

Postparalysis Facial Synkinesis: Clinical Classification and Surgical Strategies

David Chwei-Chin Chuang,
MD

Tommy Nai-Jen Chang, MD

Johnny Chuieng-Yi Lu, MD

Background: Postparalysis facial synkinesis (PPFS) can occur after any cause of facial palsy. Current treatments are still inadequate. Surgical intervention, instead of Botox and rehabilitation only, for different degrees of PPFS was proposed.

Methods: Seventy patients (43 females and 27 males) with PPFS were enrolled since 1986. They were divided into 4 patterns based on quality of smile and severity of synkinesis. Data collection for clinically various presentations was made: pattern I ($n = 14$) with good smile but synkinesis, pattern II ($n = 17$) with acceptable smile but dominant synkinesis, pattern III ($n = 34$) unacceptable smile and dominant synkinesis, and pattern IV ($n = 5$) poor smile and synkinesis. Surgical interventions were based on patterns of PPFS. Selective myectomy and some cosmetic procedures were performed for pattern I and II patients. Extensive myectomy and neurectomy of the involved muscles and nerves followed by functioning free-muscle transplantation for facial reanimation in 1- or 2-stage procedure were performed for pattern III and many pattern II patients. A classic 2-stage procedure for facial reanimation was performed for pattern IV patients.

Results: Minor aesthetic procedures provided some help to pattern I patients but did not cure the problem. They all had short follow-up. Most patients in patterns II (14/17, 82%) and III (34/34, 100%) showed a significant improvement of eye and smile appearance and significant decrease in synkinetic movements following the aggressively major surgical intervention. Nearly, all of the patients treated by the authors did not need repeated botulinum toxin A injection nor require a profound rehabilitation program in the follow-up period.

Conclusions: Treatment of PPFS remains a challenging problem. Major surgical reconstruction showed more promising and long-lasting results than botulinum toxin A and/or rehabilitation on pattern III and II patients. (*Plast Reconstr Surg Glob Open* 2015;3:e320; doi: 10.1097/GOX.0000000000000283; Published online 6 March 2015.)

Postparalysis facial synkinesis (PPFS) represents a wide spectrum of unwanted facial movements after recovery of facial palsy from any etiology.

The possible pathogenesis of synkinesis is cross-talks in brain cortex, facial motor neurons, or facial nerve fibers.¹⁻⁶ Hypothesis of aberrant reinnervation among facial nerve fibers following nerve injury is more preferred.^{1,3,6} PPFS should be clearly differentiated from

From the Department of Plastic Surgery, Chang Gung Memorial Hospital, Chang Gung University, Taipei-Linkou, Taiwan.

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hemifacial spasm,^{7,8} which is caused by vascular loop compression of the facial nerve at facial nerve exit zone from the brain stem, and facial muscle tethering after facial trauma, which causes adhesion between eye and cheek muscles.

PPFS occurs not only always during facial expression but also at rest (intermittent blinking reflex causes intermittent cheek muscles twitching) and at sleeping (upper and lower lip constantly retracted), which are often not noticed by the patients. Long-term unresolved synkinesis may result in permanent contracture, such as hypertrophy of corrugator muscle, deep nasolabial fold, lower lip retraction, chin skin dimples, and neck bands. (See Video 1, Supplemental Digital Content 1, which shows a patient who had right facial palsy caused by parotid gland tumor resection for 2 years and developed right PPFS. The video showed her preoperative facial expression and will be available in the “Related Videos” section of the full-text article on <http://links.lww.com/PRSGO/A92>.) These will disrupt the resting facial posture and the involved face and neck will become tight and sore. Those symptoms and signs make patients with PPFS distressed with severe emotional sequelae.

Several treatments have been proposed, including facial rehabilitation,⁹⁻¹² botulinum toxin A (BTX-A) injections,¹³⁻¹⁷ and minor surgical procedures, such as selective myectomy¹⁷⁻²¹ and neurectomy.^{19,22,23} However, these treatments were all inadequate and not convincing. The aim of this article was to give a comprehensive overview of our surgical interventions based on different patterns of PPFS.

MATERIALS AND METHODS

A retrospective review was performed from 1986 to 2012 (a 27-year period). A total of 343 facial palsy patients were reconstructed by functioning free-muscle transplantation (FFMT) for facial reanimation. Ninety-nine percent of FFMT utilized gracilis muscle. They all were operated on by the senior surgeon (D.C.-C.C.). Fifty-three were patients with PPFS. Incidence of PPFS was at least 15% (53/343).

Seventy patients with PPFS were randomly enrolled for clinical evaluation and classification. Patients’ demographics including mean age at time of



Video 1. See video, Supplemental Digital Content 1, which shows a patient who had right facial palsy caused by parotid gland tumor resection for 2 years and developed right PPFS. The video showed her preoperative facial expression and will be available in the “Related Videos” section of the full-text article on <http://www.PRSGO.com> or available at <http://links.lww.com/PRSGO/A92>.

first clinic visit, sex, involved side, and etiology are shown in Table 1.

