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Is pre-operative electromyography a reliable tool in differentiating acute and chronic facial palsy? A preliminary evaluation in patients treated with triple innervation facial reanimation

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A R T I C L E I N F O

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A B S T R A C T

Electromyographic evaluation is a reliable tool for confirming facial palsy and assessing its severity. It allows differentiating facial paresis and paralysis, and further distinguishes acute palsies, still showing muscle fibrillations, from chronic cases. This article aims to show that EMG fibrillations might represent a better criterion to differentiate acute and chronic palsies than the standard 18–24 months' cut-off usually employed for classification and treatment purposes.

We performed a cohort study using the eFACE tool for comparing triple innervation facial reanimation results in patients with EMG fibrillation treated <12 months, 12–18 months, and >18 months from paralysis onset.

Patients showed a statistically significant post-operative improvement in all eFACE items, both in the whole sample and in the three groups. Only the deviation from the optimal score for the gentle eye closure item in group 2 didn't reach statistical significance ($p = 0.173$). The post-operative results were comparable in the three groups, as the Kruskal-Wallis test showed a difference only for the platysmal synkinesis item scores, which were significantly lower in group 3 ($p = 0.025$).

EMG should represent a further tool to wide the group of paralysis patients that could be treated as recent facial palsy patients; Further prospective studies on pre-operative EMG fibrillations might allow for further refinement of the technique selection process.

1. Introduction

Electromyography (EMG) is an important means of neurophysiological evaluation in facial palsy patients. Its diagnostic role is widely recognized, as it allows one to confirm a facial nerve injury and to assess its severity (Rubin DI, 2019; Lee DH, 2016).

This ability is due to the peculiar neuromuscular behaviour of facial muscles affected by facial palsy. Facial paresis patients maintain some degree of facial muscular contraction; early facial paralysis patients present with spontaneous action potentials (fibrillations), and chronic facial palsy patients are unresponsive to electrical stimulation due to the fibro-adipose substitution of muscular tissues. Furthermore, preoperative EMG also allows possible donor nerves (masseteric, hypoglossus, temporalis, spinal, contralateral branches of the facial nerve) functionality assessment, to determine a neurological mapping (Biglioli, 2015a; Guntinas-Lichius O, et al., 2020).

Although EMG studies allow for differentiating acute and chronic facial palsy according to fibrillation status, most studies and practices classify acute and chronic palsies on the basis of an 18- to 24-month cut-off and select treatment accordingly. That is not precise, and timing may shorten according to personal characteristics, previous palsy episodes, and duration of palsy onset (Heaton and Kobler, 2005; Jiang JL et al., 2000; Midrio M, 2006; Pond A et al., 2014).

Given the possibilities offered by EMG, as well as its relatively low cost and invasiveness, using time from paralysis onset as the only parameter for choosing how to restore facial movements is somehow limited. The presence of mimic muscle fibrillations suggests that mimic muscles are viable and able to restore movements in the presence of an

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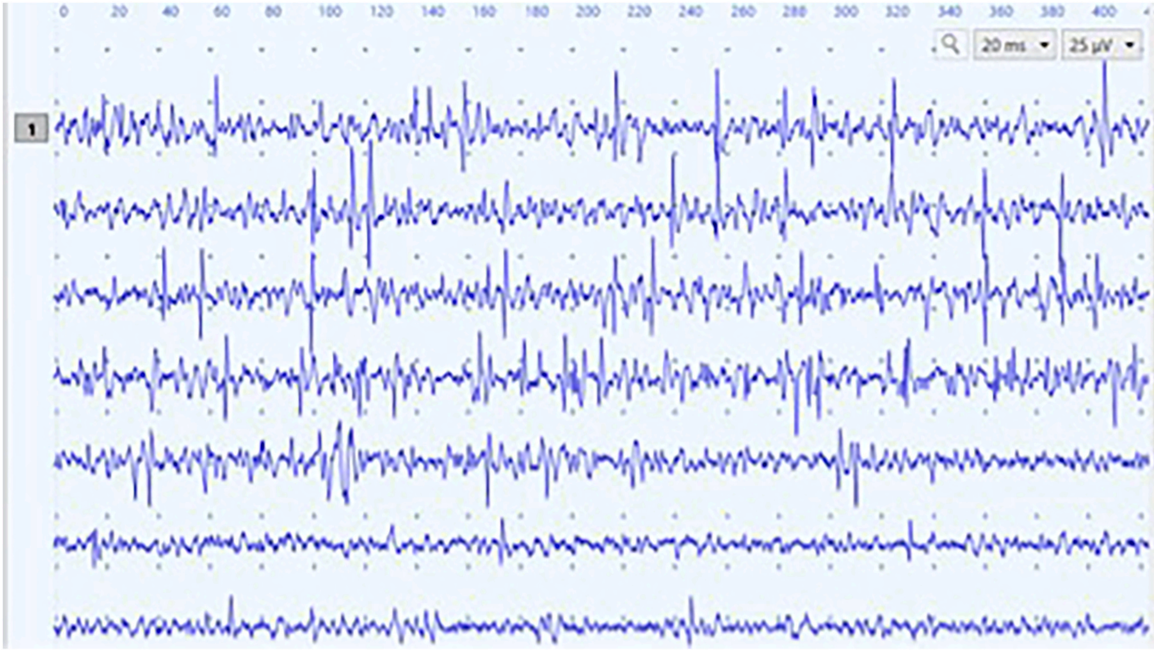

