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Electromyography and Facial Paralysis

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1. Introduction

The facial motor system is responsible for functions critical to physical, social and psychological well-being (VanSwearingen & Brach, 1996). Facial nerve paralysis is a life-altering clinical condition, with functional, aesthetic and communication implications for the individuals who are afflicted (Hadlock, 2008). It differs from most other clinical conditions in that it is the end result of a very wide variety of underlying conditions; ranging from skull base trauma, congenital syndromes, skull base tumors, infectious diseases, among others, leading to a single disability (Diels, 2000; Hadlock, 2008). Several studies have presented conflicting results regarding its epidemiology. The precise annual incidence of Bell's palsy, the most common cause of unilateral facial weakness, in the Western world is probably around 20 to 25 per 100,000 people (Peitersen, 1982; Morgan & Nathwani, 1982). Bell's palsy is defined as isolated, sudden, peripheral facial paralysis of unknown etiology. However, it is generally accepted that it is a nonsuppurative, inflammatory, generative disease of the facial nerve within the stylomastoid foramen (Proctor, Corgill & Proud, 1976). The vast majority (around 80-84%) of patients will recover completely, but a few (16-20%) will remain with chronic facial paralysis or paresis (Peitersen, 1982; Morgan & Nathwani, 1982).

Although Bell's palsy may develop at any age, literature often points that it is more common among young or middle-aged adults (onset between 31-60 years) (Kukimoto et al., 1988; Gonçalves-Coelho et al., 1997; Bradbury, Simons & Sanders, 2006). The longer the recovery is delayed, the higher is the incidence of sequelae such as synkinesis and contracture (Ghali, MacQuillan & Gorbbellaar, 2001). Completeness of recovery also decreases with age with 90% complete remission up to the age of 14 compared below 40% for the over 60 age group (Peitersen, 1982). Results about distribution between genders are also conflicting. While a few authors point that the disease is equally distributed between genders (Morgan & Nathwani, 1982), others point that it is more common among females (Bradbury, Simons & Sanders, 2006; Garcia et al., 2010).

Literature indicates that head trauma is the second most frequent cause of facial paralysis (Atolini Junior et al., 2009; Pinna, Testa & Fukuda, 2004). Causes of head trauma are usually related to traffic injuries (82.5%), fall from height (7.5%), assault (5%), and gunshot (2.5%), although numbers can vary significantly from one country to the next (Pinna, Testa & Fukuda, 2004; Odebode & Ologe, 2006). Until the end of the 19th century, the treatment of facial paralysis involved non-surgical means such as ointments, medicines and electrotherapy (van de Graaf & Nicolai, 2005). With the advent and refinement of microvascular surgical techniques in the latter half of the 20th century, vascularised free muscle transfer coupled with cross-facial nerve grafts were introduced, allowing the possibility of spontaneous emotion being restored to the paralysed face became reality (Ghali, MacQuillan & Grobbelaar, 2011). The clinical or surgical treatment will depend on lesion extension.

Other causes of facial paralysis include the presence of infections, among which are the herpes group of viruses, especially herpes simplex virus and varicella-zoster virus (Morgan & Nathwani, 1992; Yeo et al., 2007), complication of acute otitis media or in the presence of cholesteatoma (Atolini Junior et al., 2009) and Schwanomas of the 7th and 8th cranial pairs (Rosenberg, 2000; Lee et al., 2007; Saito & Cheung, 2010).

Considering the anatomy and function of the facial nerve, the stylomastoid foramen marks the beginning of the facial nerve's extracranial course. The nerve becomes superficial rendering it susceptible to trauma before entering the parotid gland and dividing into two main trunks within the substance of the gland (Seikel, King & Darmright, 2010; Ghali, MacQuillan & Grobbellaar, 2010). On exiting the gland, there are between 8 and 15 branches making up the five of the facial nerve; temporal, zygomatic, buccal, marginal mandibular and cervical. Beyond the parotid gland, there is a significant arborisation and interconnection of these divisions resulting in a degree of functional overlap between branches. The facial nerve controls all the superficial facial musculature and therefore controls the appearance of the face, the ability to show expression and most of the functions about forehead, eye, cheeks and mouth (see Table 1). The main complaint in lower facial paralysis, as is the case of individuals with Bell's palsy, is the inability to smile. The most important muscles involved in smiling are zygomaticus major and levator labii superioris (Proctor, Corgill & Proud, 1976; Ghali, MacQuillan & Grobbellaar, 2010).

Muscle	Action
Corrugator supercilii	Moves eyebrow downward and medially
Procerus	Wrinkles skin of the nose
Orbicularis oculi	Closes eye
Orbicularis oris	Closes mouth
Compressor naris	Compresses nasal cartilage
Dilator naris	Dilates nostrils
Levator labii superioris	Lifts upper lip
Zygomaticus major and minor	Raise and pull upper lip laterally
Levator anguli oris	Raise corner of the mouth
Risorius	Smiling (lateral pull on the corner of the mouth)
Depressor anguli oris	Pulls down the corner of the mouth
Depressor labii inferioris	Depresses lower lip
Mentalis	Wrinkles skin of the chin
Buccinator	Compresses mouth and keeps food between teeth when chewing
Frontalis	Raises eyebrows
Platysma	Moves skin of the neck

Table 1. Action of face muscles

Given the trend of evidence-based practice (Sackett et al., 2000), it has become important to establish which facial paralysis assessment and management strategies demonstrate significant answers and benefit, either with respect to function, aesthetic appearance, ability to communicate, or a combination of these. Patients presenting with facial paralysis usually undergo subjective assessments of facial function (House & Brackmann, 1985; Berg et al., 2004), standard photographic documentation, and sometimes videographic imaging (Hadlock, 2008). As a general rule, individual practitioners have selected specific grading scales based on training, exposure and institutional experience, rather than clinical relevance to outcomes. Although these procedures may provide an accurate depiction of a patient's level of facial paresis, they do not address how this handicap may affect a patient's quality of life.

