of facial nerve US CSA to predict complete improvement, considering ENOG of nasalis muscle

Citation

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