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Specific Impairment of Smiling Increases the Severity of Depressive Symptoms in Patients with Facial Neuromuscular Disorders

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Abstract. Depressive symptoms and related emotional distress are prevalent among patients with facial neuromuscular disorders, and the psychological distress impacts the functional disabilities associated with the facial impairment. A specific impairment in the ability to smile may elevate the risk for depression, with patients experiencing a reduced physiological feedback associated with smiling as well as the social consequences of the inability to communicate positive emotion. We tested the hypothesis that specific impairments in the ability to smile increase the severity of depressive symptoms in patients with facial neuromuscular disorders. Twenty-nine consecutive patients (mean age, 50.2 years; SD, 17.0 years; range, 18–81 years) with a facial neuromuscular disorder, who volunteered and completed all of the assessment measures participated. Facial neuromuscular impairments were assessed using multiple measures of facial motility and dysfunction, and emotional functioning was assessed using self-report measures of depression, anxiety, and positive and negative affect. Severity of global facial impairment was statistically controlled in evaluating the association between specific impairment in smiling and the degree of depressive symptoms. Separate hierarchical linear regression analyses indicated the specific impairment of smiling contributed to the prediction of depression ($R^2 = .41$, df = 3,25, $p = .00$) and anxiety ($R^2 = .35$, df = 3,25, $p = .00$), controlling first for the contribution of global impairment and facial physical disability. The specific impairment of smiling did not contribute to the prediction of positive emotional experience. Specific impairment of smiling and physical disability, but not global impairment of facial motion, were key predictors of depression in patients with facial neuromuscular disorders. The results emphasize the need to assess and treat depression and anxiety in patients with a facial neuromuscular disorder.

Key words: Facial nerve diseases—Facial paralysis—Psychology

In patients with facial neuromuscular disorders, depressive symptoms and related emotional distress are common [8,14,28,31,38], are often severe [24,38], and exacerbate the functional disabilities associated with their impairments [6,24,39,40]. Approximately 40% of such patients experience depressive symptoms in the mild range and another 25% experience symptoms in the more serious moderate to severe range typical of major depressive disorder [40]. The approximately 65% prevalence of depression among outpatients with a facial neuromotor disorder is three to five times higher than the rate found in unselected community [10,29] and general medical [21] samples. Depression and emotional distress increase lead to social isolation and maladaptive coping [14,24,38] and heighten the impact of neuromuscular impairment on functional disability [40].

Previous research has identified the severity of facial neuromuscular disorder and associated disability in facial functions as a primary risk factor for the development of depression [40]. Another key factor may be the type of functional impairment patients experience. A specific impairment in the ability to smile may be especially critical in elevating risk for depression. In daily life, smiling occurs predominantly in social contexts [22,32], communicates an intention to continue ongoing

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activity [16], elicits reciprocal positive interactions [12,17], and promotes social cohesion [15]. Individuals who are impaired in their ability to smile and communicate positive emotion may, as a consequence, experience less frequent positive social interaction and greater social isolation, which are frequently observed in patients with facial neuromuscular disorders.

In individuals without facial neuromuscular disorder, activation of the zygomaticus major in smiling is strongly associated with positive emotion (initially described by Darwin [13]) [9], while decreased tonic activation is strongly associated with depression [39]. Based on theory [18,37] and some data, several investigators have suggested that activation of the zygomaticus major is sufficient to produce feelings of positive emotion and emotion-specific changes in peripheral physiology [23,36]. Patients with specific impairment of smiling experience attenuated facial feedback; this, together with the social consequences of a specific impairment in smiling, may further predispose them to become depressed.

The present study tests the hypothesis that specific impairments in the ability to smile increase the severity of depressive symptoms in patients with facial neuromuscular disorders. Facial neuromuscular impairments were assessed using multiple measures of facial motility and dysfunction, and emotional functioning was assessed using self-report measures of depression, anxiety, and positive and negative affect. The severity of global facial impairment was statistically controlled in evaluating the association between specific impairment in smiling and the degree of depressive symptoms.