The psychological literature on the subject of facial disfigurement has consistently shown that those with facial disfigurement do experience psychological and social problems, resulting in fear of public places and impaired socialization (Tate & Tollefson, 2006; Bradbury, Simons & Sanders, 2006; Hadlock, 2008). There is evidence in the literature that individuals with facial palsy experience marked psychological and social problems. Normal face-to-face communication can be interrupted by altered or diminished facial expressions (Keillor et al., 2002). The aesthetic impact of the disfigurement caused by facial palsy is exacerbated by impaired facial movement and, therefore the individual may try to restrict expressive facial movements to minimize the disfigurement. This can be interpreted as hostile by others, provoking aggressive responses, and can increase social anxiety and avoidance. In addition the individual may become self-conscious when eating or drinking because of functional problems (Bradbury, Simons & Sanders, 2006). Symptoms can range from altered emotional well-being, decreased self-esteem, anxiety, depression, and alternative behaviors such as social isolation and addiction (Ross et al., 1991; VanSwearingen & Brach, 2003; Finn et al., 2003; Hadlock, 2008). In this sense, self-report scales are of extreme importance in order to enhance the assessment of facial neuromuscular dysfunction. Although the clinical recognition of the above mentioned problems exist, very few studies using self-reports as a form to control the outcome of treatment were found in the literature (Salles et al., 2009).

As reported in studies about disfigurement, psychological distress rather than functional impairment has been found to be the most significant predictor of social disability in patients with hemi-facial palsy (VanSwearingen, Turnbull & Mrzai, 1998). VanSwearingen and Brach (1996) have pointed that patients with facial neuromuscular dysfunction have disability associated with the disorder. The terms impairment and disability are defined within the World Health Organization's International Classification of Impairments, Disabilities, and Handicaps (Barbotte et al., 2001). Impairments refer to any physiologic or anatomic abnormalities at the organ or tissue system level, such as muscle weakness. Disabilities are person-level problems characterized by the inability to perform any of the activities considered usual for a human being, such as limitations in walking or limited ability to communicate. Wilson and Cleary (1995) suggested that the patient's emotional well-being may influence the relationship between impairment and disabilities.

To enhance the assessment of facial neuromuscular dysfunction beyond the impairment domain, VanSwearingen and Brach (1996) developed a disability assessment instrument, the Facial Disability Index (FDI). The FDI is a self-report, disease-specific instrument designed to provide the clinician with information about the disability and related social and emotional well-being of patients with facial nerve palsy. According to the authors, the FDI can be used as an initial assessment tool and as a monitoring instrument, providing the clinician with the patient's view of the outcome of the intervention in progress. The FDI is composed by two subscales: Physical Function and Social/well-being function. The Physical Function subscale involves questions related to difficulty in eating, difficulty in drinking, difficulty in speaking, excessive tearing or drying of the eye and difficulty in brushing/rinsing the teeth. The Social/well-being subscale involves questions related to feeling calm and peaceful, isolating self from people, feeling irritable toward those around, waking up early or several times at night and avoiding going out to eat, shop or participating in social activities.

Besides proposing the FDI, the authors also examined the reliability and validity of the questionnaire. The questionnaire was administered to 46 ambulatory patients with facial palsy. The results of the study indicated that the FDI subscales produced reliable scores and that the subscale of Physical Function presented a higher reliability when compared with that of Social/well-being. The authors argue that this result may be due to the fact that the facial functions assessed are largely behaviors that necessarily occur more than once a day. The authors also found a significant association of the FDI subscales with the clinical measures of facial movement and psychosocial status. Other studies have been conducted trying to correlate measures of impairment and disability using the FDI. Overall, these studies indicate a positive correlation between impairment and disability measures in patients with facial nerve paralysis (VanSwearigen et al., 1998; Coulson et al., 2004).

The most important, impeding need to improve the clinical care of the facial paralysis patient is an objective, quantitative, comprehensive evaluation of function. In this sense, surface electromyography (sEMG) can give clinicians valuable information because it provides easy access to physiological processes that cause muscle to generate force, produce movement and accomplish the countless functions which allow us to interact with the world around us (De Luca, 1997).

Studies have already been successful in reporting the outcome of neuromuscular retraining in combination with sEMG (Daniel & Guitar, 1978; Balliet et al., 1982; May et al., 1989; Ross et al., 1991; Segal et al., 1995; Brach et al., 1997; Cronin & Steenerson, 2003; VanSwearingen & Brach, 2003; Vaiman et al., 2005). Biofeedback sEMG instruments are essentially general purpose physiological monitoring devices that are designed to provide ongoing information about physiological function, such as muscle tension level (Vaiman et al., 2005). Using neuromuscular retraining in combination with sEMG is based on the plasticity of the central nervous system. The brain is capable of reorganizing using the visual and/or auditory feedback provided by sEMG (Cronin & Steenerson). Literature points that the therapeutic use of sEMG helps patients to develop selective muscle control and decreases synkinesis. No studies were found in the consulted literature related to the use of sEMG in the assessment of impairment caused by facial paralysis.

Although facial movement and muscle activity can be quantified using one of several techniques (House & Brackmann, 1985; Kayhan et al., 2000; Linstrom et al., 2000; Linstrom, 2002; Kang et al., 2002; Mehta et al., 2008) and facial disability can be quantified using self-report instruments (VanSwearingen & Brach, 1996), a relationship between objective and subjective measurements has not yet been described. The purpose of this study was to correlate electromyographic data of the anguli oris elevators to the facial disability index in long standing facial paralysis patients. We hypothesized that individuals with greater facial asymmetry (i.e. lower readings on surface electromyography) would present lower scores on the facial disability index.

