Facial Synkinesia before and after Surgical Reanimation of the Paralyzed Face

Eva Placheta, M.D.
Chieh-Han John Tzou, M.D.
Alina Hold, M.D.
Igor Pona, M.D.
Manfred Frey, M.D.

Vienna, Austria

Background: Facial synkinesia is a common sequela of facial palsy, affecting 15 to 20 percent of patients. The rate of postoperative synkinesia after facial reanimation is not clearly established. The severity and type of synkinesia determine the degree of clinical relevance.
Methods: One hundred sixty-seven patients with facial palsy were included in this retrospective cohort study. Three-dimensional video analysis of facial movements was performed preoperatively and 18 months after facial reanimation. The severity of synkinesia was rated subjectively on a four-degree severity scale. Objective three-dimensional analysis of synkinesia was performed on patients with 18-month follow-up times.
Results: Preoperatively, 84.4 percent of patients were not affected by synkinesia, 9 percent presented with mild synkinesia, 4.2 percent presented with moderate synkinesia, and 2.4 percent presented with severe synkinesia. Postoperatively, 51 percent of all patients presented with facial synkinesia (41.8 percent mild, 17.3 percent moderate, and 1 percent severe synkinesia; some patients had more than one type). Patients treated with territorially differentiated gracilis muscle transplantation were most frequently affected (69.8 percent), followed by patients treated with gracilis muscle transplantation in combination with temporalis muscle transposition to the eye (51.8 percent). Oculo-oral synkinesia was the most frequent form of synkinesia.
Conclusions: After surgical reanimation of the paralyzed face, half of the patients presented with synkinesia. The majority of patients developed mild or moderate forms of synkinesia; therefore, the clinical relevance of synkinesia has to be seen in the context of total facial function. Because of the high prevalence of synkinesia, it should be documented and addressed in patients undergoing facial reanimation. (*Plast. Reconstr. Surg.* 133: 842e, 2014.)
CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, IV.

Synkinesia, which is defined as an involuntary facial movement during the voluntary movement of a different facial muscle group, is a common and distressing sequela of facial paralysis.[1,2] The amplitude of synkinesia on the paralyzed side of the face exceeds the amplitude of the "natural" synkinesia on the healthy side of the face.[3] Synkinesia occurs during voluntary facial movements but may also be triggered by the blink reflex.[4,5] The movement on the healthy side of the face can be impaired as patients try to avoid synkinesia by reducing voluntary facial expression.[6] In severe cases, it can be associated with pain and spasms of facial muscles,[2] and may cause contractions of the resting face.[7] Quality-of-life assessments revealed that synkinesia impaired patients' social life and reduced their productivity.[8]

The incidence of synkinesia after the recovery of facial nerve function ranges from 15 to 20 percent up to more than 50 percent, depending on the case series.[2,9] Patients with spontaneously recovered facial nerve function and patients who have undergone facial reanimation surgery are affected.[10,11] The cause of synkinesia is not fully

From the Department of Surgery, Division of Plastic and Reconstructive Surgery, Medical University of Vienna.
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established. It is more commonly found after severe injuries of the facial nerve.[2,9] The most widely recognized causes are aberrant nerve regeneration and sprouting of regenerated axons[1,12–17]; other suggested mechanisms include ephaptic transmission,[18–20] the alteration of the somatotopic organization of the facial nucleus,[14,15,21] and the increased excitability of the facial nucleus.[7,22–24] Moran and Neely described that facial synkinesia occurs in a nonrandom pattern.[3] Oculo-oral synkinesia, the involuntary movement of the mouth during eyelid closure, is widely described as the most common type of synkinesia.[3,6,23] VanSwearingen and Brach introduced the expression "multiway synkinesis," describing patients who are affected by synkinesia during more than one voluntary facial movement.[7]

Multiple subjective[7,25–30] and objective[4,6,9,23,31–34] diagnostic tools and grading systems have been developed for the diagnosis of facial synkinesia. Treatment of synkinesia consists of physiotherapy,[7] biofeedback rehabilitation,[7,35,36] and botulinum toxin injections.[34,37–39] Surgical treatment options include selective neurectomy and myectomy.[40,41] Zhang et al. recently reported on the treatment of oculo-oral synkinesia with cross-facial nerve grafting.[42]

In this study, the authors aimed to assess the prevalence and severity of synkinetic facial movements in patients who have undergone facial reanimation surgery, preoperatively and postoperatively, with at least 18 months' follow-up. Subsequently, the time pattern of the development of synkinesia was evaluated.