Methods

Subjects

All patients who were seen at the Facial Nerve Center at the University of Pittsburgh Medical Center between May and October 1995 were given the opportunity to participate in the study. Ninety-nine patients were approached and 56 patients gave informed consent to participate. The participants in this study were the patients who completed all of the following clinical assessments: (1) the Maximal Static Response Assay of facial motion [19], a quantitative measure of impairment; (2) the Facial Disability Index [39], a self-report, region-specific index of physical and social disability related to facial impairment; (3) the Positive Negative Affect Schedule [42–44], a self-report measure of dimensions of emotional experience related to general factors of personality; and (4) the Beck Depression Inventory [5] and Beck Anxiety Inventory [3], self-report assessments of depressed mood and anxiety, respectively. Five patients who incorrectly completed one or more of the assessments, and 22 patients for whom data were missing or who had not completed one of the assessments were excluded from the study. Based on the mean of the data that were collected, the patients excluded demonstrated moderate to severe global facial motion impairment ($n = 6$) and facial disability ($n = 8$), mild to moderate depression ($n = 23$), and moderate anxiety ($n = 20$). Sixty-nine percent of the patients were depressed (BDI score ≥ 10; $n = 18$), compared to 62% of the patients who were included in the study analyses.

Participants with complete data were 29 patients with a facial nerve disorder of various etiologies (e.g., Bell's palsy, cranial-base and facial tumor removal, congenital). Twenty-three were women and six were men (mean age, 50.2 years; SD, 17.0 years; range, 18–81 years). The mean duration of facial neuromuscular symptoms was 6 years (range, 1 to 40 years).

Procedures

Measurement of Facial Motion. The Maximal Static Response Assay (MSRA), described in detail elsewhere [19], was used to record facial motion. Briefly, the assay is a videographic system that quantifies region-specific motion of the face during maximal voluntary movement by tracking specific facial points. Blue adhesive markers 0.25 in. in diameter are placed in predefined locations on the face, and a 2-cm ruler is applied to the tip of the nose using soft plastic tape to provide a standard measure in the video recording for the calibration of distances. The position of the facial markers is recorded at rest and when the patient attempts the following (bilateral) voluntary facial movements: (1) maximal brow lift, (2) maximal tight eye closure, (3) maximal smile, and (4) maximal pucker.

The videotape is reviewed and the repose image and each of the maximal response images are digitized for computer display. Images are calibrated on the computer screen and geometrically normalized for variation in position, rotation, and scale. Transcanthal and transnasal x and y axes are assigned, enabling the identification of a common origin and Cartesian coordinate system for each image. The position of each predefined facial marker in the repose image is subtracted from the position of the markers in the images captured at the peak of each of the maximal voluntary facial movements to derive a measure of facial displacement. The x and y coordinates and the computed displacement for each marker position are saved in a Microsoft Excel spreadsheet for analysis. Data are recorded as lateral or medial displacement (positive or negative x coordinate) and elevation (positive, y coordinate) or depression (negative, y coordinate).

Quantification of Global Impairment of Facial Motion. To quantify global impairment of unilateral facial motion we used the results of the MSRA for representative facial movements. A summary score was determined from the peak displacement of facial markers in expected directions of movement for voluntary maximal attempts to raise the eyebrows, close the eyes tightly, and pucker, similar to the determination of the Anatomic Index of Facial Motion, described previously [1].

Facial muscles have known anatomic orientations, and muscle contraction produces motion, apparent in the overlying skin, of one end of the muscle moving toward

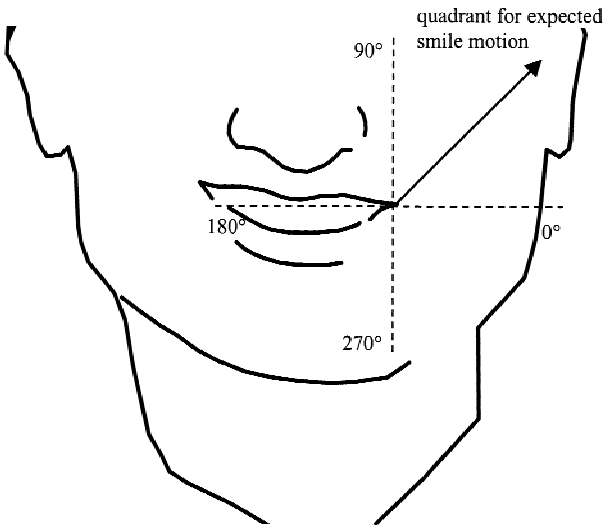

Fig. 1. Horizontal and vertical axes through the left modiolus (e.g., corner of the mouth). The arrow represents the direction of a vector representing motion of the left modiolus with smiling in the quadrant for expected smile motion, 0 to 90°.