2. Methods and materials

The population in this study was defined as 17 patients (mean age 42 years; age range from 35 to 60), all females, with unilateral facial nerve paralysis. All of the patients presented static and/or dynamic facial asymmetry. Patients who presented systemic or neuromuscular disease, impaired cognition and asymmetry due to craniofacial deformities were excluded from the research. A control group with 17 normal volunteers, matched for age and gender to the research group, was also included in the study. All of the selected individuals, in the research and control groups, signed an informed consent approved by the review board and ethics committee of the institution (CAPPesq HCFMUSP no 0201/08).

Inclusion criteria for the research group:

a. to present medical diagnosis of long-standing unilateral peripheral facial paralysis, i.e. with more than two years since the beginning of symptoms, with or without previous treatment by surgical methods (reconstruction or reanimation);
b. to present scores between 4 and 11 on the Clinical Score for Facial Palsy Protocol (Salles et al., 2009).

Category	N.
Acoustic neuroma	2
Bell's palsy	12
Facial nerve trauma (temporal/basilar skull fractures)	3

Table 2. Participants' distribution per diagnostic categories of facial dysfunction – Research group

Inclusion criteria for the control group:

a. to present no medical history of facial paralysis or head and neck trauma;
b. to present scores between 19 and 20 on the Clinical Score for Facial Palsy Protocol (Salles et al., 2009).

Procedure

Clinical score for facial palsy protocol

Facial symmetry was evaluated by two staff members. As already described in the literature, with this scale every voluntary movement for both sides of the face is evaluated independently, as well as the involuntary (emotional) motion. The protocol is composed by three sections: force of voluntary movement (eyebrow raise, eyelid closure, upper lip elevation - sniff, upper-lateral traction of lips, horizontal traction of lips; lip closure; lower lip depression); force of involuntary movements (eyelid closure when blinking, when speaking; when spontaneously smiling); negative findings (eyelid deformity at rest, lip deformity at rest; synkinesis/spasms). Movements were graded as absent (0), partial (1), or full (2). Negative aspects received negative scores ((0) absent, (-1) moderate, (-2) pronounced). The sum of individual scores gives a final score that ranges up to 20 points, or 100%.

Surface electromyography (sEMG) evaluation

One muscle group was examined in the study: the anguli oris elevators (zygomaticus major and minor, levator anguli oris). This muscle group was selected because it is directly involved in the action of smiling.

All EMG recordings were made using standard surface sensors (SDS500). We used the Miotool 400 (Miotec® Biomedical Equipments, Brazil) 4-channel computer-based system and disposable double electrodes (SDS 500 Ag/AgCl, contact surfaces with 10mm diameter). This EMG system has wide bandpass filter, bandwidth (RMS) 20 to 500 Hz and a 60-Hz notch filter. The system uses the Active Electrode, a compact sensor assembly that includes a miniaturized instrument preamplifier. Locating the amplifier at the electrode site allows artifacts to be canceled and the signal boosted before being transferred down the electrode cable (noise level < 5μV RMS). Each EMG record was full-wave and low-passed filtered. The computer program indicates mean, SD, minimum, maximum and range of muscle activity during each trial. Muscle activity (EMG) was quantified in microvolts (μV).

The interelectrode distance was 10mm; two sets of two bipolar pre-gelled stick-on surface electrodes were applied to the skin on each side of the face, over the anguli oris elevators to record myoelectrical activity during the production of a voluntary smile (Figure 1). This electrode arrangement had a third electrode as ground positioned on the right wrist. Electrical impedance at the sites of electrode contact was reduced because skin was scrubbed with alcohol gauze pads.

Fig. 1. Electrode placement

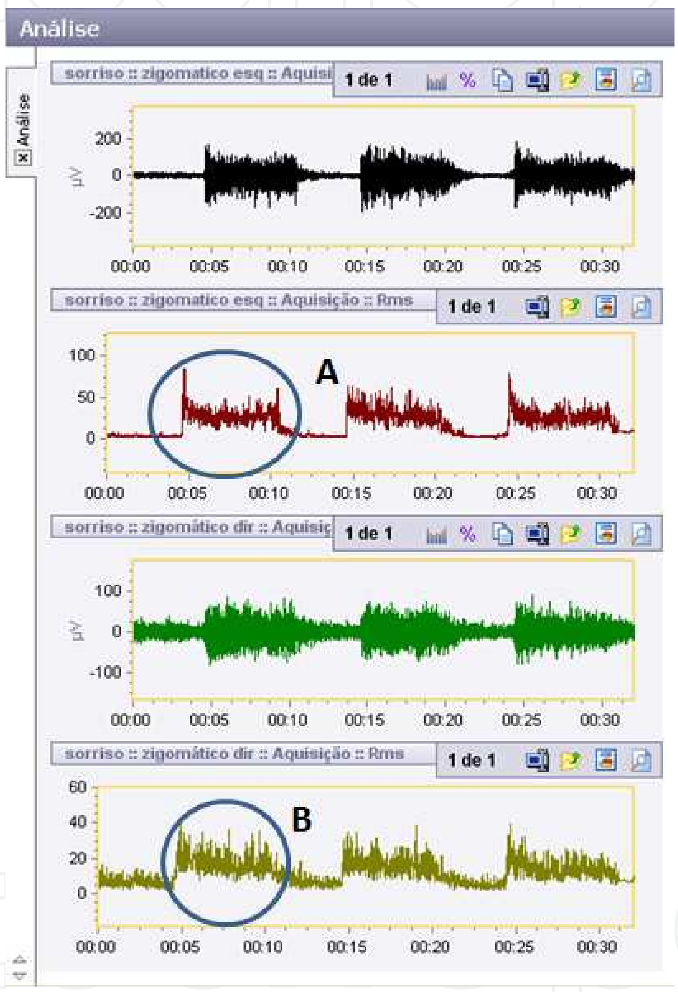
At first, mean electric activity of resting muscle anguli oris elevators was obtained. Following this, three tests of voluntary smiles were examined.