Fig. 1. Evidence of fibrillations in the zygomaticus major muscle.

Fig. 2. Preoperative picture showing asymmetry of the face at rest.

Fig. 3. Preoperative picture showing incomplete eye closure.

adequate new motor stimulus (e.g. the association of masseteric and hypoglossal nerve and some distal branches of the contralateral facial nerve through one or two cross-face sural nerve grafts) (Biglioli F, et al., 2018). On the other hand, the absence of mimic muscle fibrillations implies the need for muscular transplantation to restore facial movements (Biglioli, 2015a; 2015b); this latter option provides solid results, although it is inferior to recent facial palsy techniques.

In this paper, the authors aim to demonstrate that EMG fibrillations

Fig. 4. Preoperative picture showing asymmetry of the face during smiling.

Fig. 5. Postoperative picture showing good symmetry of the face at rest.

add important criteria to the temporal one for selecting acute facial palsy patients for reanimation purposes. With this purpose, we conducted a prospective cohort study comparing triple innervation facial reanimation results in patients with EMG fibrillation treated <12 months, 12–18 months, and >18 months from paralysis onset.

2. Materials and methods

This study was designed as a non-inferiority prospective cohort study. Given its observational and non-operative nature, it was granted an exemption by our institution's ethics committee.

We reviewed the charts of patients treated for facial palsy from 2015 onwards and identified all patients meeting our inclusion and exclusion criteria.

The inclusion criteria were as follows: diagnosis of unilateral complete facial paralysis (VI degree according to House-Brackmann classification) (House and Brackmann, 1985); EMG demonstration of homolateral mimic muscle fibrillations; EMG demonstration of homolateral masseteric nerve, hypoglossal nerve, and contralateral facial nerve normal functioning at the preoperative EMG; and patients who underwent facial reanimation with a one- or two-step triple reinnervation technique (Biglioli et al., 2018, 2021) (Fig. 1).

The study exclusion criteria were as follows: diagnosis of incomplete or bilateral facial palsy; post-operative follow-up <24 months; unavailable pre-operative eFACE score (Banks et al., 2015); and patients unable or unwilling to report to the clinic for a new eFACE score evaluation.

For each enrolled patient, we recorded age at surgery, sex, time from paralysis onset, paralysis etiology, number of surgical steps (one or two), and complete pre-operative eFACE score for all items.

Patients identified through chart review were enrolled and underwent a re-evaluation evaluation of treatment results with the eFACE score. All raters in the eFACE re-evaluation were not informed of the endpoint of the study and were blinded to the paralysis onset-treatment interval of each patient.

Among eFACE items, we analyzed selectively palpebral fissure at rest, nasolabial fold depth at rest, nasolabial fold orientation at rest, oral commissure at rest, gentle eye closure, full eye closure, oral commissure movement with smile, nasolabial fold depth with smile, nasolabial fold orientation with smile, and synkinesis (ocular, midfacial, mentalis, and platysmal) (Figs. 2–7). For each item, we considered the average of each rater score and the absolute value of the difference between 100 (normal value) and that average.

Patients were then classified into three groups, according to the timing between the onset of the palsy and the surgical treatment (group A, <12 months to surgical treatment; group B, 12–18 months to surgical treatment; and group C, >18 months to surgery), and collected data were compared.

Statistical analysis was performed for all eFACE items. The Wilcoxon signed-rank test for paired groups was used to compare the pre- and post-operative eFACE scores in all patients first, and then for the three groups. The Krusal-Wallis test was used to compare age at surgery, time to surgery, and pre- and post-operative eFACE scores in the different groups of patients (average and absolute delta to 100). A chi-square test was used to compare the distribution of sex and the triple innervation technique used in the three groups. A p-value of less than 0.05 was considered to be statistically significant. All statistical analyses were performed with the SPSS software (Version 28.0.0.1, IBM Corporation, Armonk, NY, USA) (Miller MQ et al., 2021).