PATIENTS AND METHODS

Patients treated for facial palsy from 1998 to 2008 were included in this retrospective study. The approval of the Ethics Committee of the Medical University of Vienna was obtained, and all included patients gave their informed consent.

Three-Dimensional Video Analysis of Facial Movements

Three-dimensional video analysis of facial movements was routinely performed preoperatively and 6, 12, 18, and 24 months postoperatively.[43–46] The video analysis is based on the three-dimensional tracking of static and dynamic facial markers (Fig. 1).[44]

Severity and Types of Facial Synkinesia

For this study, synkinetic facial movements occurring during nine standardized movements[43] and the blink reflex were analyzed. All videos taken in the time period from 1998 to 2008 were reviewed.

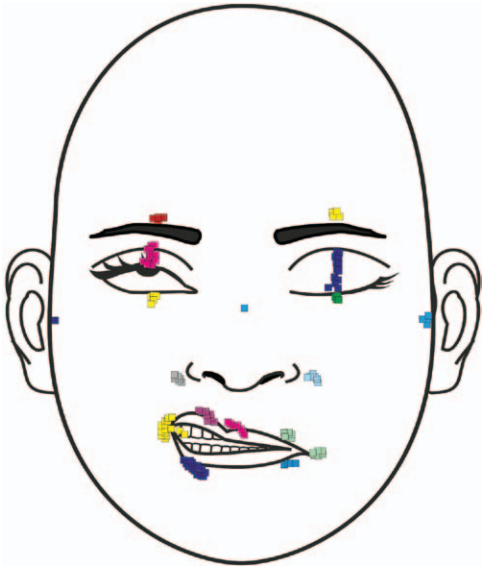

Fig. 1. Scheme of oculo-oral synkinesia. Three-dimensional motion of facial markers during the voluntary motion closure of eyelids as in sleep and synkinetic movement of the paralyzed right side of the mouth.

The types and severity of synkinesia were graded subjectively using a four-degree severity scale (i.e., no, mild, moderate, or severe synkinesia), which has previously been applied in the Sunnybrook and Sydney facial grading systems.[25,27] Patients with postoperative follow-up times of at least 18 months were included in the three-dimensional analysis of voluntary and synkinetic facial movements.

Patient History of Facial Palsy

One hundred eighty-four patients with facial palsy were treated from 1998 to 2008, and a total

Table 1. Facial Palsy Patients Treated with Facial Reanimation Surgery

Parameters	Patients	%
Total no. of patients	184	
Sex		
Female	111	60.3
Male	73	39.7
Facial nerve deficit		
Complete	102	55.4
Incomplete	73	39.7
Unknown	9	4.9
Facial nerve branches affected		
Total facial palsy	153	83.2
Partial facial palsy	24	13.0
Unknown	7	3.8
Parameters, mean ± SD		
Age, yr	45 ± 20 (5–90)	
Age at first reconstructive surgery (range), yr	40 ± 20 (4–85)	
Duration of facial palsy (range), yr	10 ± 12 (0–61)	
Follow-up time (range), mo	28 ± 27 (6–120)	

of 904 videos were reviewed for this study. The patients' characteristics are listed in Table 1. One hundred sixty-seven patients were included in the analysis of preoperative synkinesia during the preoperative presentation before reconstructive surgery (the preoperative video was not available in 17 cases).

Facial Reanimation Procedures

Patients included in this study underwent different facial reanimation procedures (Table 2). Gracilis muscle transplantation (innervated by a cross-facial nerve graft) and temporalis transposition to the eye ($n = 27$), territorially differentiated gracilis muscle transplantation (innervated by two cross-facial nerve grafts) ($n = 26$), temporalis transposition to the eye and/or masseter transposition to the mouth ($n = 15$), and gracilis muscle transplantation (innervated by a cross-facial nerve graft) to the mouth ($n = 13$) were the most common procedures.[10,47] Few patients underwent cross-facial nerve grafting with distal end-to-side coaptation ($n = 8$)[46] or distal end-to-end coaptation ($n = 2$) or static procedures ($n = 6$).[48]

Statistical Analysis

Statistical analysis was performed using SPSS statistical software for Windows Version 17.0 (SPSS, Inc., Chicago, Ill.). All tests were based on a nominal two-sided 5 percent significance level. Nominal variables were analyzed with chi-square tests, and metric variables were analyzed with independent two-sample t tests. The preoperative and postoperative measurements of facial movements were evaluated by multiple paired t tests. All t tests were based on nonequal variances.