Step 1: Participants remained seated with their heads positioned horizontally according to the Frankfort plane. After the pairs of EMG electrodes were placed over the skin each participant was instructed to remain quiet and relaxed for the period of 1 minute. Three separate recordings of resting condition were made, with the duration of 30 seconds each.

Step 2: Each participant was asked to smile for 5 seconds and then relax for 5 seconds, three times. Participants were instructed to avoid sharp head movements. The request to begin sEMG recording was provided only when the sEMG baseline activity returned to resting levels.

sEMG data analysis

Surface EMG traces were evaluated for onset, peak and offset of activity during smiling events (Figure 2). Onset was identified as the point of upward excursion of the sEMG trace from resting baseline that led into the smiling event. Peak was the highest amplitude point of the sEMG smile trace. Offset was the point at which sEMG activity returned to baseline. Computer software calculated the mean value of the action potential during the movements (onset-peak-offset). In order to compare the results between participants, sEMG amplitude values were normalized relative to rest in order to give evidence to possible differences in symmetry.



*Note: A – sEMG smile trace of the nonparalyzed side; B – sEMG smile trace of the paralyzed side

Fig. 2. sEMG smile trace

sEMG data reliability

Because subjective judgment was used for sEMG measures, interjudge reliability was estimated. To establish interjudge reliability of the measurements used in the study, a second experienced staff member, who was blinded to the original results, measured the same parameters of 30 randomly selected samples from the 204 total smiling events. Intraclass correlation coefficients were high for all comparisons (range of lower 95% confidence interval [CI] = .9788-.9965), suggesting strong consistency between examiners.

Facial Disability Index (FDI)

The FDI is a brief self-report questionnaire of physical disability and psychosocial factors related to facial neuromuscular function (VanSwearingen & Brach, 1996). It is designed to provide an account of the patient´s daily experience of living with a facial nerve disorder. It has two subscales: the Social/Well-Being Function subscale (SWBF), that contains items related to the psychological and social role aspects, and the Physical Function subscale (PF), with items that evaluate difficulties with daily activities (e.g. brushing the teeth, eating or drinking). Only participants of the research group answered the questionnaire.

Data analysis

Statistical analysis included paired-samples T- test and Spearman coefficient correlation, with a significance level of 0.05. The coefficient of asymmetry between both sides of the face during rest and muscle contraction was calculated for both groups as follows: research group – ratio Nonparalyzed side/Paralyzed side; control group - Right side/Left side.

3. Results

Surface Electromyography (sEMG) Evaluation

Differences were observed between the research and control groups. Descriptive statistics indicate that the research group presented lower electromyographic values for the resting and smiling conditions than the control group. Greater variability among the recordings was observed for the similing condition for both groups (Table 3).

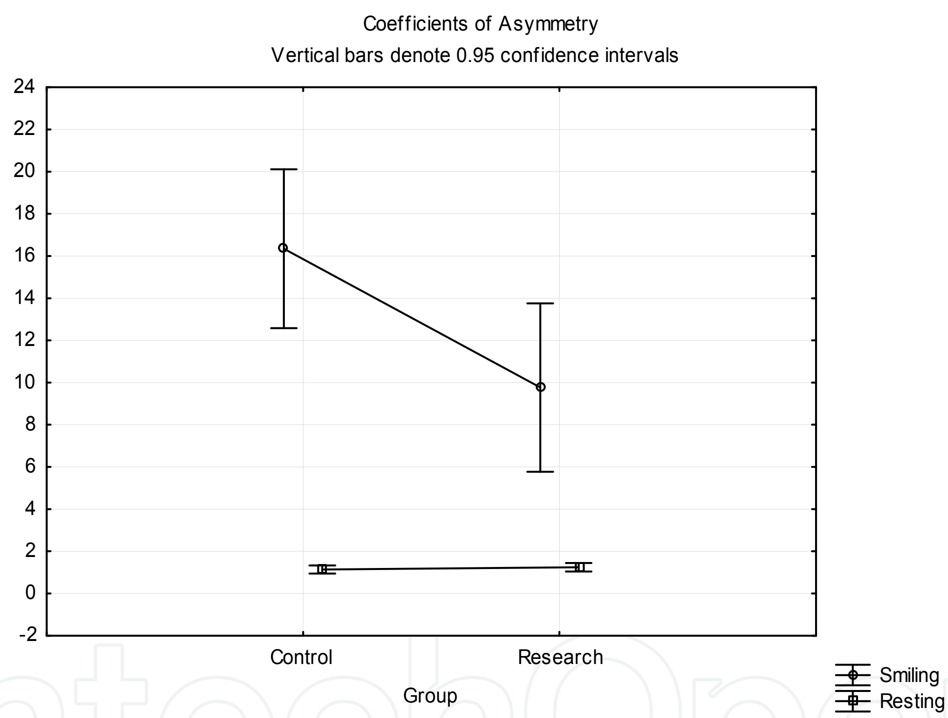
Descriptive Statistics						
Group	**Condition**	**Side**	**Minimum**	**Maximum**	**Mean**	**SD**
Research	Resting	P (raw data)	2.4	7.30	4.36	1.45
		NP (raw data)	2.2	6.80	3.55	1.07
	Smiling	P (raw data)	4.7	59.70	20.41	14.13
		P (normalized data)	1.75	12.19	4.57	2.59
		NP (raw data)	15.03	183.80	61.67	46.77
		NP (normalized data)	4.42	65.64	18.39	15.37
Control	Resting	R (raw data)	2.21	17.00	6.12	3.40
		L (raw data)	2.25	9.78	5.59	2.35
	Smiling	R (raw data)	15.92	99.26	66.52	23.39
		L (raw data)	21.51	98.75	67.79	19.88
		R (normalized data)	5.84	65.10	15.70	13.57
		L (normalized data)	6.38	40.13	14.33	8.99