3. Results

A total of 46 patients met the inclusion criteria for the study. One

Fig. 6. Postoperative picture showing restoration of eye closure after surgery.

Fig. 7. Postoperative picture showing restoration of smile after surgery.

Table 1
Demographic and surgical data for study patients, broken down by group.

		Whole sample (n = 43)	Group A (n = 22)	Group B (n = 13)	Group C (n = 8)	Statistical comparison and *p* value
Sex (n)	Female	28	15	7	6	0.559, Pearson chi square
	Male	15	7	6	2	
Age (years)	Mean	42.33	39.68	45.69	44.13	0.333, Kruskal-Wallis test
	SD	15.2	16.6	12.87	15.11	
Time to surgery (months)	Mean	13.44	8.41	14.92	24.88	<0.001, Kruskal-Wallis test
	SD	7.09	3.2	1.19	5.94	
Triple innerveation technique (n)	One-step	17	9	5	3	0.981, Pearson chi square
	Two-step	26	13	8	5	

patient was excluded for not consenting to attend the re-evaluation, while two had an insufficient follow-up. In the end, 43 consecutive patients (28 female and 15 male) were enrolled in the study. The mean age was 42.33 ± 15.2 years. The time between the onset of paralysis and surgery was 13.44 ± 7.09 months. The etiology of paralysis was iatrogenic in 31 patients (72%), idiopathic (Bell palsy) in 9 patients (21%), and traumatic in 3 patients (7%). Twenty-six patients underwent facial reanimation in two surgical steps, while 17 patients underwent a single-stage procedure. Twenty-two patients underwent surgery <12 months before paralysis onset (group A), 13 patients underwent surgery between 12 and 18 months after paralysis onset (group B), and 8 patients underwent surgery >18 months after paralysis onset (group C). Table 1 reports the data breakdown for each of the three study groups. There were no significant differences between the three groups in terms of sex distribution, age at surgery, type, and triple reanimation performed (respectively, $p = 0.559$, Pearson chi-square, $p = 0.333$, Kruskal-Wallis test, and $p = 0.981$ Pearson chi-square). When comparing time from paralysis onset to surgery, differences among the three groups were significant ($p < 0.001$, Kruskal-Wallis test).

The mean results for each parameter and the mean difference from the respective optimal scores are presented for the three groups and for the whole sample in Tables 2 and 3, respectively. Tables 2 and 3 report the results of the statistical comparison between itemized pre- and post-surgical scores (for each group and for the whole sample) and between the post-surgical scores for each group.

The comparison between pre- and post-operative eFACE scores (both in absolute terms and as a deviation from the optimal score) showed statistically significant improvements for all items for the whole sample and for each study group. Only the deviation from the optimal score for the gentle eye closure item in group 2 did not reach statistical significance ($p = 0.173$). For this comparison, only static and dynamic parameters were taken into account, since the synkinesis items were not evaluated in the pre-operative phase.

When comparing post-operative results in the three study groups, the Kruskal-Wallis test showed a difference only for the platysmal synkinesis item scores, which were significantly lower in group 3 ($p = 0.025$).

4. Discussion

The triple innervation technique yields excellent functional and morphologic outcomes in patients with acute facial paralysis (Biglioli, 2015a; Biglioli et al., 2018; Biglioli and Allevi, 2023). This is the first article focusing on the results of this technique in patients defined as "acute" on the basis of the EMG results and not on the standard temporal criterion. Our preliminary article shows that, as long as EMG fibrillation is detected, patients can similarly benefit from triple innervation reanimation. Furthermore, postoperative results appear to be preliminary comparable and not directly affected by the paralysis onset–surgery interval length.

This study confirms that a preoperative EMG allows for assessing the mimic muscle state via muscle fibrillation identification regardless of the time of the palsy onset. In our population, EMG allowed assessment of the timing of the palsy, distinguishing recent paralysis from chronic paralysis.

Our aim was to propose a standardized EMG protocol when evaluating candidates for facial reanimation surgery with triple innervation, thus allowing a widening of the group of patients who could be treated with this technique. As the 12- to 18-month paralysis–surgery period appears as a "grey area" in most articles, we chose to separately analyse data for early, middle, and late operated patients. Our analysis showed that the EMG evaluation can be a staple for all groups, "grey area" included. Thanks to the use of preoperative EMG, 21 more patients in our case series were allowed acial reanimation through the triple innervation technique.