RESULTS

Prevalence and Severity of Facial Synkinesia Preexisting to Facial Reanimation Surgery

Preoperatively, 84.4 percent of patients did not present with synkinesia. Nine percent of patients showed mild, 4.2 percent showed moderate, and 2.4 percent showed severe synkinetic

Table 2. The Prevalence of Preexisting and Postoperative Synkinesia in Patients with 18 Months or More Postoperative Follow-Up Grouped by Operation

Operation	No Synkinesia	Preexisting Synkinesia That Resolved Postoperatively	Preexisting and Postoperative Synkinesia	New Postoperative Synkinesia	Total
Gracilis MTPL	4	1	2	6	13
Territorially differentiated gracilis MTPL	8	0	0	18	26
Gracilis MTPL and temporalis transposition to the eye	10	1	2	14	27
Latissimus dorsi MTPL	0	0	0	1	1
Temporalis transposition to the eye and/or masseter transposition to the mouth	8	0	2	5	15
Cross-facial nerve graft with distal end-to-side neurorrhaphy	4	0	2	2	8
Cross-facial nerve graft with distal end-to-end neurorrhaphy	0	0	1	1	2
Static procedure	3	0	0	3	6
Total	37	2	9	50	98

MTPL, muscle transplantation.

Table 3. Patients with Preexisting Facial Synkinesia before Facial Reanimation Surgery, Grouped by Cause

Causes of Facial Palsy	Severity of Preexisting Synkinesia				Total
	None	Mild	Moderate	Severe	
Unknown	8	3	1	1	13
Idiopathic	10	1	2	1	14
Congenital	11	0	1	0	12
Möbius syndrome	9	0	0	0	9
Surgery/iatrogenic	72	4	2	1	79
Trauma	15	4	0	1	20
Infection	7	3	1	0	11
Tumor	5	0	0	0	5
Ischemic stroke	2	0	0	0	2
Cerebral hemorrhage	2	0	0	0	2
Total	141	15	7	4	167

movement. The prevalence grouped by the cause of facial palsy is shown in Table 3. In the majority of patients, the continuity of the facial nerve was preserved, except for rare posttraumatic and postoperative iatrogenic or oncologic cases. Patients most affected by synkinesia during the preoperative presentation suffered from facial palsy resulting from an infectious cause (36.4 percent), idiopathic facial palsy (28.6 percent), and traumatic facial palsy (25 percent). In the group of patients with an unknown cause of facial palsy, the prevalence of synkinesia was 38.5 percent. In the largest patient group, which suffered from iatrogenic facial palsy after a surgical intervention, the prevalence of synkinesia was 8.9 percent.

Types of Synkinesia Existing before Facial Reanimation Surgery

Preoperatively, 24 different types of synkinetic movements were found. The most severe case presented with 13 different types of facial synkinesia. The most common type was involuntary movement of the mouth during closure of the eyelids as in sleep ($n = 10$), the second most common types were both involuntary motion of the mouth during maximal lifting of the eyebrows ($n = 9$) and involuntary movement of the mouth during the blink reflex ($n = 9$). The third most common form was involuntary closure of the eyelid during smiling ($n = 8$). (Please note that the types of synkinesia surpass the number of patients, as some patients presented with more than one type of synkinesia.)

Facial Nerve Deficit and Facial Synkinesia Existing before Facial Reanimation Surgery

Subgroup analysis revealed that patients with incomplete ($p < 0.001$) and partial facial palsy ($p = 0.023$) were significantly more frequently affected by synkinesia. The mean ± SD age of patients with preoperative synkinesia (50.7 ± 13.9 years) was significantly higher than in the nonaffected group (43.7 ± 21.1 years; $p = 0.035$). There were no significant differences in sex or duration of facial palsy in the patient group that presented with synkinesia.