*Note: SD – standard deviation; NP – nonparalyzed side; P – paralyzed side; R – right side; L – left side.

Table 3. Surface electromyography descriptive statistics (μV)

When comparing both groups, participants of the research group presented a significant difference between both sides of the face for the resting ($p=0.041$; $T=2.225$) and smiling ($p=0.001$; $T=-4.151$) conditions. The coefficient of asymmetry was higher for the smiling condition (resting condition mean 1.28±0.42; smiling condition mean 11.48±8.36). On the other hand, participants of the control group did not present significant difference between the right and left sides of the face for the resting ($p=0.373$; $T=0.917$) and smiling ($p=0.735$; $T=0.344$) conditions. As observed for the research group, the control group also presented a higher coefficient of asymmetry for the smiling condition (resting condition mean 1.10±0.36; smiling condition mean 15.02±8.05).

In order to verify differences between facial asymmetry, the coefficient of asymmetry obtained for the resting and smiling conditions for both groups were compared (Figure 3). Statistical analyses indicated no differences between the groups for the resting (p=0.3; T=-1,288) and for the smiling condition (p=0.848; T=1,235).



*Note: NP:P – ratio nonparalized side/paralyzed side; R:L- ratio right side/left side

Fig. 3. Coefficients of Asymmetry – Between groups comparison

Facial Disability Index (FDI)

Only participants of the research group answered the Facial Disability Index. The mean Physical Function (PF) subscale value of the FDI was of 70 (Minimum 50; Maximum 95) and of the Social/Well-Being Function (SWBF) subscale was of 68 (Minimum 40; Maximum 92).

Spearman coefficient correlation was performed in order to verify possible associations between the subscales of the FDI and between the coefficient of asymmetry (sEMG) and the subscales of the FDI. Figure 4 shows data dispersion and Table 4 and 5 shows the correlation results between the coefficient of asymmetry for resting and smiling and the FDI subscales.

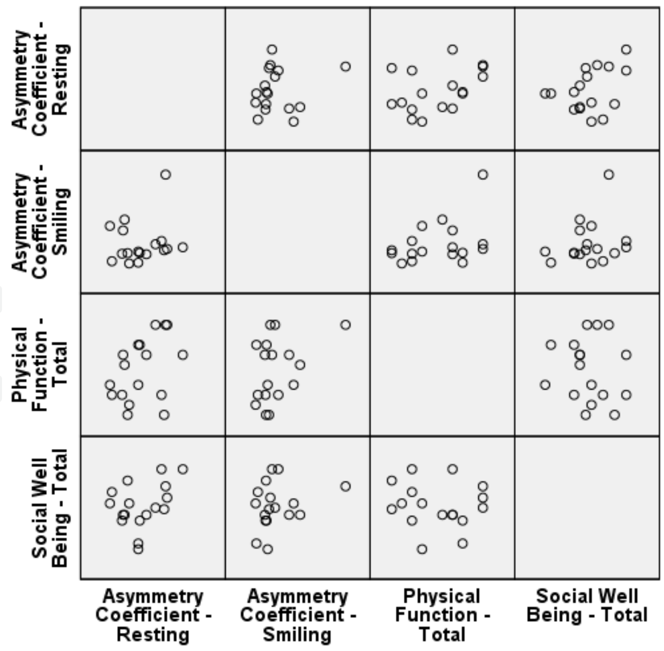


Fig. 4. Correlation between FDI subscales and sEMG - data dispersion

	Question	Correlation Coefficient	Significance
PF	1. Difficulty eating	.317	.215
	2. Difficulty drinking from a cup	.392	.119
	3. Difficulty speaking	.448	.071
	4. Excessive tearing or drying of the eye	.122	.642
	5. Difficulty brushing/rinsing teeth	.300	.242
	Total	.428	.087
SWBF	1. Feel calm and peaceful	.334	.190
	2. Isolate self from people	.269	.296
	3. Irritable toward those around you	.321	.210
	4. Wake up early, wake up several times	-.060	.819
	5. Avoid going out to eat, shop or participate in social activities	.147	.573
	Total	.324	.205

*Note: PF – Physical Function; SWBF – Social/Well being function

Table 4. Spearman correlation between Facial Asymmetry Coefficient for Resting and Scores on the FDI subscales

	Question	Correlation Coefficient	Significance
PF	1. Difficulty eating	.384	.129
	2. Difficulty drinking from a cup	-.266	.302
	3. Difficulty speaking	.133	.610
	4. Excessive tearing or drying of the eye	.344	.177
	5. Difficulty brushing/rinsing teeth	.453	.068
	Total	.333	.192
SWBF	1. Feel calm and peaceful	.571*	.017
	2. Isolate self from people	-.186	.476
	3. Irritable toward those around you	-.031	.907
	4. Wake up early, wake up several times	.286	.265
	5. Avoid going out to eat, shop or participate in social activities	.025	.924
	Total	.276	.284

*Note: PF – Physical Function; SWBF – Social/Well being function; * significant results

Table 5. Spearman correlation between Facial Asymmetry Coefficient for Smiling and Scores on the FDI subscales

Results indicate a significant correlation between the facial asymmetry coefficient for smiling and question one on the SWBF (p=.017). Individuals who presented greater differences in sEMG amplitude values when comparing the paralyzed and nonparalyzed sides of the face, tended to present lower scores on the question related to feeling calm and peaceful. No other significant correlations were observed.