The results showed that all groups showed an increase in diagnostic scores calculated with the eFACE scale. There were no noticeable differences between groups, despite the small size of the late samples, suggesting a cautious interpretation of our results. The two only items dissociating from the general trend (deviation from the optimal score for the gentle eye closure item in group 2 and post-operative platysma synkinesis item scores across all groups) are of little significance to the general picture. The former item still showed improvements in absolute terms, while the latter performed even better in late operated patients. Although some limitations might appear in a wider patient population, these data do not hinder, in our opinion, the general value of this work.

These results indicate that EMG evaluation should be a critical time for surgical management of facial paralysis. EMG appears to be the only tool that allows distinguishing which patients, regardless of the distance from the time of onset of paralysis, still bear a fibrillating and trophic musculature, required for surgical nervous supply–only reinnervations. This aspect greatly affects the treatment of paralysis, as it allows for greater flexibility in operating timing and programming of the type of surgery because it points out that even patients who have had several months of previous paralysis or even years of previous paralysis may benefit from triple innervation.

5. Conclusion

EMG fibrillations should represent a further tool for defining patients who should receive treatment for acute facial palsy. This might allow a

Table 2
Mean pre- and post-operative scores for each eFACE item for the three study groups and the whole sample.

		Group 1					Group 2					Group 3					Total					Inter-group post-op results comparison with KW test, p
		Pre-operative		Post-operative			Pre-operative		Post-operative			Pre-operative		Post-operative			Pre-operative		Post-operative			
Class	Item	Mean	SD	Mean	SD	Wilcoxon test p	Mean	SD	Mean	SD	Wilcoxon test p	Mean	SD	Mean	SD	Wilcoxon test p	Mean	SD	Mean	SD	Wilcoxon test p	
Static items	Palpebral fissure at rest	69.27	16.10	94.77	15.59	<0.001	60.08	23.56	93.65	15.46	0.001	77.25	15.68	94.88	6.08	0.018	67.98	19.12	94.45	14.01	<0.001	0.810
	Nasolabial fold depth at rest	36.41	32.04	100.56	13.46	<0.001	24.88	32.21	91.23	24.91	0.001	28.88	26.70	107.00	19.01	0.012	31.52	30.92	98.94	18.98	<0.001	0.578
	Nasolabial fold orientation at rest	38.95	35.04	105.38	8.63	0.017	31.42	35.05	99.96	15.29	0.001	33.88	35.09	103.88	18.90	0.012	35.73	34.38	103.46	13.01	<0.001	0.985
	Oral commissure at rest	38.84	30.94	100.16	7.45	0.022	28.96	31.15	95.48	12.78	0.001	34.38	34.50	106.25	7.74	0.018	35.02	31.20	99.88	9.91	<0.001	0.089
Dynamic items	Gentle eye closure	28.82	31.02	85.39	20.90	<0.001	13.15	23.77	73.92	29.02	0.002	21.00	29.91	84.25	15.16	0.012	22.63	28.98	81.71	22.90	<0.001	0.753
	Full eye closure	29.43	33.04	95.00	9.87	<0.001	14.92	26.08	88.54	14.03	0.001	23.13	31.01	94.13	13.88	0.012	23.87	30.68	92.88	12.06	<0.001	0.253
	Oral commissure movement with smile	0.30	0.77	95.50	11.61	<0.001	0.85	2.15	89.02	12.07	0.001	0.25	0.71	93.88	5.77	0.012	0.45	1.33	93.24	11.08	<0.001	0.550
	Nasolabial fold depth with smile	2.32	7.54	99.20	10.56	<0.001	6.54	20.38	91.77	25.08	0.001	6.00	15.38	98.63	11.53	0.012	4.28	13.81	96.85	16.41	<0.001	0.642
	Nasolabial fold orientation with smile	4.09	16.37	102.66	9.20	<0.001	1.00	2.45	95.60	12.12	0.001	4.25	9.65	105.50	17.97	0.012	3.19	12.38	101.05	12.35	<0.001	0.429
Synkinesis	Ocular	n/a	n/a	74.26	22.41	n/a	n/a	n/a	83.65	12.63	n/a	n/a	n/a	82.38	21.33	n/a	n/a	n/a	78.61	19.82	n/a	0.936
	Midfacial	n/a	n/a	87.73	11.01	n/a	n/a	n/a	87.54	14.93	n/a	n/a	n/a	83.13	11.36	n/a	n/a	n/a	86.81	12.20	n/a	0.284
	Mentalis	n/a	n/a	93.55	10.68	n/a	n/a	n/a	89.88	18.69	n/a	n/a	n/a	71.25	33.81	n/a	n/a	n/a	88.29	20.44	n/a	0.111
	Platysmal	n/a	n/a	97.39	9.63	n/a	n/a	n/a	95.00	7.64	n/a	n/a	n/a	88.63	22.07	n/a	n/a	n/a	95.03	12.45	n/a	0.025

SD = standard deviation; n/a = not available; KW =Kruskal-Wallis.