Prevalence and Severity of Facial Synkinesia after Facial Reanimation Surgery

Ninety-eight patients with postoperative follow-up times that exceeded 18 months were included. Preoperatively, 87.8 percent of this patient group did not present with synkinesia, 8.2 percent were affected by mild synkinesia, 3 percent were affected by moderate synkinesia, and 1 percent were affected by severe synkinesia. The prevalence of synkinesia grouped by surgical procedure is shown in Table 2. After facial reanimation, 51 percent of patients developed facial synkinesia. Eleven patients were affected by preexisting synkinesia. The preexisting synkinesia resolved in two patients after facial reanimation surgery. Nine patients were affected by synkinesia both preoperatively and postoperatively. Among these nine patients, the types of synkinesia remained the same in three patients. One patient presented with fewer forms of synkinesia postoperatively, and five patients developed additional ones.

Patients treated with territorially differentiated gracilis muscle transplantation, innervated by two separate cross-facial nerve grafts,[49] were most frequently affected by postoperative synkinesia (69.8 percent); 51.8 percent of patients after gracilis muscle transplantation innervated by a cross-facial nerve graft for smile reanimation in combination with temporalis transposition to the eye[10] (Figs. 2 and 3) were affected. Of patients treated with gracilis transplantation for smile reanimation[50] alone, 46.2 percent were affected. After temporalis and/or masseter transposition, 33.3 percent of patients presented with synkinesia, as did 25 percent of patients treated with cross-facial nerve grafts with distal end-to-side neurorrhaphy.[46]

Severity and Types of Facial Synkinesia after Facial Reanimation Surgery

After facial reanimation, 69.5 percent of synkinesia was mild, 28.8 percent was moderate, and 1.7 percent was severe. Figure 4 shows the comparison of severity of synkinesia before and after facial reanimation surgery. Postoperatively, 22 different forms of synkinetic movements were found. The most common types of synkinesia were involuntary movement of the mouth during closure of the eyelids as in sleep ($n = 41$) and synkinesia of the mouth during maximal closure of the eyelids ($n = 33$). Involuntary movement of the mouth during the blink reflex was the third most common form ($n = 22$), followed by movement of the mouth during maximal lifting of the eyelids ($n = 20$). The involuntary closure of the eyelid with smiling with showing teeth ($n = 4$) and with maximal showing of the teeth ($n = 3$) were less common. (Please note that the types of synkinesia surpass the number of patients, as some patients presented with more than one type of synkinesia.)

Patient Factors and Deficit of the Facial Nerve in Facial Synkinesia after Facial Reanimation Surgery

Postoperatively, there was no significant differences in sex, severity of facial nerve lesion (complete or incomplete facial palsy), affected