the other end of the facial muscle. For brow raise, motion of the brow is expected superiorly; for tight eye closure, the margins of the eyelids and the surrounding supra- and infraorbital tissues are expected to move toward each other; and for pucker, motion of the corners of the mouth is expected in a medial direction toward the center of the face. To quantify the anatomic motion, vector magnitudes (cm) are calculated using the Pythagorean Theorem [vector magnitude in cm $= (x^2 + y^2)^{-0.5}$], with x and y referring to the horizontal and vertical change in positions of facial markers. The vector magnitudes for unilateral maximal brow raise, eye closure, and pucker are summed, and a ratio of the affected side to the unaffected side is calculated. The ratio represents the global impairment of facial motion score.

Quantification of Specific Impairment in Smiling. Recently, Johnson et al. [20] described a method by which to determine the direction of the vector of movement of the modioli (corners of the mouth) while smiling. For example, while smiling, the modioli move in an upward and lateral direction due presumably to the predominant action of the zygomaticus major muscle (Fig. 1). The movement corresponds to motion of the modioli in the quadrant from 0 to 90°, with 0° located on the x axis and 90°, perpendicular to the x axis. Johnson et al. reported a mean, 58.3°, and range, 32.5 to 83.1°, for the direction of vectors of the movement of the modioli with smiling recorded for a group of individuals without facial impairment [20].

Direction of motion for each modiolus was quantified by assigning an angle of direction to each vector. Direction was first calculated in radians and then converted to degrees as described in the Appendix. A positive result represents a cephalad angle (0 to 180°), while a negative result represents a caudal angle (0 to −180°). The negative angle was subtracted from 360°, enabling all angles to be expressed as a positive value from 0 to 360°. Vector magnitudes for the anatomic motion of smiling were determined using the Pythagorean Theorem and the x and y coordinates representing horizontal and vertical change in position of the marker for the modiolus with smiling (as described above for the quantification of global impairment).

Measurement of Disability. The patient's perspective of disability was assessed using the Facial Disability Index (FDI) [39]. The facial disability index is a brief, disease-specific, self-report questionnaire of facial disability, with physical and social well-being subscale components. The FDI was developed and validated to provide an account of the patient's daily experience while living with a facial nerve disorder. The FDI has physical disability and social disability components, with subscale scores for each transformed to a 100-point basis. Higher scores on the FDI physical and FDI social subscales represent less disability. Since the results of our previous study revealed psychological distress to be a linking factor between impairment and social disability [40], we did not include social disability with psychological distress as a variable in the present study, using only physical disability in the present analyses.

Measurement of Psychological and Emotional Adjustment. Symptoms of anxiety and depression were assessed using the Beck Anxiety Inventory (BAI) [3] and the Beck Depression Inventory (BDI) [5]. These instruments have been widely used to assess anxiety and depression in psychological research and practice and have known reliability and validity [3–5,35]. A BDI score higher than 10 was used to identify patients who were depressed [4].

Trait positive affect was assessed using the Positive and Negative Affect Schedule [44]. The Positive and Negative Affect Schedule, expanded version (PANAS-X), is a self-report instrument used to assess dimensions of emotional experience which are related to general factors of personality [42,43]. The PANAS-X has been used in previous studies of trait emotion [43,44].

Statistical Analysis

Descriptive statistics were used to describe facial impairment, physical disability, positive affect, and self-reported anxiety and depression for the group of patients who were and were not depressed, as defined by a BDI score higher than 10. Differences between the group of patients who were depressed and the group who were not depressed were determined using an independent t test for comparison.

In separate hierarchical linear regressions, we examined the impact of a specific impairment of smiling on depressive symptoms, on anxiety, and on positive affect. To control for the impact of global impairment and disability, global impairment and physical disability were

entered into the regression equations prior to the entry of specific facial impairment, as illustrated for depression:

depression = global facial impairment + disability + impairment of smiling.