Clinically, PPFS involves 2 movements: trigger and synkinesis movements.

The trigger muscle(s) may be active or paralytic, but synkinetic muscle(s) is always active. There are basically 5 trigger and 6 synkinesis movements. The 5 trigger movements, which were regularly ordered to the patients, include forehead raise, eye closure, smile, lower lip pulled down, and lip pout or whistling. The 6 synkinetic movements, following the ordered movements, involve corrugators, eye, cheek, lower lip, chin skin, and platysma synkinesis. Since 2002, we have designed an examination sheet for PPFS, which was renewed in 2010 (Table 2).

Through that, patients were divided into 4 patterns based on quality of smile and degree of synkinesis. Table 3 shows the characteristics of different patterns of PPFS following the above patients’ evaluation.

Pattern I: Good Smile but Synkinesis

In pattern I, patients were aware of their altered facial expression, but observers including physicians might not fully recognize the problems due to their mildness. Patients themselves were even not aware that

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Table 1. Patient Demographics

| | |
|---|---------------|
| Total no. patients | 70 |
| Mean age (range), y | 30 (5–72) |
| Gender (male:female) | 27:43 |
| Left:right | 39:31 |
| Etiology: Bell’s:traffic:infection:tumor: | 30:19:7:6:4:4 |
| facial nerve repair:herpes zoster | |
| Total no. FFMTs | 53 |

Table 2. PPFS Examination Sheet (Chang Gung Memorial Hospital, 2010)

| | | Chart No.: | | | | Pattern | | | | | | | | | |
|--|--|--|--|---------------------------------|--|----------------------------------|--|----------------------------------|--|---------------------------------|--|--|--|----------------------------|--|
| | | I | | II | | III | | IV | | | | | | | |
| Name: | | Cause: | | Duration: | | | | | | | | | | | |
| Age: | | | | | | | | | | | | | | | |
| At rest | | () tension face at paretic side () hypertrophy of corrugator () cheek twitching | | () chin dimples () neck bands | | Others: | | | | | | | | | |
| Trigger Movement (Five) | | Corrugator synkinesis | | Eye synkinesis (eye narrowing) | | Upper lip synkinesis (twitching) | | Lower lip synkinesis (retracted) | | Chin skin synkinesis (dimpling) | | Platysma synkinesis (neck twitching or neck bands) | | Severity of face asymmetry | |
| Forehead raise <input type="checkbox"/> Palsy <input type="checkbox"/> Weak <input type="checkbox"/> Non-palsy | | | | | | | | | | | | | | | |
| Eye closure : lagophthalmos () mm | | | | | | | | | | | | | | | |
| Smile : visible tooth (0 1 2 3 ≥ 4) | | | | | | | | | | | | | | | |
| Lower lip pulled down <input type="checkbox"/> Palsy <input type="checkbox"/> Weak <input type="checkbox"/> Non-palsy | | | | | | | | | | | | | | | |
| Whistling <input type="checkbox"/> Palsy <input type="checkbox"/> Weak <input type="checkbox"/> Non-palsy | | | | | | | | | | | | | | | |

Table 3. Characteristics of Different Patterns of Patients with PPFs

| | Pattern I (Data from 13 Patients) | Pattern II (Data from 18 Patients) | Pattern III (Data from 31 Patients) | Pattern IV (Data from 5 Patients) |
|---|---|--|---|---|
| Mean age (range) | 35 (14–53) | 29 (20–50) | 33 (16–72) | 24 (5–43) |
| Mean interval of symptoms and signs (range) | 10 y (1–49) | 10.6 y (0.5–27) | 11.6 y (0.4–40) | 7.6 y (3–21) |
| Rest status | Grossly, natural, or normal | Grossly, acceptable, or okay | Asymmetry, moderate to severe | 100%, sad on the affected side |
| Forehead raise | Detailedly, 60%, tension on affected side Asymmetry: mild | Detailedly, 100%, sad on the affected side | 100%, sad on the affected side | Asymmetry, moderate to severe |
| Eye closure | Okay or weak Most, reactor; few, a starter Okay (lagophthalmos: 0 mm) A dominant starter to upper lip (blinking trigger) | Some, contracture Asymmetry: moderate Palsy or weak A starter (some, a dominant starter) Okay or weak (lagophthalmos: 0–1 mm) A dominant starter to upper lip, chin, and neck | Some, contracture Most are paralytic, but will trigger synkinesis Lagophthalmos, >1 mm A dominant starter to forehead, upper lip, chin, and neck | All are paralytic Lagophthalmos, > 2 mm A weak starter to mouth, chin, and neck |
| Oral smiling | Natural, 4 teeth visible A weak starter: to eye or neck | Weak, 3–2 teeth visible A dominant starter to eye and chin and neck | Paresis, 1–0 teeth visible A dominant starter to eye, chin and, neck | Palsy, 1 or no tooth visible A weak starter |
| Lower lip pulled down | Natural or weak A weak starter to neck | Weak or palsy A weak starter | Palsy or contracture A dominant starter | Palsy Most, weak starter |
| Whistling | Okay or weak Some, a strong starter to eye | Weak or palsy A weak starter to eye or corrugators | Palsy A dominant starter | Palsy |

they had synkinesis. Their big smile could always show at least 4 teeth. However, they always had intermittent perioral twitching following eye blinking. Some patients had an unique synkinesis with bizarre facial expression, such as lip pouting–induced eye narrowing on the affected side (oral-eye synkinesis) during spitting or whistling. Pattern I patients were mostly concerned more with cosmetic problems than synkinesis.