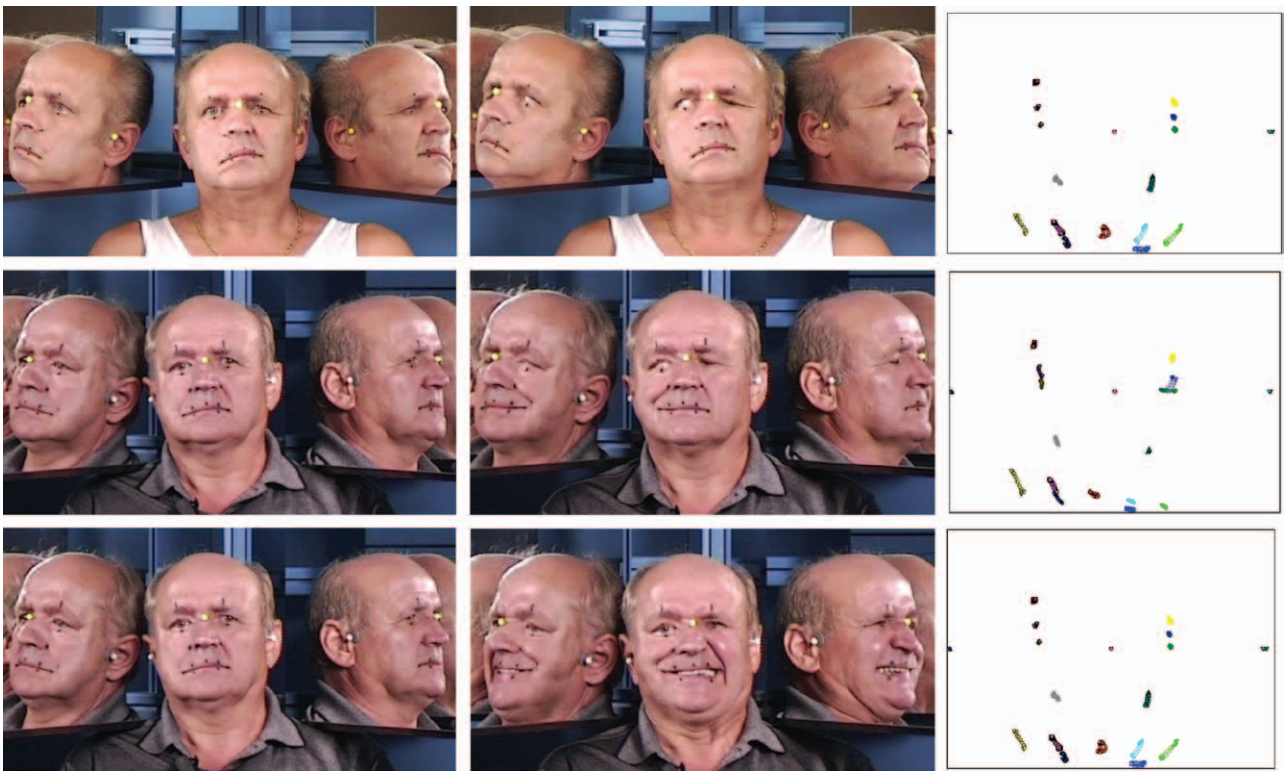

Fig. 2. Patient with oculo-oral synkinesia. A 63-year-old patient presenting with complete, total facial palsy on the right side after extirpation of a cholesteatoma (*left column*, resting position; *center column*, maximal movement; *right column*, three-dimensional graph). The diagnosis was cholesteatoma recurrence with partial facial palsy after the first cholesteatoma operation, and abscess of the cerebellopontine angle. The procedure was performed by an ear, nose, and throat surgeon and included abscess drainage and partial petrosectomy—the continuity of the facial nerve was preserved. (*Above*) Closure of the eyes as in sleep preoperatively (6 months after abscess drainage and partial petrosectomy). (*Center*) Severe oculo-oral synkinesia 44 months after gracilis muscle transplantation to the mouth innervated by a cross-face nerve graft and 50 months after temporalis transposition to the eye during closure of the eyes as in sleep. (*Below*) Voluntary smiling with showing of the teeth postoperatively (note that there is no synkinesia of the eyelid).

branches of the facial nerve (total or partial facial palsy), duration of facial palsy, or age in patients presenting with synkinesia.

Time Pattern of the Development of Facial Synkinesia after Facial Reanimation Surgery

The time pattern of the development of new postoperative synkinesia was analyzed (Fig. 5). The mean time until the onset of postoperative synkinesia was 12.7 ± 7.4 months.

Three-Dimensional Video-Analysis of Facial Movement

The facial movements of 25 patients with oculo-oral synkinesia with onset after facial reanimation surgery were analyzed. The mean lagophthalmus during the closure of the eyelids as in sleep improved from 6.9 ± 4.2 mm preoperatively to 4.5 ± 3.6 mm postoperatively. The mean Index of Dynamic Symmetry[47] of the synkinetic movement of the mouth was calculated (comparison of the amplitude of motion on the paretic side to the amplitude of motion on the healthy side), which was −0.03 ± 1.51 preoperatively and −1.12 ± 17.59 postoperatively. To compare the synkinetic movement of the mouth to the voluntary smile excursion on the paralyzed side, the mean Dynamic Symmetry Index during the voluntary motion smiling with showing of the teeth was analyzed. The smile motion improved from 0.05 ± 0.45 preoperatively to 0.49 ± 0.46 postoperatively. This indicates that the mean voluntary smile motion on the paretic side after facial reanimation improved to 49 percent of the mean smile amplitude on the healthy side. Subsequently, the mean amplitude of the synkinetic movement of the mouth on the paretic side during eyelid closure was compared with the mean amplitude of the voluntary smile motion on the paretic side to assess the severity of synkinesia in correlation to the reconstructed voluntary smile. In patients with postreconstruction oculo-oral synkinesia, the mean excursion of