Thus, the contribution of the specific impairment of smiling was tested after controlling for global facial impairment and disability. For the regression analyses, the angles of direction assigned to the vectors for smiling were transformed to a reference axis bisecting the quadrant of expected smile movement (0 to 90°; Fig. 1). An angle of 45° in the quadrant was designated 180°, while vectors at an angle 180° to the 45° angle were designated 0°, representing the severity of impairment of a smile whose vector was opposite the expected direction for motion of the modioli with smiling. Angles located clockwise and counterclockwise from the designated 180° angle on the reference axis in the quadrant of expected smile motion were expressed as positive values representing a rank ordering of vectors relative to the vector of a smile that bisected the quadrant.

Results

The patients studied demonstrated moderate to severe facial motion impairment and moderate disability in physical functions involving the face. Positive affect was mildly decreased and depression was mild to moderate for the group (Table 1). Based on a cutoff score for depression of 10 on the BDI [4], 18 patients had mild to moderate depression and 11 patients were not depressed. The group of patients with depression demonstrated no greater global impairment of facial motion than the group of patients who were not depressed. Compared with the individuals with a facial neuromotor disorder but without depression, the group of patients with depression demonstrated a greater impairment of smiling motion, physical disability in facial function, and positive affect (Table 1). The direction of the vectors representing the specific impairment of smiling for patients who were depressed were located predominantly in quadrants other than the quadrant for expected smile motion, in contrast to the position of the smile vectors for the patients who were not depressed (Fig. 2). Vector magnitude for smiling did not differ between the group of patients who were depressed (0.48 cm) and the group who were not depressed (0.47 cm) ($t = 0.015$, $p = 0.99$).

Hierarchical linear regression analyses indicated the specific impairment of smiling contributed to the prediction of depression (Table 2) and anxiety (Table 3) while first controlling for the contribution of global impairment and facial physical disability to the prediction. The specific impairment of smiling did not contribute to the prediction of positive emotional experience as measured by the PANAS-X, controlling initially for global impairment and facial physical disability (Table 4). Subsequent stepwise linear regression analyses indicated that (1) facial physical disability and the specific impairment of smiling were independent predictors of depression ($R^2 = 0.41$; df = 3,25; $F = 5.51$; $p = 0.00$); (2) facial physical disability was the only independent predictor of anxiety ($R^2 = 0.35$; df = 3,25; $F = 6.12$; $p = 0.00$); and (3) there was no significant contribution of global impairment, facial physical disability, or smiling impairment to the prediction of positive affect ($R^2 = 0.07$; df = 3,25; $F = 1.71$; $p = 0.19$).

Table 1. Psychological distress, clinical factors, and characteristics of patients with facial neuromuscular disorders.

	Depressed ($n = 18$)	Not depressed ($n = 11$)
Age (years)		
Mean	49.3	51.6
SD	15.7	19.8
Duration of disorder (years)		
Mean	6.87	4.50
SD	11.89	5.60
Global impairment (0–1)		
Mean	.38	.52
SD	.24	.18
Specific impairment of smiling (degrees)		
Mean	168.4*	68.9
SD	99.1	40.3
Disability (0–100)		
Mean	62.2*	77.7
SD	16.2	18.6
Depression (BDI) (0–63)		
Mean	17.6*	4.5
SD	8.2	2.8
Anxiety (BAI) (0–63)		
Mean	35.8*	22.5
SD	12.4	1.4
PA (PANAS-X) (0–5)		
Mean	3.1*	3.7
SD	.8	.6

* Different compared to patients not depressed (independent *t* test, df = 1,27, $p < 0.05$).

Discussion

Depressive symptoms are commonly experienced by patients with facial neuromuscular disorders, and a significant proportion of these patients experiences symptoms in the moderate to severe range associated with major depressive disorder [40]. The prevalence of depression in these patients led us to the current exploration of the relation among impairment, disability, depressive symptoms, and positive affect. The purpose of this study was to identify clinical (impairment and disability) variables that may contribute to the prediction of depression and reduced positive affect in patients with facial neuromuscular disorders.