4. Discussion

This study analyzed the correlation between electromyographic data of the anguli oris elevators (smile) to the scores obtained in a self-report questionnaire (FDI) in long standing facial paralysis patients. Our results indicated a single correlation between objective (sEMG) and self-assessment measurements; therefore our hypothesis was not confirmed. Although there was a wide variation for muscle activation among the tested individuals (sEMG), our results also indicated that individuals with facial paralysis presented significant differences between the paralyzed and nonparalyzed sides of the face, whereas healthy individuals presented no such differences. These results indicating muscle activation differences between the paralyzed and nonparalyzed side of the face have already been reported in the literature and indicate that the integrity of the facial nerve is essential for the balance and symmetry when producing facial mimetic expressions (Deleyiannis et al., 2005; Salles et al., 2009).

Facial paralysis causes both anatomical and physiological changes. Asymmetries can be caused not only by weaker muscle contractions on the paralyzed side, but also by overactivation of the nonparalyzed side (Pennock et al., 1999). A few consequences tend to appear four months after the onset, with muscle contractures and hypertrophy in association with synkinesis (Diels, 2000). A limiting factor is the viability of the facial muscles, generally because 12 months after nervous degeneration, muscles suffer atrophy very rapidly. In our study, the nonparalyzed side of the face of the research group was approximately 26% less active when compared to the muscle activation of the control group during the smiling condition (comparison for normalized data).

Management of long-standing facial paralysis has been controversial. The inability to smile effectively has been a primary motivator for surgical and nonsurgical management of the face after facial nerve palsy (Ross et al., 1991; Pennock et al., 1999; Croxson et al., 2000; Diels, 2000; VanSwearingen & Brach, 2003; Beurskens, 2004; Vaiman et al., 2005; Coulson et al., 2006; Tate & Tollefson, 2006; Salles et al., 2009). Nonsurgical management include application of botulinum toxin, phsysiotherapy techniques and muscle retraining such as mime therapy, electromyographic biofeedback and specific facial exercises. Problematically, even well-designed studies often reflect differing results, based on the inherent difficulty in precisely measuring recovery (Pinna, Testa & Fukuda, 2004; Beurskens, Heymans & Oostendorp, 2006; Hadlock, 2008; Ghali, MacQuillan & Grobbelaar, 2011). Once the field of facial nerve management reaches a consensus on quantitative facial function analysis and global results comparisons, the role of muscle retraining techniques will be clarified.

Literature has shown that the normal human face presents 6% of asymmetry during the production facial mimetic expressions (Burres, 1985). These differences were observed when combining linear measurements and integrated invasive electromyography (iEMG) and would correspond to asymmetries in anatomy, in muscle contraction caused by non-balanced forces and due to differences in measuring techniques. Our study found no such difference in muscle activation when comparing the right and left sides of the face in healthy individuals. However, the coefficient of asymmetry suggests some degree of facial asymmetry in the control group. Surface electromyography is less specific for measuring muscle activation than invasive electromyography, this will probably account for the differences in result in our study and the later. According to Castroflorio et al. (2006), methodological factors associated with the recording of sEMG may have been the cause of controversial results reported in different studies developed with muscles of the head and neck. Although no studies using sEMG for the assessment of facial paralysis where found in the literature and despite the problems with methodological difficulties inherent to use of sEMG, applications of this technological device in facial muscles seem to be promising. Moreover, technological advances in signal detection and processing have improved the quality of the information extracted from sEMG and furthered our understanding of the anatomy and physiology of the stomatognathic apparatus.

Although the literature points that FDI subscales produce reliable measurements for reporting outcomes for individuals with disorders of the facial motor system (VanSwearingen & Brach, 2003) and even to report treatment outcomes (Salles et al., 2009), our study found no correlation between these subscales and objective measurements. This fact should be carefully examined. In our study we only measured muscle activity of the anguli oris elevators (zygomaticus major and minor, levator anguli oris), mostly related to smiling. Questions on the Physical Function subscale are largely related to the functions developed by the orbicularis oris and buccinators, the investigation of these muscles should be explored in futures studies of facial paralysis using sEMG.

The only significant correlation observed was between facial asymmetry and the question related to feeling calm and peaceful on Social/Well-being Function subscale. The literature points that facial nerve dysfunction can be a devastating handicap. Facial nerve dysfunction may be classified into two components: facial impairment which describes the anatomical abnormality, and facial disability which pertains to the functional and social deficits caused by the impairments (Saito & Cheung, 2010). Studies have shown a significant relationship of acquired facial palsy with depression, anxiety and high levels of psychological stress (Bull, 1998; VanSwearigen et al., 1998; Bradbury, Simons & Sanders, 2006).

5. Conclusion

The use of modern scientific techniques of data analysis, such as the use of sEMG, combined with self-report measurements most certainly offers great promise to clinicians and their patients. The FDI seems the capture information that goes beyond strict muscle function, i.e. the impairment rather than the function level. The combination of different measurements in randomized trials examining whether, or what type of therapy design offers optimal benefit to patients suffering from facial paralysis should be our future initiative.