Pattern II: Acceptable Smile but Moderate-to-severe Synkinesis

In pattern II, patients were classified as having an acceptable smile but with moderate-to-severe synkinesis. (See Video 1, Supplemental Digital Content 1, which shows a patient who had right facial palsy caused by parotid gland tumor resection for 2 years and developed right PPFs. The video showed her preoperative facial expression and will be available in the “Related Videos” section of the full-text article on <http://www.PRSGO.com> or available at <http://links.lww.com/PRSGO/A92>.) Facial disfiguration in pattern II majority came from synkinesis. Their big smile could usually show 0–1 tooth. Such synkinesis could not be cured or improved by cosmetic surgery. Some aesthetic surgery might even make the appearance worse.

Pattern III: Unacceptable Smile and Severe Synkinesis

In pattern III, patients were classified as having a poor smile and severe synkinesis. They had lagophthalmos with weak eye closure, poor smile with one or no tooth visible, hypertrophic corrugators, narrow eye, dominant nasolabial fold, chin skin dimples, and neck bands on the affected side. Patients in this pattern all demonstrated more courage to accept more aggressive procedures to correct their disfigures.

Pattern IV: Poor Smile and Mild Synkinesis

In pattern IV, patients were classified as having a poor smile and synkinesis. The patients’ complaints in this pattern were focused on the paralytic face, less on the synkinetic movements. All patients in this pattern requested more aggressive procedures for correction.

SURGICAL PROCEDURES

Myectomy

Orbicularis Oculi Muscle

In PPFs, orbicularis oculi muscle is the most trigger and/or synkinetic muscle. Myectomy of the orbicularis oculi muscle, upper and lower eyelids, can reduce the synkinesis (Fig. 1). There were 2 incisions, upper incision along the upper lid crease if present and lower incision along and 2mm below the lower

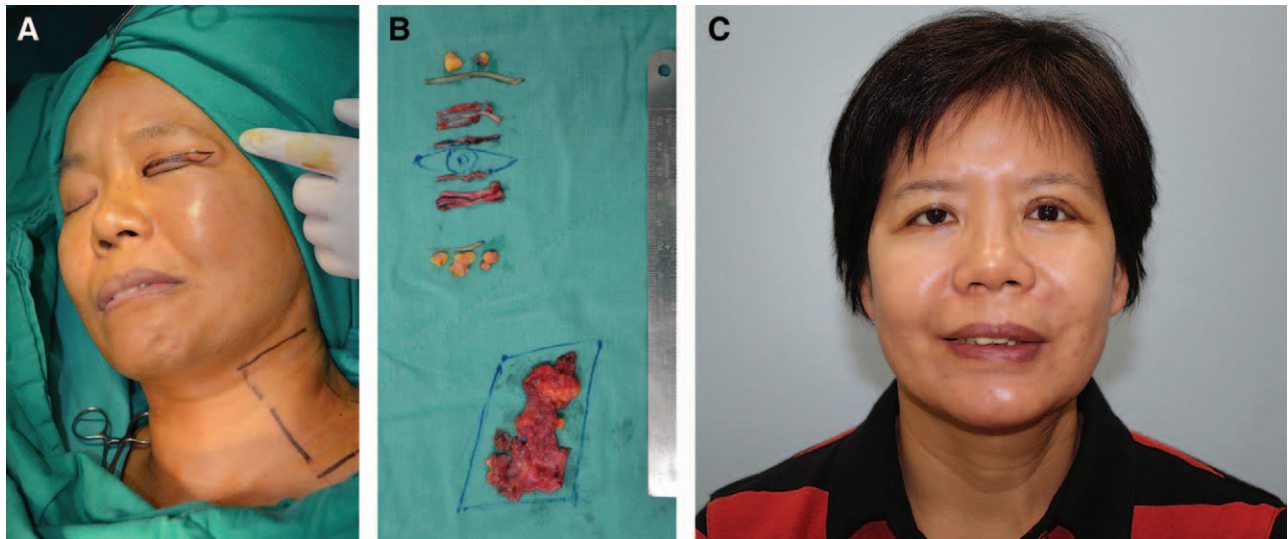


Fig. 1. A, A 47-year-old woman (patient 13, Table 4) has developed left PPFPS, pattern I and II, due to Bell’s palsy for 2 years. She presented left face with narrow eye, dominant nasolabial fold, chin dimples, and neck bands when she was smiling. B, She received myectomy of the orbicularis oculi (upper and lower lids) and platysma, blepharoplasty, and late rigotomy and fat grafts for nasolabial fold and chin. C, The results showed much improvement of smile and decreased left facial synkinesis 1 year postoperatively.

lid margin, to expose the orbicularis oculi muscle. Orbicularis oculi muscle has 3 components: pretarsus, preseptum, and preorbital portions. Only segmental resection of the former 2 portions in the upper and lower eyelids is enough to decrease synkinesis. It was a new procedure performed in recent 2 years.