Patients with specific impairment in the ability to smile showed more severe levels of depressive symp-

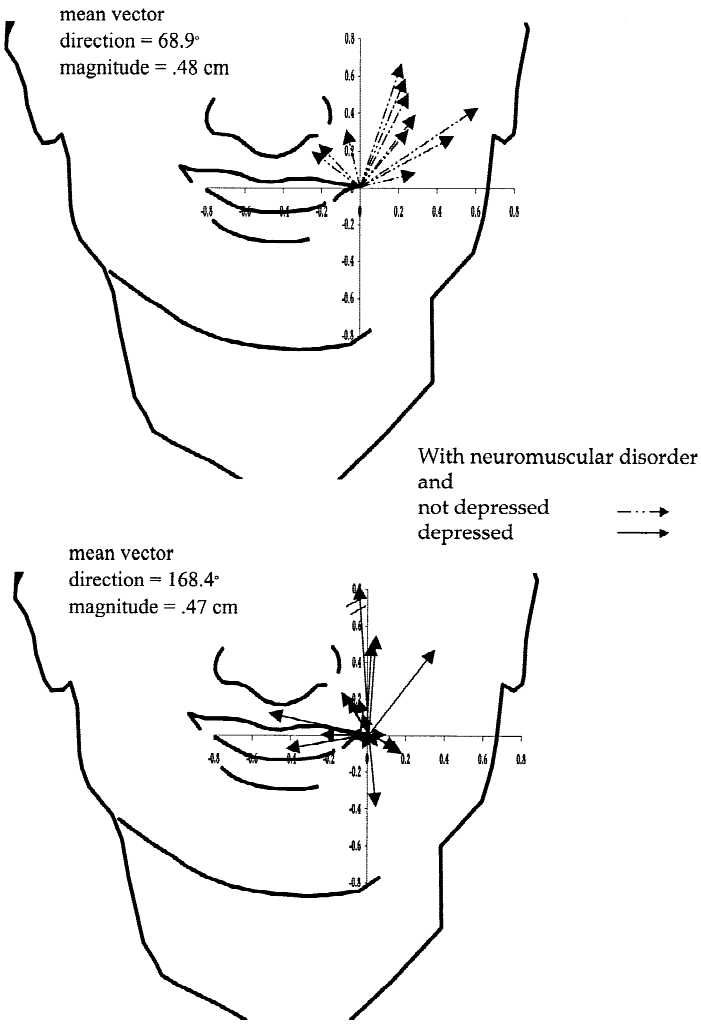

Fig. 2. Direction of vectors representing the motion of the modiolus with smiling for patients with a facial neuromuscular disorder. *Dashed arrows* represent the vector direction of smiles for patients who were not depressed; *solid arrows* represent the vector direction of smiles for patients who were depressed.

Table 2. Hierarchical regression analysis of global impairment, disability, and impairment of smiling on depression.

Variable	R	Change in R^2	p (of change)	Adjusted R^2	p
Added					
Global impairment	0.39	0.15	<0.04	0.12	<0.04
Disability	0.54	0.14	<0.03	0.24	<0.00
Smile impairment	0.68	0.18	<0.00	0.41	<0.00

toms. This difference could not be accounted for by variation in global impairment or disability alone. Although the reasons for the greater depression in patients with impairment of smiling were not assessed, basic research in emotion implicates both intra- and interpersonal processes. Theory and some empirical research suggest that activation of the zygomaticus major and peripheral feedback from smiling may contribute to positive emotion [11,44,45]. Smiling occurs primarily in social contexts, and the communication of positive emotion through smiling promotes reciprocal social exchanges. If patients with facial neuromuscular disorders are unable to find alternative modes of nonverbal communication [26] [e.g., prosody (Cohn and Katz, in press)], they may experience increased social isolation and depression. The finding that specific impairment of smiling was related to depression but not trait emotion suggests that social processes may be especially important in producing depression in these patients.

The results indicated a specific impairment of smiling affected depression and anxiety, negative affects, but not positive affect. No contribution was found for global impairment, facial physical disability, or the specific impairment of smiling to the prediction of positive affect. Only perceived facial physical disability related to positive affect (Pearson correlation coefficient, $r = 0.40$, p

Table 3. Hierarchical regression analysis of global impairment, disability, and impairment of smiling on anxiety.

Variable	R	Change in R^2	p (of change)	Adjusted R^2	p
Added					
Global impairment	0.39	0.16	<0.04	0.12	<0.04
Disability	0.62	0.24	<0.00	0.34	<0.00
Smile impairment	0.65	0.03	<0.24	0.35	<0.00

Table 4. Hierarchical regression analysis of global impairment, disability, and impairment of smiling on positive affect.