Table 3
Pre- and post-operative differences from the optimal score for each eFACE item for the three study groups and the whole sample.

		Group 1					Group 2					Group 3					Total					Inter-group post-op results comparison with KW test, p
		Pre-operative		Post-operative			Pre-operative		Post-operative			Pre-operative		Post-operative			Pre-operative		Post-operative			
Class	Item	Mean	SD	Mean	SD	Wilcoxon test p	Mean	SD	Mean	SD	Wilcoxon test p	Mean	SD	Mean	SD	Wilcoxon test p	Mean	SD	Mean	SD	Wilcoxon test p	
Static items	Palpebral fissure at rest	30.73	16.10	10.55	12.46	0.011	39.92	23.56	12.65	10.45	0.025	22.75	15.68	5.13	6.08	0.018	32.02	19.12	10.17	11.04	<0.001	0.123
	Nasolabial fold depth at rest	63.59	32.04	9.49	9.33	0.013	75.12	32.21	14.00	21.60	0.005	71.13	26.70	14.75	12.99	0.012	68.48	30.92	11.83	14.52	<0.001	0.999
	Nasolabial fold orientation at rest	62.14	32.97	7.72	6.50	<0.001	68.58	35.05	11.73	9.20	0.041	66.13	35.09	14.88	11.03	0.017	64.83	33.29	10.26	8.59	<0.001	0.080
	Oral commissure at rest	61.16	30.94	4.20	6.08	<0.001	71.04	31.15	6.56	11.78	0.001	65.63	34.50	6.25	7.74	0.018	64.98	31.20	5.30	8.33	<0.001	0.804
Dynamic items	Gentle eye closure	71.18	31.02	14.61	20.90	<0.001	86.85	23.77	28.54	26.39	0.173	79.00	29.91	15.75	15.16	0.012	77.37	28.98	19.03	22.27	<0.001	0.200
	Full eye closure	70.57	33.04	5.00	9.87	<0.001	85.08	26.08	11.46	14.03	0.001	76.88	31.01	5.88	13.88	0.012	76.13	30.68	7.12	12.06	<0.001	0.253
	Oral commissure movement with smile	99.70	0.77	8.14	9.31	<0.001	99.15	2.15	10.98	12.07	0.039	99.75	0.71	7.13	4.26	0.012	99.55	1.33	8.81	9.50	<0.001	0.596
	Nasolabial fold depth with smile	97.68	7.54	8.43	6.13	<0.001	93.46	20.38	14.77	21.59	0.003	94.00	15.38	8.13	7.72	0.012	95.72	13.81	10.29	13.07	<0.001	0.481
	Nasolabial fold orientation with smile	95.91	16.37	7.52	5.72	<0.001	99.00	2.45	9.94	7.80	0.023	95.75	9.65	14.25	11.20	0.012	96.81	12.38	9.51	7.81	<0.001	0.608
Synkinesis	Ocular	n/a	n/a	25.74	22.41	n/a	n/a	n/a	16.35	12.63	n/a	n/a	n/a	17.63	21.33	n/a	n/a	n/a	21.39	19.82	n/a	0.391
	Midfacial	n/a	n/a	12.27	11.01	n/a	n/a	n/a	12.46	14.93	n/a	n/a	n/a	16.88	11.36	n/a	n/a	n/a	13.19	12.20	n/a	0.963
	Mentalis	n/a	n/a	6.45	10.68	n/a	n/a	n/a	10.12	18.69	n/a	n/a	n/a	28.75	33.81	n/a	n/a	n/a	11.71	20.44	n/a	0.431
	Platysmal	n/a	n/a	2.61	9.63	n/a	n/a	n/a	5.00	7.64	n/a	n/a	n/a	11.38	22.07	n/a	n/a	n/a	4.97	12.45	n/a	0.090

SD = standard deviation; n/a = not available; KW = Kruskal-Wallis.

wider group of paralysis patients to be treated with more effective dynamic techniques. Further prospective studies examining EMG fibrillations in patients in the pre-surgical phase might allow for further refinement of the technique selection process.

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None.

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