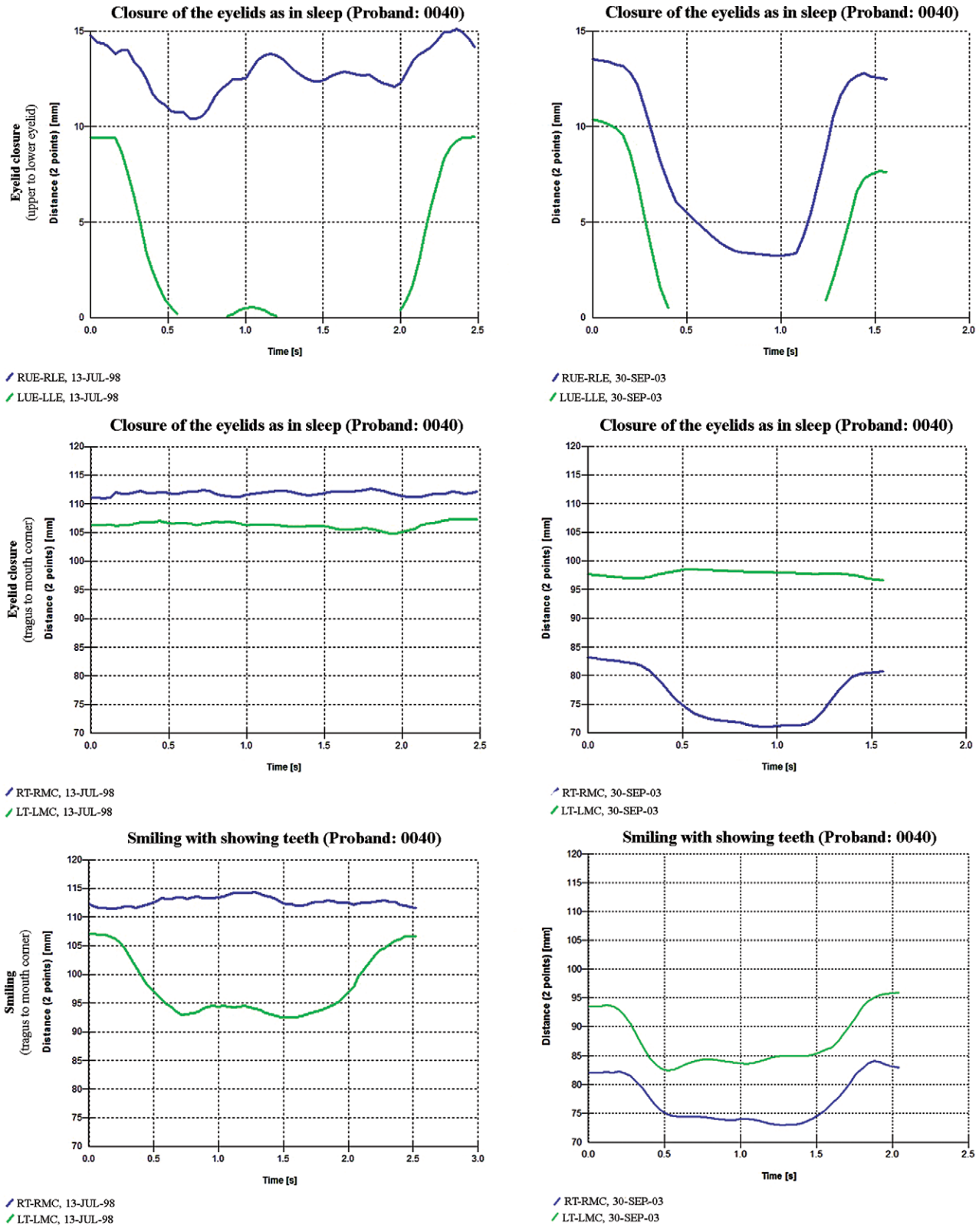

Fig. 3. Three-dimensional video analysis of facial movement of a patient with oculo-oral synkinesia (*left*, preoperative; *right*, postoperative). A 63-year old patient (Fig. 2) with severe oculo-oral synkinesia (*blue*, paralyzed side; *green*, healthy side). (*Above*) Eyelid closure (closure of the eyes as in sleep), note improvement postoperatively (*blue curve*). (*Center*) movement of the mouth during closure of the eyes as in sleep, strong excursion of the right (reconstructed, *blue*) side postoperatively. (*Below*) Voluntary movement of the mouth during smiling with showing of the teeth and improvement of the excursion of the reconstructed side postoperatively (*blue*).