Variable	R	Change in R^2	p (of change)	Adjusted R^2	p
Added					
Global impairment	0.21	0.04	<0.28	0.01	<0.28
Disability	0.40	0.12	<0.07	0.10	<0.10
Smile impairment	0.41	0.01	<0.59	0.07	<0.19

$= 0.02$). The difference in the relations of negative and positive affect with smiling impairment is consistent with prior research, suggesting that positive and negative affect represent separate dimensions of emotional experience [41]. Self-report and behavioral measures of negative and positive emotion have only a low to moderate correlation [25,41]. Thus an important consideration is that facial neuromuscular disorders may differentially affect positive and negative emotion.

An additional factor contributing to depression in individuals with facial neuromotor disorders may be changes in the pattern of smiling on the uninvolved side of the face. Altered facial movement of the uninvolved side of the face has been reported by several investigators [2,34,27] for individuals with a facial nerve disorder. Johnson et al. [20] indicated among individuals with longstanding unilateral facial paralysis, the angle and magnitude of the vector for smile motion on the unaffected side of the face were lower than similar values in a comparison group of individuals without a facial neuromotor disorder. After surgical free muscle reanimation procedures, the magnitude of the vector for smile on the unaffected side of the face was reduced by more than one-third, demonstrating the adaptive response to the contralateral change in facial movement. Comparing patterns of facial movement in individuals with facial neuromotor disorders involving synkinesis (i.e., abnormal movement of the face accompanying intended voluntary facial movement) to hemifacial motion in individuals without impairment, Bajaj-Luthra et al. [2] described reduced motion about the brow and eye and increased motion of the corner of the mouth in the horizontal plane of the unaffected side of the face of the patients. Other investigators [27,34] reported abnormal positioning of the corner of the mouth on both the involved and uninvolved sides of the face following voluntary movement attempts in patients with synkinesis. The change in position might be assumed to influence the pattern of subsequent facial expressions. In our experience, repeating assessments of individuals with longstanding facial neuromotor disorders undergoing facial rehabilitation, some patients varied the symmetry of voluntary facial movement by fluctuating movement of the uninvolved side of the face.

In a pilot study of the psychological impact of functional limitations and disability of facial paralysis, Neely et al. [28] reported differential impact of regional facial dysfunction for patients with facial neuromuscular disorders. In the early stages of facial paralysis, problems related to function of the eye were most disturbing. Later problems in oral function were more disruptive to psychosocial well-being [28]. Findings of the present investigation further define the oral function to a specific impairment of smiling as a key factor in psychological distress of patients with a facial neuromotor disorder. Similarly, Neely et al. [28] emphasized the importance of the ability to smile, reporting that the patients studied wished most for a "normal smile."

The results of this study of a group of individuals with a facial neuromotor disorder indicate the specific impairment of smiling and the physical disability associated with the disorder contribute to psychiatric symptoms (depression and anxiety) and a diminished ability to experience positive emotion. Though surgical procedures and conservative rehabilitative measures such as physical, occupational, and speech therapy may restore facial movement and posture, the process is typically gradual and prolonged. For many, facial reanimation and rehabilitation takes place over months to years, and the outcome may be a more acceptable appearance, communication, and expression, but often not "normal." The prevalence, the severity, and the scope of the psychological distress associated with facial neuromotor disorders [40], and the likelihood of a long duration of the disorder, emphasize the need for professional attention to the psychiatric signs and symptoms in addition to intervening for the facial impairment and disability. From the outset of a facial neuromotor disorder, treating the recognized psychiatric symptoms, as well as the physical impairment (e.g., primary prevention), may optimize pa-

tient outcomes, improve the rate of recovery, and prevent chronic disability, including the loss of work and increased utilization of health care services that commonly accompany chronic disability [7,30].

Conclusions

A specific impairment of smiling and physical disability, but not global impairment of facial motion, were key predictors of depression in patients with facial neuromuscular disorders. The findings support the work of neuropsychologists on the relations between specific facial actions and specific emotional states, and of social psychologists who have described the role of smiling in experiencing positive social interactions and social cohesion. From the patient's perspective, the recovery of health means the recovery of physical function, but also the recovery of emotional and social well-being. The relation of smiling impairment with psychological and emotional distress emphasizes the need to assess and treat depression and anxiety in patients with a facial neuromuscular disorder to improve the outcome of intervention, the recovery of health.