Platysma Muscle

Platysma muscle on the affected side is quite often a synkinetic muscle. Myectomy of the platysma can decrease synkinesis. Two parallel incisions, 1 submandibular and 1 above clavicle, to nearly total resection of the platysma were regularly performed (Fig. 1).

Corrugator Muscle

Hypertrophy or involuntary movement of the corrugators would cause bizarre appearance when smiling. BTX-A injection is effective, but more patients will request myectomy for one procedure with permanent result. Suprabrow incision along the medial upper margin of the eyebrow to expose the corrugator muscle and nearly total resection of the muscle were performed.

A 2-stage Procedure

First stage involves short cross-face nerve graft (CFNG); second stage (6–9 months later) involves

Table 4. Pattern I Patients

| Patient | Botox Injection (Site) | Blepharoplasty | Platysma Resection | Corrugator Resection | Orbicularis Oculi Resection | Other Procedures |
|--------------|-------------------------|--------------------------------------|--------------------|----------------------|-----------------------------|---|
| 1 | Yes (lower lip) | | | | | |
| 2 | Yes (lower lip) | | | | | |
| 3 | Yes (corrugators) | | | | | |
| 4 | Yes (orbicularis oculi) | | | Yes | | Browlift |
| 5 | Yes (orbicularis oculi) | | | | | |
| 6 | Yes (orbicularis oculi) | Yes | | Yes | | Change hair style |
| 7 | | | | | | Platysma transfer |
| 8 | | Yes (upper and lower blepharoplasty) | Yes | Yes | | |
| 9 | Yes (orbicularis oculi) | | | | | Fat grafts |
| 10 | Yes (orbicularis oculi) | | | Yes | | Browlift |
| 11 | | | | | Yes | |
| 12 | Yes (lip depressor) | Yes | | | Yes | |
| 13* (Fig. 1) | | Yes | | | Yes | Fat graft for deep nasolabial fold and chin |
| 14 | | | | | | No treatment |

* Patient shown in figures or supplemental videos.

extensive myectomy of the cheek and platysma muscles, neurectomy of the zygomatic, buccal and cervical facial nerve branches, and gracilis FFMT for facial reanimation.

In the first stage, short CFNG has been evolved (since 2001).^{24,25} Sural nerve was placed subcutaneously from the preauricular wound on the intact side to the nasolabial fold small wound on the affected side. One stump was coapted to the facial nerve branches under microscopy, and the other stump was sutured to the dermis of the nasolabial fold. (See **Video 2, Supplemental Digital Content 2**, which shows a patient who received extensive myectomy and neurectomy and reconstruction by CFNG-innervated gracilis, a 2-stage procedure. The video showed excellent results of 1 year after free-muscle transplantation and is available in the “Related Videos” section of the full-text article on <http://links.lww.com/PRSGO/A93>.)

In the second stage, 1 small upper lip wound was made to identify the CFNG stump. A long second preauricular wound down to submandibular extension was made, and subcutaneous facelift from the upper zygomatic arch to the upper and lower lip was performed. All peripheral branches of the facial nerve should be identified. All zygomatic and buccal branches and their innervated muscles in the cheek area were excised en bloc (Fig. 2). The excision should be as extensive as possible down to the oral mucosa attachment to avoid late residual synkinetic movements. The neck cervical branch of the facial nerve and platysma were removed simultaneously. Stenson’s duct should be preserved. The frontal and mandibular branches were preserved

if possible to preserve some function on eye and lower lip.

A gracilis muscle from the contralateral thigh was trimmed,²⁵ harvested, and transferred to the face. Vessels were anastomosed to the facial artery and vein. The motor nerve of the gracilis muscle which was passing under the muscle to the upper lip wound was coapted to the previous CFNG under the operative microscope.

A 1-stage Procedure

Extensive Myectomy and Neurectomy and Gracilis FFMT Innervated by the Spinal Accessory or Masseter (V3) Nerve Simultaneously

The spinal accessory (XI) nerve was found on the anterior margin of the trapezius muscle through a posterior neck incision.²⁶ Dissection of the XI nerve should be as distal as possible, divided, and transferred to the mandibular angle.

The V3 nerve was found at the posterior margin of the masseter muscle just below the zygomatic arch.²⁷ A 1–1.5cm of the nerve was dissected, divided, and transferred for nerve coaptation. Facelift, myectomy and neurectomy, gracilis FFMT, vessel anastomoses, and nerve coaptation were performed as described.