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7. References

Atolini Junior N, Jorge Junior JJ, Gignon VF, Kitice AT, Prado LSA, Santos VGW. Facial nerve palsy: incidence of different ethiologies in a tertiary ambulatory. International Archives of Otohinolaryngology. 2009; 167-171.

Balliet R, Shinn JB, Bach-Y-Rita P. Facial paralysis rehabilitation: retraining selective muscle control. International Rehabilitation Medicine. 1982: 4:67-74.

Barbotte E, Guillemin F, Chau N, Lorhandicap group. Prevalence of impairment, disabilities, handicaps and quality of life in the general population: a review of the literature. Bulletin of the World Health Organization. 2001;79:1047-1055.

Berg T, Jonsson L, Engström M. Agreement between the Sunnybrook, House-Brackmann, and Yanagihara facial nerve grading systems in Bell's palsy. Otology & Neurotology. 2004; 25:1020-1026.

Beurskens C. Positive effects of mime therapy on sequelae of facial paralysis: stiffness, lip mobility, and social and physical aspects of facial disability. Journal of Otology & Neurotology. 2004; 24:2003.

Beurskens CHG, Heymans PG, Oostendorp RAB. Stability of benefits of mime therapy in sequelae of facial nerve paresis during a 1-year period. Otology & Neurotology. 2006; 27:1037-1042.

Brach JS, VanSwearingen JM, Lenert J, Jonhson PC. Facial neuromuscular retraining for oral synkinesis. Plastic Reconstructive Surgery. 1997; 99:1922-31.

Bradbury ET, Simons W, Sanders R. Psychological and social factors in reconstructive surgery for hemi-facial palsy. Journal of Plastic Reconstructive Aesthetic Surgery. 2006; 59:272-278.

Bull R, Rumsey N. The social psychology of facial appearance. Berlin: Springer, 1988.

Burres SA. Facial biomechanics: the standards of normal. Laryngoscope. 1985; 95(6):708-714.

Castroflorio T, Icardi K, Becchino B, Merlo E, Debernardi C, Bracco P, Farina D. Reproductibility of surface EMG variables in isometric sub-maximal contractions of jaw elevator muscles. Journal of Electromyography Kinesiology. 2006; 16:498-505.

Coulson SE, Adams RD, O'Dwyer NJ, Croxson GR. Physiotherapy rehabilitation of the smile after long-term facial nerve palsy using video self-modeling and implementation intentions. Otolaryngology – Head and Neck Surgery. 2006; 134:48-55.

Cronin GW, Steenerson RL. The effectiveness of neuromuscular facial retraining combined with electromyography in facial paralysis. Otolaryngology – Head and Neck Surgery. 2003; 128(4):534-538.

Croxson G, Quinn M, Coulson S. Temporalis muscle transfer. A further refinement. Facial Plastic Surgery. 2000; 16:351-356.

Daniel B, Guitar B. EMG feedback and recovery of facial and speech gestures following neural anastomosis. Journal of Speech and Hearing Disorders. 1978; 43:9-20.

De Luca CJ. The use of surface electromyography in biomechanics. Journal of Applied Biomechanics. 1997; 13(2):135-163.

Deleyiannis FW, Askari M, Schmidt KL, Henkelmann TC, VanSwearingen JM, Manders EK. Muscle activity in the partially paralyzed face after placement of a fascial sling: preliminary report. Annals of Plastic Surgery. 2005; 55(5):449-455.

Diels HJ. Facial paralysis: is there a role for a therapist? Facial Plastic Surgery. 2000; 16:361-364.

Finn JC, Cox SE, Earl ML. Social implications of hyperfunctional facial lines. Dermatologic Surgery. 2003; 29:450-455.

Garcia RB, Pérez SC, Suárez-Varela MM, Torella ME, Galofre JD. Sequelae of peripheral facial palsy. Acta Otorrinolaringológica Española. 2010; 61:89-93.

Ghali S, MacQuillan A, Gobbelaar AO. Reanimation of the middle and lower face in facial paralysis: review of the literature and personal approach. Journal of Plastic, Reconstructive and Aesthetic Surgery. 2011; 64:423-431.

Gonçalves-Coelho TD, Pinheiro CN, Ferraz EV, Alonson-Nieto JL. Clusters of Bell's palsy. Arquivos de Neuropsiquiatria. 1997; 55:722-727.

Hadlock T. Facial paralysis: research and future directions. Facial Plastic Surgery. 2008; 24(2): 260-266.

House JW, Brackmann DE. Facial Nerve grading system. Otolaryngology - Head and Neck Surgery. 1985; 93(2):146-147.

Kang TS, Vrabec JT, Giddings N, Terris DJ. Facial Nerve Grading Systems (1985–2002): Beyond the House-Brackmann Scale. Otology & Neurotology. 2002; .23(5):767-771.

Kayhan FT, Zurakowski D, Rauch SD. Toronto facial grading system: interobserver reliability. Otolaryngol Head and Neck Surgery. 2000; 122(2):212-215.

Keillor JM, Barrett AM, Crucian GP, Kortenkamp S, Helman KM. Emotional experience and perception in the absence of facial feedback. Journal of the International Neuropsychology Society. 2002; 8:130-135.

Kukimoto N, Ikeda M, Yamada K, Tanaka M, Tsurumachi M, Tomita H. Viral infections in acute peripheral facial paralysis. Nationwide analysis centering on CF. Acta Otolaryngology [Suppl] (Stokh). 1988; 97:3-4

Lee J, Fung K, Lownie SP, Parnes LS. Assessing impairment and disability of facial paralysis in patients with vestibular schwannoma. Archives of Otolaryngology Head and Neck Surgery. 2007; 133:56-70.

Linstrom CJ, Silverman CA, Susman WM. Facial –motion analysis with a video and computer system: a preliminary report. American Journal of Otology. 2000; 21(1):123-9.