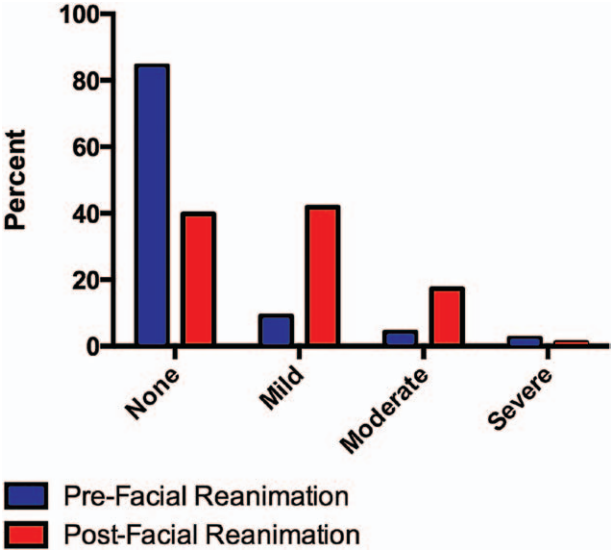

Fig. 4. Pre–facial reanimation and post–facial reanimation synkinesia grouped by severity.

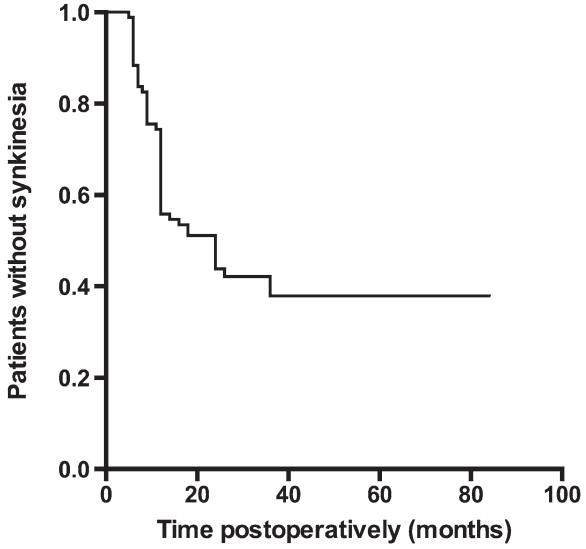

Fig. 5. Time pattern of the development of post–facial reanimation synkinesia.

the synkinetic mouth movement was 22 percent of the mean voluntary smile motion of the reconstructed side.

DISCUSSION

Synkinesia is a common sequela of regenerated facial palsy and facial reanimation. The incidence of 15.6 percent post–facial palsy synkinesia in the current study was within the incidence rates reported by Husseman and Mehta.[2] Patients with partially recovered facial nerve function after idiopathic, traumatic, or inflammatory facial palsy were most affected. Patients with postoperative/iatrogenic facial palsy, which represented the largest subgroup in the current patient population (47 percent), were affected in only 9 percent. Analysis of patient-based factors, such as sex, age, and duration of facial palsy, revealed that the mean age of patients presenting with post–facial palsy synkinesia was significantly higher, which was also found by Beurskens et al.[16] This finding might be influenced by the age-specific distribution of facial nerve injury and the higher percentage of congenital cases in the younger patient group, who are less affected by synkinesia. The duration of facial paralysis was not significantly different, which is consistent with previous studies.[16] Sex was not identified as a risk factor, although it was previously reported that female patients were more affected by synkinesia.[16]

After facial reanimation surgery, patients who were followed up for at least 18 months were included to assess the final functional reconstructive result. Postoperative synkinesia was most frequent in patients treated with territorially differentiated gracilis muscle transplantation innervated by two cross-facial nerve grafts. Frey and Giovanoli have previously described that postoperative synkinesia in this patient group is partially caused by insufficient separability of the territories of innervation of the gracilis muscle.[49] The relatively high rate of postoperative synkinesia after temporal muscle transpositions in combination with gracilis muscle transplants innervated by cross-facial nerve grafts or as independent procedures has not been previously reported. Compared with the free muscle transplantations and muscle transfers, only 25 percent of patients treated with cross-facial nerve grafts with distal end-to-side neurorrhaphy[46] developed postoperative synkinesia.

The time until the onset of synkinesia after spontaneous recovery of facial nerve function has been described to range from 3.5 to 6 months.[39,51] In the current study, the time until the onset of preexistent synkinesia could not be assessed, as patients were usually referred for pre–facial reanimation surgery evaluation. The mean time until the onset of postoperative synkinesia, however, was 12.7 months, which correlates well with the duration of functional recovery after facial reanimation.