Postoperative Rehabilitation

CFNG-innervated and V3-innervated gracilis needed no splint immobilization. However, XI-innervated gracilis required face and neck splint immobilization for 3 weeks. Three weeks after surgery, electric stimulation was started. At approximately 4 months postoperatively, “induction exercise”^{3,26} was initiated. Once the transferred muscle achieved upper lip movement, “smile training”²⁶ was prescribed



Video 2. See video, Supplemental Digital Content 2, which shows a patient who received extensive myectomy and neurectomy and reconstruction by CFNG-innervated gracilis, a 2-stage procedure. The video showed excellent results of 1 year after free-muscle transplantation and is available in the “Related Videos” section of the full-text article on <http://www.PRSGO.com> or available at <http://links.lww.com/PRSGO/A93>.

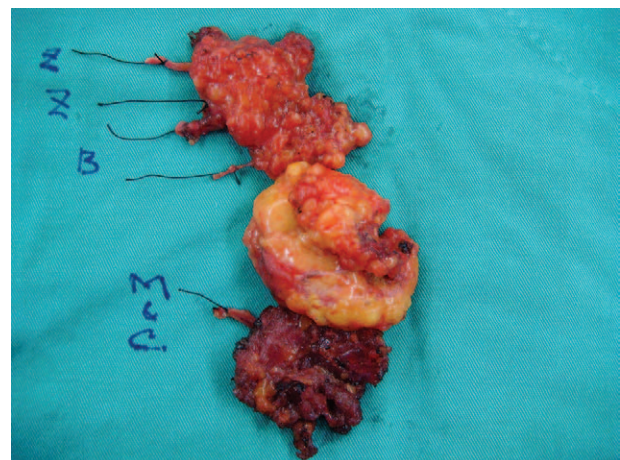


Fig. 2. Sample of myectomy of cheek muscles and platysma and neurectomy of whole zygomatic and buccal facial nerve branches. B indicates buccal; C&M, cervical and mandibular branch; Z, upper and lower zygomatic.

to achieve independent and spontaneous movement. This smile training should be performed in front of a mirror.

OUTCOME ASSESSMENT

All treated patients were closely followed a minimum of 1 year. Outcomes were assessed in terms of success of decreasing synkinesis and achieving facial symmetry at rest and smiling. There were 4 methods that were used for outcome assessment^{26,28,29}:

1. Smiling Score is a score system (0–4) based on how many teeth expose during smile: score 0, no or partial first incisor visible; score 1, the full first incisor visible; score 2, 2 teeth visible, and so forth. A maximum score of 4 is given if at least 4 teeth are visible. If reaching \geq score 2, it was acceptable.
2. Cortical Adaption Stage System (I–V) is a system to evaluate functional recovery of an FFMT: no movement (stage I), dependent movement (stage II), independent movement (stage III), spontaneous but with involuntary movement (stage IV), and spontaneous with little or no involuntary movement (stage V). If reaching \geq stage III, it was acceptable.
3. Synkinesis Grading System is utilized: mild, moderate, and severe synkinesis.³⁰ Only the mild one was acceptable in outcome result.
4. Satisfactory Score, a questionnaire to evaluate patient satisfaction was performed, including patient's complaint, self-image, use of the newly acquired smile, the possible complications, and symptoms by donor nerve transfer.²⁶ Finally, a "satisfactory score" was made: score 1, not acceptable and regret surgery; score 2, not acceptable but did not regret surgery; score 3, acceptable but required further refinement surgery; score 4, satisfied but request minor procedure to improve the results; and score 5, completely satisfied.

RESULTS

Pattern I (n = 14)

BTX-A injection at eyelid muscle (1 shot at upper, 2 shots at lower eyelid; Botox, 0.025 ml = 1.0 IU/shot, 100 IU/2.5 ml), lower lip depressors (affected side or nonaffected side, 5–6 shots, 0.05 ml = 2 IU/shot), and corrugator muscle (2 shots, 0.05 ml = 2 IU/shot) was the most common procedure for pattern I patients (Table 4). They all achieved temporary decrease of synkinesis, but were not completely satisfied. Changing hair style or wearing glasses to cover the synkinesis was advised with some help. Myectomy of the orbicularis oculi showed some help to decrease synkinesis and

decrease requirement of the repeated BTX-A injection (Fig. 1) (patient 13, Table 4). One patient (patient 7, Table 4) had platysma muscle transfer to the ipsilateral weak lower lip for balance. Many pattern I patients knew that the synkinesis could not be cured by such minor procedures and tended to stop clinical follow-up after a short time of visiting. A few patients chose no treatment at all (patient 14, Table 4).