Appendix: Calculating the Angle of Direction for Each Vector

Calculation of Direction in Radians

$$\text{Angle in radians } (A) = \arctan \frac{y}{x} \quad \begin{matrix} \frac{\pi}{2} \\ \frac{-\pi}{2} \end{matrix}$$

where x = movement in the horizontal axis [x coordinate (cm)] and y = movement in the vertical axis [y coordinate (cm)] with smiling.

Conversion of Radians to Degrees

$$\text{Direction} = A \left(\frac{180}{\pi} \right) \quad \begin{matrix} 180 \\ -180 \end{matrix}$$

where A = the angle of the vector of movement with smile (radians).

References

1. Bajaj-Luthra A, Mueller T, Johnson PC: Quantitative analysis of facial motion components: Anatomic and nonanatomic motion in normal persons and in patients with complete facial paralysis. *Plast Reconstr Surg* **99:**1894, 1997
2. Bajaj-Luthra A, VanSwearingen J, Thornton RH, Johnson PC: Quanitation of patterns of facial movement in patients with ocular to oral synkinesis. *Plast Reconstr Surg* **104:**1473, 1998
3. Beck AT, Epstein N, Brown G, Steer RA: An inventory for measuring clinical anxiety: Psychometric properties. *J Consult Clin Psychol* **56:**893, 1988
4. Beck AT, Steer RA, Garbin MG: Psychometric properties of the Beck Depression Inventory: Twenty-five years of evaluation. *Clin Psychol Rev* **8:**77, 1988
5. Beck AT, Ward GH, Mendelson M, Erbaugh MJ: An inventory for measuring depression. *Arch Gen Psychiatry* **4:**561, 1961
6. Brach JS, VanSwearingen J, Delitto A, Johnson PC: Impairment and disability in patients with facial neuromuscular dysfunction. *Otolaryngol Head Neck Surg* **117:**315, 1997
7. Broadhead WE, Blazer DG, George LK, Tse CK: Depression, disability days, and days lost from work in a prospective epidemiologic survey. *JAMA* **264:**2524, 1990
8. Brudny J, Hammerschlag PE, Cohen NL, *et al.:* Electromyographic rehabilitation of facial function and introduction of a facial paralysis grading scale for hypoglossalfacial nerve anastomosis. *Laryngoscope* **98:**405, 1988
9. Cacioppo JT, Bush LK, Tassinary LG: Microexpressive facial actions as a function of affective stimuli: Replication and extension. *Person Soc Psychol Bull* **18:**515, 1992
10. Campbell SB, Cohn JF: Prevalence and correlates of postpartum depression in first-time mothers. *J Abnorm Psychol* **100:**594, 1991
11. Clark LA, Watson D: Tripartite model of anxiety and depression: Psychometric evidence and taxonomic implications. *J Abnorm Psychol* **100:**316, 1991
12. Cohn JF, Tronick EZ: Mother-infant interaction: The sequence of dyadic states at three, six, and nine months. *Dev Psychol* **23:**68, 1987
13. Darwin C: Expression of the emotions in man and animals. Chicago, IL, University of Chicago Press, 1965
14. Ekman P: Psychosocial aspects of facial paralysis. In: May M (ed) The facial nerve. Thieme: New York, pp 781–787, 1986
15. Fridlund AJ: The behavioral ecology and sociality of human faces. In: Clark M (ed) Review of personality and social psychology. Sage: Beverly Hills, CA, pp 90–121, 1991
16. Fridlund AJ: Human facial expression. Academic Press: New York, 1994
17. Hatfield E, Cacioppo JT, Rapson RL: Emotional contagion. Cambridge University Press: New York, 1994
18. Izard CE, Malatesta CZ: Perspectives on emotional development I: Differential emotions theory of early emotional development. In: JD Osofsky (ed) Handbook of infant development. Wiley: New York, pp 494–554, 1987
19. Johnson PC, Brown H, Casein WM, et al.: Simultaneous quantification of facial movements: The maximal static response assay of facial nerve function. *Ann Plast Surg* **32:**171, 1994
20. Johnson PJ, Bajaj-Luthra A, Llull R, Johnson PC: Quantitative facial motion after functional free muscle reanimation procedures. *Plast Reconstr Surg* **100:**1710, 1997
21. Katon W, Schulberg H: Epidemiology of depression in primary care. *Gen Hosp Psychiatry* **14:**237, 1992
22. Kraut R, Johnson RE: Social and emotional messages of smiling: An ethological approach. *J Person Soc Psychol* **37:**1539, 1979
23. Levenson RW, Ekman P, Friesen WV: Voluntary facial