Linstrom CJ. Objective facial motion analysis in patients with facial nerve dysfunction. Laryngoscope. 2002; 112: 1129-1147.

May M, Croxson G, Klein S. Bell's palsy. Management of using EMG rehabilitation, botulinum toxin and surgery. American Journal of Otolaryngology. 1989; 10:220-229.

Mehta RP, Zhang S, Hadlock TA. Novel 3-D video for quantification of facial movement. Otolaryngology - Head and Neck Surgery. 2008; 138(4): 468-472.

Odebode TO, Ologe FE. Facial nerve palsy after head injury: case incidence, causes, clinical profile and outcome. The Journal of Trauma. 2006; 61:388-391.

Peitersen E. The natural history of Bell's palsy. American Journal of Otolaryngology. 1982; 4:107.

Pennock JD, Peter C, Manders EK, VanSwearingen JM. Relationship between muscle activity of the frontalis and the associated brow displacement. Plastic & Reconstructive Surgery. 1999; 104(6):1789-1797.

Pinna BR, Testa JRG, Fukuda Y. Traumatic facial paralysis's study: clinical and surgical review. Revista Brasileira de Otorrinolaringologia. 2004; 70:479-482.

Proctor B, Corgill DA, Proud G. The pathology of Bell's palsy. Transactions of the American Academy of Ophtalmology and Otolaryngology. 1976;82:ORL 70-80.

Morgan M, Nathwani D. Facial Palsy and Infection: The Unfolding Story. Clinical Infectious Diseases. 1992;14:263-71.

Rosenberg SI. Natural history of acoustic neuromas. Laryngoscope. 2000; 110:497-508.

Ross B, NNedzelski JM, McLean JA. Efficacy of feedback training in long-standing facial nerve paresis. Laryngoscope. 1991; 101:744-750.

Sackett D, Strauss, SE, Richardson WS, Rosemberg W, Haynes RB. Evidence-based medicine: how to practice and teach EMB. Edinburgh:Churchill Livingstone, 2nd ed, 2000. P.436.

Saito DM, Cheung SW. A comparison of facial nerve disability between patients with Bell's palsy and vestibular shwannoma. Journal of Clinical Neuroscience. 2010; 17:1122-1125.

Salles AG, Toledo AN, Ferreira MC. Botulinum toxin injection in long-standing facial paralysis patients: improvement of facial symmetry observed up to 6 months. Aesthetic Plastic Surgery. 2009; 33:582-590.

Segal B, Zompa I, Danys I, Black M, Shapiro M, Melmed C, Arthurs B. Symmetry and synkinesis during rehabilitation of unilateral facial paralysis. Journal of Otolaryngology. 1995; 24:143-148.

Seikel JA, King DW, Darmright DG. Anatomy & Physiology for Speech, Language and Hearing. 4th ed,. Delmar Cengage Learning: New York, 2010.

Tate JR, Tollefson TT. Advances in facial reanimation. Current Opinion on Otolaryngology Head and Neck Surgery. 2006; 14:242-248.

Vaiman M, Shlamkovich N, Kessler A, Eviatar E, Segal S. Biofeedback training of nasal muscles using internal and external surface electromyography of the nose. American Journal of Otolaryngology. 2005; 26:302-307.

Van de Graaf RC, Nicolai JP. Bell's palsy before Bell: Cornelis Stalpart van der Wiel's observation of Bell's palsy in 1683. Otology Neurotology. 2005; 26:1235-1238.

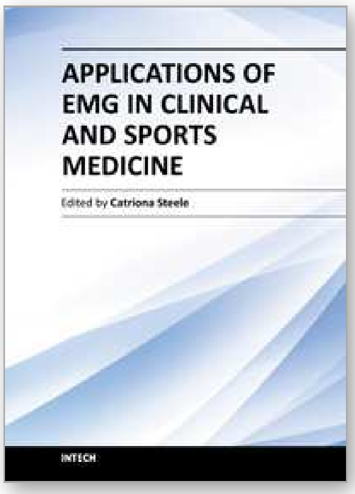
VanSwearingen JM, Brach JS. The facial disability index: reliability and validity of a disability assessment instrument for disorders of the facial neuromuscular system. Physical Therapy. 1996; 76:1288-1300.

VanSwearingen JM, Cohn JF, Turnbull J, Mrzai T, Johnson P. Psychological distress: linking impairment with disability in facial neuromotor disorders. Otolaryngology Head and Neck Surgery. 1998; 118:790-796.

VanSwearingen JM, Brach JS. Changes in facial movement and synkinesis with facial neuromuscular reeducation. Plastic Reconstructive Surgery. 2003; 111:2370-2375.

Wilson JB, Cleary PD. Linking clinical variables with health-related quality of life. JAMA. 1995; 273:59-65.

Yeo SW, Lee DH, Jun BC, Chang KH, Park YS. Analysis of prognostic factors in Bell's palsy and Ramsay Hunt syndrome. Auris Nasus Larynx. 2007; 34:159-164.



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This second of two volumes on EMG (Electromyography) covers a wide range of clinical applications, as a complement to the methods discussed in volume 1. Topics range from gait and vibration analysis, through posture and falls prevention, to biofeedback in the treatment of neurologic swallowing impairment. The volume includes sections on back care, sports and performance medicine, gynecology/urology and orofacial function. Authors describe the procedures for their experimental studies with detailed and clear illustrations and references to the literature. The limitations of SEMG measures and methods for careful analysis are discussed. This broad compilation of articles discussing the use of EMG in both clinical and research applications demonstrates the utility of the method as a tool in a wide variety of disciplines and clinical fields.

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