Pattern II (n = 17)

Fourteen patients (82%) requested more aggressive surgical procedures after explanation (Table 5). All were treated with extensive myectomy and neurotomy and reconstructed by CFNG-innervated gracilis. They achieved a more symmetric smile (smile score from average 2.6 preoperatively to 4.0 postoperatively, Table 7) and significantly decreased synkinetic movements (from moderate or severe down to mild, $P < 0.001$; Table 7). The cortical adaptation was all scored at stage V (spontaneous smile). Clinically, it was more witnessed in eye opening and teeth visibility (Fig. 3). Adjuvant surgeries included lip revision, blepharoplasty, tensor fasciae latae sling, or fat grafts to improve results. Most of them received no more BT-A injection. Satisfactory Score showed at least score 3. Six patients had lip contracture and required release procedure. Two patients (patients 2 and 6, Table 5) required lip adhesion (Fig. 4) for 1 year to overcome the lip contracture. Two patients (patients 15 and 16, Table 5) only accepted minor procedures with repeated BT-A injections. One patient (patient 17, Table 5) refused the treatment after explanation.

Pattern III (n = 34)

All patients accepted and received the extensive surgical procedures for treatment (Table 6). Similar to the pattern II surgical-treated patients, the most improved parts with less synkinesis were eye opening and teeth visibility (Figs. 5–7). The smile score improved from an average 0.86 preoperatively to 3.57 postoperatively in the CFNG-innervated gracilis series (21 patients) and from an average 0.6 preoperatively to 3.5 postoperatively in the XI-innervated gracilis series (12 patients). The cortical adaptation stage showed at least stage III. The synkinesis was significantly improved in all from grade II or III down to I ($P < 0.001$, Table 7). One patient was an exceptional child, 6 years old when he was surgically treated by CFNG-innervated gracilis, with near 10-year follow-up (patient 8, Table 6; Fig. 6). In 1 girl patient (patient 23, Table 6) after CFNG-innervated gracilis, although showing little movement of the transferred muscle (smile score 1) after 2-year follow-up with unknown reason, her synkinesis grading

Table 5. Pattern II Patients

| Patients | Myectomy | | Facial Reanimation (Neurotizer-innervated Muscle) | | Blepharoplasty | Lip Revision | Rigotomy + Fat Injection | Other Procedures | Smile Score (0-4) | | Cortical Adaptation Stage (I-V) | Synkinesis Grading (I-III) | | Satisfactory Score (1-5) |
|---|--------------|------------|---|--------|----------------|--|--------------------------|--|-------------------|---------------|---------------------------------|----------------------------|---------------|--------------------------|
| | Neurectomy | Neurectomy | Neurotizer | Muscle | | | | | Preoperative | Postoperative | | Preoperative | Postoperative | |
| 1* (Fig. 3) | Ch, Pl | Z, B, C | CFNG-gracilis | | Yes | Yes (lip contracture release and lip adhesion) | Yes | TFSL sling for deep NLF | 2→4 | 3→4 | Yes | III→I | 4 | |
| 2 | Ch, Pl | Z, B, C | CFNG-gracilis | | Yes | Yes (lip contracture release) | Yes | | 3→4 | 3→4 | Yes | III→I | 3 | |
| 3 | Ch | Z, B, C | CFNG-gracilis | | Yes | Yes (lip contracture release) | | | 2→4 | 2→4 | Yes | II→I | 4 | |
| 4 | Ch, Pl | Z, B, C | CFNG-gracilis | | Yes | Yes (lip contracture release and lip adhesion) | Yes | Rigotomy and fat graft | 3→4 | 3→4 | Yes | II→I | 5 | |
| 5 | Ch, Pl | Z, B, C | CFNG-gracilis | | Yes | Yes (lip contracture release) | Yes | | 2→4 | 2→4 | Yes | II→I | 5 | |
| 6 | Ch, Pl | Z, B, C | CFNG-gracilis | | Yes | Yes (lip contracture release) | Yes | | 4→4 | 4→4 | Yes | III→I | 3 | |
| 7 | Ch, Pl | Z, B, C | CFNG-gracilis | | Yes | Yes (lip contracture release) | Yes | | 4→4 | 4→4 | Yes | II→I | 4 | |
| 8 | Ch, Pl | Z, B, C | CFNG-gracilis | | Yes | Yes (lip contracture release) | Yes | TFSL sling for deep NLF | 4→4 | 4→4 | Yes | III→I | 4 | |
| 9 | Ch, Pl, Co | Z, B, C | CFNG-gracilis | | Yes | Yes (lip contracture release) | Yes | Temporalis for lagophthalmos Rigotomy and fat grafts | 3→4 | 3→4 | Yes | III→I | 4 | |
| 10 | Ch, Pl | Z, B, C | CFNG-gracilis | | Yes | Yes (lip contracture release) | Yes | TFSL sling for deep NLF | 2→4 | 2→4 | Yes | II→I | 5 | |
| 11 | Ch, Pl | Z, B, C | CFNG-gracilis | | Yes | Yes (lip contracture release) | Yes | Breast augmentation Rigotomy and fat grafts | 2→4 | 2→4 | Yes | II→I | 4 | |
| 12 | Ch, Pl | Z, B, C | CFNG-gracilis | | Yes | Yes (lip contracture release) | Yes | TFSL sling for deep NLF | 3→4 | 3→4 | Yes | II→I | 5 | |
| 13 | Ch, Pl | Z, B, C | CFNG-gracilis | | Yes | Yes (lip contracture release) | Yes | Rigotomy and fat grafts | 2→4 | 2→4 | Yes | III→I | 4 | |
| 14* (Video 1 and 2, Supplemental Digital Content) | Ch, Pl, Oo | Z, B, C | CFNG-gracilis | | Yes | Yes (lip contracture release) | Yes | Lower lip thinning | 3→4 | 3→4 | Yes | III→I | 5 | |
| 15 | Pl, Co. | — | — | | Yes | — | Yes | Browlift Botox injection (×6) | 3→3 | 3→3 | Nil | III→III | 3 | |
| 16 | Pl, Oo | — | — | | Yes | — | Yes | Browlift | 2→2 | 2→2 | Nil | III→II | 3 | |
| 17 | No treatment | — | — | | — | — | — | — | — | — | — | — | — | |