action generates emotion-specific autonomic nervous system activity. *Psychophysiology* **27:**363, 1990
24. MacGregor FC: Facial disfigurement: Problems and management of social interaction and implications for mental health. *Aesth Plast Surg* **14:**249, 1990
25. Matias R, Cohn JF, Ross S: A comparison of two systems that code infant affective expression. *Dev Psychol* **25:**483, 1989
26. Moore CA, Cohn JF, Katz GS: Quantitative description and differentiation of fundamental frequency contours. *Comput Speech Lang* **8:**385, 1994
27. Moran CJ, Neely JG: Patterns of facial synkinesis. *Laryngoscope* **106:**1491, 1996
28. Neely JG, Neufeld PS: Defining functional limitation, disability, and societal limitations in patients with facial paresis: Initial pilot questionnaire. *Am J Otol* **17:**340, 1996
29. Oliver JM, Simmons ME: Depression as measured by the DSM-III and the Beck depression inventory in an unselected adult population. *J Consult Clin Psychol* **52:**892, 1984
30. Ormell J, Vankorff M, Ustun TBeal: Common mental disorders and disability across cultures. Results from the WHO collaborative study on psychological problems in general health care. *JAMA* **272:**1741, 1994
31. Ross B, Nedzelski JM, McLean JA: Efficacy of feedback training in longstanding facial nerve paresis. *Laryngoscope* **101:**744, 1991
32. Scanlon Jones S, Collins K, Hong HW: An audience effect on smile production in 10-month-old infants. *Psychol Sci* **2:**45, 1991
33. Schwartz GE, Fair PL, Salt P, et al.: Facial muscle patterning to affective imagery in depressed and nondepressed subjects. *Science* **192:**489, 1976
34. Segal B, Hunter T, Danys I, Freedman C, Black M: Minimizing synkinesis during rehabilitation of the paralyzed face; Preliminary assessment of a new small-movement therapy. *Otolaryngology* **24:**149, 1995
35. Steer RA, Ranieri WF: Further evidence for the validity of the Beck Anxiety Inventory with psychiatric outpatients. *J Anxiety Dis* **7:**195, 1993
36. Strack F, Martin LL, Stepper S: Inhibiting and facilitating conditions of the human smile: A nonobtrusive test of the facial feedback hypothesis. *J Person Soc Psychol* **54:**768, 1988
37. Tomkins SS: Affect, imagery, and consciousness: Vol I. The positive effects. Springer: New York, 1960
38. Twerski AJ, Twerski B: The emotional impact of facial paralysis. In: May M (ed) The facial nerve. Thieme: New York, pp 788–794, 1986
39. VanSwearingen JM, Brach JS: The facial disability index: Reliability and validity of a disability assessment instrument for disorders of the facial neuromuscular system. *Phys Ther* **76:**1288, 1996
40. VanSwearingen JM, Cohn JF, Turnbull J, Mrzai T, Johnson PC: Psychological distress: Linking impairment with disability in facial neuromuscular disorders. *Otolaryngol Head Neck Surg* **118:**790, 1998
41. Watson D, Tellegen A: Toward a consensual structure of mood. *Psychol Bull* **98:**219, 1985
42. Watson D, Clark LA: On traits and temperament: General and specific factors of emotional experience and their relation to the five-factor model. *J Person Soc Psychol* **60:**441, 1992
43. Watson D, Clark LA, McIntyre CW, Hamaker S: Affect, personality, and social activity. *J Person Soc Psychol* **63:**1011, 1992
44. Watson D, Clark LA, Weber K, Assenheimer JS, Strauss ME, McCormick RA: Testing a tripartite model: I. Evaluating the convergent and discriminant validity of anxiety and depression symptom scales. *J Abnorm Psychol* **104:**3, 1995
45. Watson D, Clark LA, Weber K, Assenheimer JS, Strauss ME, McCormick RA: Testing a tripartite model: II. Exploring the symptom structure of anxiety and depression in student, adult and patient samples. *J Abnorm Psychol* **104:**15, 1995