The most common type of synkinesia, both before and after reconstruction, was oculo-oral synkinesia, which is consistent with previous reports.[3,6,23] In other studies, synkinesia of the mouth during voluntary lifting of the eyebrows[16] and involuntary eyelid closure during smiling[52] were described to be

most prevalent. Compared with these reports, the postoperative synkinesia of the eye during smiling, which severely impairs daily activities, was not common in the current study. Blink reflex–triggered synkinesia of the mouth was found to be the third most common type of postoperative synkinesia in our patient population. This type of synkinesia differs from other forms, as it constantly impacts the patient because of its reflex trigger.

Three-Dimensional Video Analysis of Facial Movement

Objective analysis of synkinesia is more precise than subjective methods. Wu et al. showed that synkinetic movements of the face occurring with eyelid closure are diagnosed significantly more frequently with objective than with subjective diagnostic tools.[9] Gross et al. found that two-dimensional analysis of facial movements underestimates three-dimensional amplitudes by as much as 43 percent,[53] which emphasizes the importance of three-dimensional objective analysis of facial function. In the current study, 24 different types of synkinetic movements during nine standardized facial motions and the blink reflex were documented. Compared with other objective measurement systems that focused only on the analysis of oculo-oral synkinesia,[6,23,31,35] the system developed by Frey et al.[54] provides a more flexible and comprehensive tool of analysis of synkinesia. The limitation of this method is that synkinetic movements of areas not well represented by facial markers, such as the platysma, cannot be objectively measured; however, because of the videos, subjective assessment of the patients is still possible.

Severity of Synkinesia and Clinical Context

The majority of patients were affected by mild or moderate synkinesia. The clinical relevance is determined by severity and type of synkinetic motion. Involuntary eyelid closure during voluntary motion of the mouth is more debilitating than oral synkinesia with submaximal or maximal eyelid closure. As shown in Figures 2 and 3, which demonstrate the most severe case of synkinesia (because mild forms are difficult to see in still photographs and require video analysis) in our patient cohort, the synkinetic movement of the mouth during eyelid closure is the only synkinesia this patient is affected by. The synkinetic movement is not reciprocal and therefore does not affect the eye during voluntary smiling.

Synkinesia triggered by the blink reflex should be seen as an exception because even mild synkinesia affects patients because of its constant presence, which is noticeable for patients and their surroundings even if the synkinesia is very discrete. Blink reflex–triggered synkinesia of the mouth is associated with greater morbidity than oculo-oral synkinesia during voluntary eyelid movement. Even though oculo-oral synkinesia is the most common form, it does not seem to affect patients, as voluntary eyelid closure is not a motion performed during most daily activities. The clinical relevance of synkinesia is influenced by the entire functional result after reanimation surgery. Patients with an excellent functional result who also develop synkinesia may have lower morbidity than patients who develop postoperative synkinesia while obtaining a poor functional outcome. Therefore, the form and severity of synkinesia needs to be placed in correlation to the overall functional results. In this current retrospective study, the quality of life of the patients with synkinesia was not assessed. This should be further investigated in the future to determine the efficacy of facial reanimation surgery.

The fact that synkinesia after facial reanimation surgery has not been very thoroughly studied in the past indicates that synkinesia is not a substantial problem for the majority of patients; however, those affected by severe forms of synkinesia can be significantly impaired. In this context, it is important to raise awareness for facial synkinesia in the management of facial palsy, in terms of documenting mild forms as part of successful facial reanimation and providing targeted treatment options, such as physical therapy,[23,36,39,55,56] botulinum toxin injections,[37,38] or neuroectomy/myectomy[2,40] for patients presenting with severe forms of synkinesia. The prevention of facial synkinesia needs further investigation. Recent meta-analyses have shown that patients with Bell palsy treated with corticosteroids developed significantly less postparalysis synkinesia.[57,58] The prevention and treatment of synkinesia that develops after facial reanimation surgery, however, remains the focus of future research.

CONCLUSIONS

Synkinesia is a common sequela of facial palsy that develops after recovery of facial nerve function and after facial reanimation surgery. The clinical relevance of synkinesia is determined by the severity and type of synkinetic movement, although the overall facial function always needs to be considered. The high incidence of postoperative synkinesia calls for raised awareness regarding its prevention and management.

Eva Placheta, M.D.
Department of Surgery
Division of Plastic and Reconstructive Surgery
Medical University of Vienna
Währinger Gürtel 18-20
A-1090 Vienna, Austria
eva.placheta@meduniwien.ac.at

PATIENT CONSENT

The patient provided written consent for the use of his images.

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