B, buccal branch; C, cervical branch; Ch, cheek muscles; Co, corrugator muscle; NLF, nasolabial fold; Oo, orbicularis oculi; Pl, platysma muscle; TFL, tensor fasciae latae; Z, zygomatic branch.
 * Patient shown in figures or supplemental videos.

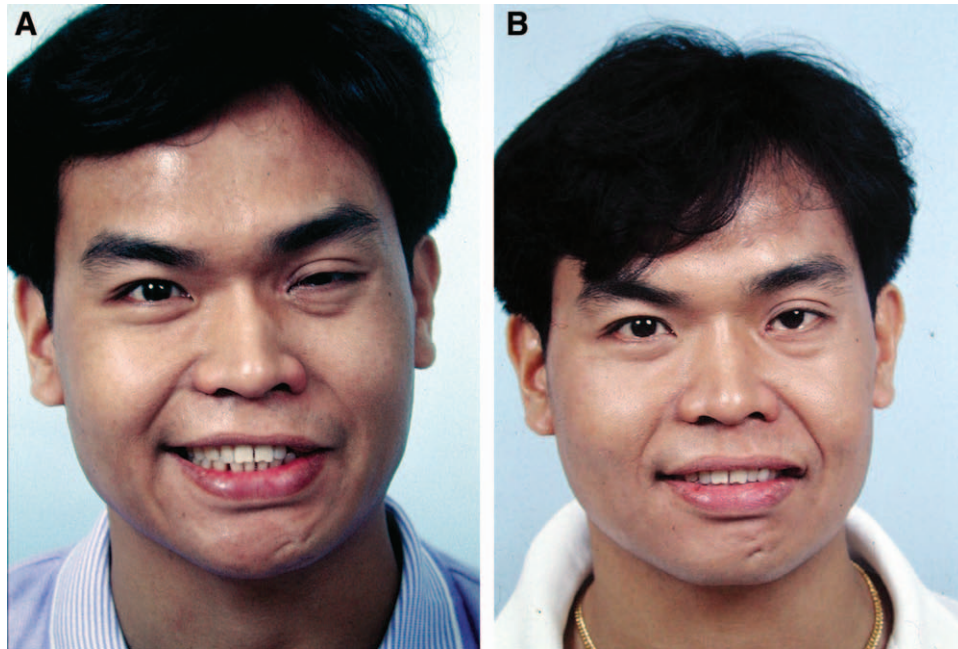


Fig. 3. A, A 31-year-old man (patient 1, Table 5) had left Bell's palsy for 6 years and developed left PPFPS, pattern II. He received extensive myectomy and neurectomy and reconstruction by CFNG-innervated gracilis, a 2-stage procedure. B, Results at 2 years after showed more natural smile.

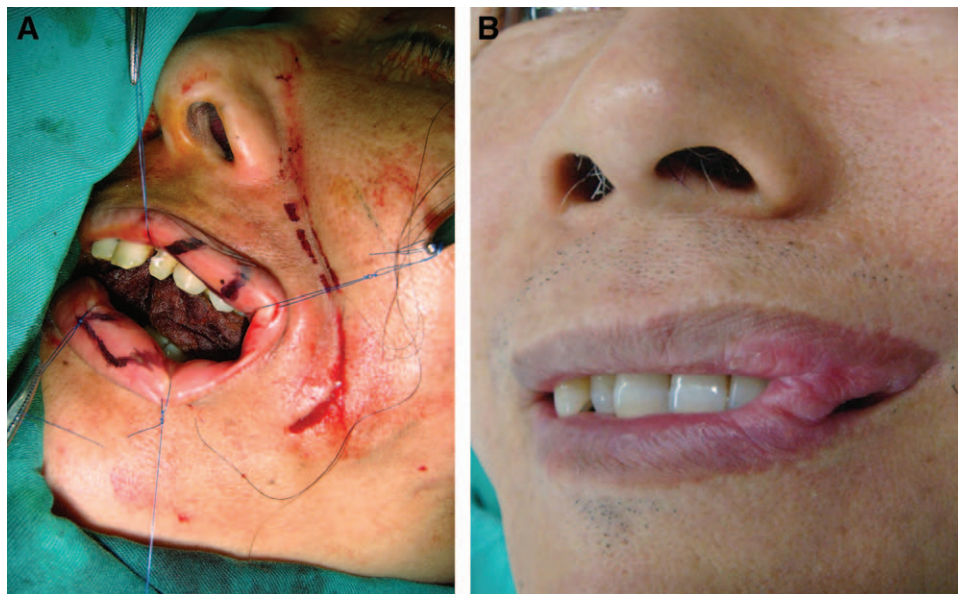


Fig. 4. A, A double opposing lip mucosa flap is designed: one inner-based and another outer-based. The muscles of the both upper and lower lips should be sutured together before both mucosal flaps are adhesive. B, The healed lip adhesion.

improved. Another patient (patient 29, Table 6) who had failed CFNG-innervated gracilis for 1 year received masseter-innervated second gracilis for reconstruction and showed improving results (Fig. 7). From Satisfactory Score, 33 patients showed significant improvement of their synkinesis ($P < 0.001$, Table 7) and more tooth exposure when smiling. The Satisfactory Score

was at least 3. The eye appeared as the most improved part with a more natural look. One patient (patient 14, Table 6) was considered as a fair result due to upper lip contracture. Four patients had lip contracture and required lip adhesion (patients 8, 10, 14, and 17, Table 6). No patient regretted having such complex surgical procedures.

Table 6. Pattern III Patients

| Patients | Facial Reanimation (Neurotizer-INNER- vated Muscle) | | | Blepharoplasty Revision | Lip Revision | Rigotomy + Fat Injection | Other Procedures | Smile Score (0-4) Preoperative → Postoperative | Cortical Adaptation Stage (I-V) | Synkinesis Grading (I-III) | | Satisfactory Score (1-5) |
|--------------|---|------------|--|-------------------------|--------------|--------------------------|---|--|---------------------------------|----------------------------|---------------|--------------------------|
| | Myectomy | Neurectomy | Neurotizer-INNER- vated Muscle | | | | | | | Preoperative | Postoperative | |
| 1* (Fig. 5) | Ch, Pl | Z, B, C | CFNG-gracilis | Yes | Yes | Yes | TFL for NLF | 0→4 | Yes | III→I | 5 | |
| 2 | Ch | Z, B, C | CFNG-gracilis | Yes | Yes | Yes | Gold weight | 1→4 | Yes | III→I | 4 | |
| 3 | Ch, Pl | Z, B, C | CFNG-gracilis | Yes | Yes | Yes | Neurectomy of contralateral side frontal branch | 1→4 | Yes | III→I | 4 | |
| 4 | Ch, Pl | Z, B, C | CFNG-gracilis | Yes | Yes | Yes | TFL suspension for deep NLF | 1→3 | Yes | III→I | 4 | |
| 5 | Ch, Pl, Co | Z, B, C | CFNG-gracilis | Yes | Yes | Yes | TFL suspension for deep NLF | 1→4 | Yes | III→I | 4 | |
| 6 | Ch, Pl, Co | Z, B, C | CFNG-gracilis | Yes | Yes | Yes | TFL suspension for deep NLF | 1→4 | Yes | III→I | 3 | |
| 7 | Ch, Pl | Z, B, C | CFNG-gracilis | Yes | Yes | Yes | TFL suspension for deep NLF | 1→4 | Yes | III→I | 4 | |
| 8* (Fig. 6) | Ch, | Z, B, C | CFNG-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 0→4 | Yes | III→I | 5 | |
| 9 | Ch, Pl | Z, B, C | CFNG-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 0→3 | Yes | III→I | 4 | |
| 10 | Ch, Pl | Z, B, C | CFNG-gracilis | Yes | Yes | Yes | TFL suspension for deep NLF | 0→3 | Yes | III→I | 3 | |
| 11 | Ch, Pl | Z, B, C | CFNG-gracilis | Yes | Yes | Yes | TFL suspension for deep NLF | 1→3 | Yes | III→I | 3 | |
| 12 | Ch, Pl | Z, B, C | CFNG-gracilis | Yes | Yes | Yes | Wear glass | 1→3 | Yes | III→I | 4 | |
| 13 | Ch, Pl | Z, B, C | CFNG-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 1→4 | Yes | III→I | 3 | |
| 14 | Ch, Pl | Z, B, C | XI-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 1→4 | Yes | III→I | 4 | |
| 15 | Ch, Pl | Z, B, C | CFNG-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 1→3 | Yes | III→I | 3 | |
| 16 | Ch, Pl | Z, B, C | XI-gracilis | Yes | Yes | Yes | Wear glass | 1→3 | Yes | III→I | 4 | |
| 17 | Ch, Pl | Z, B, C | XI-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 1→4 | Yes | III→I | 3 | |
| 18 | Ch, Pl | Z, B, C | XI-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 1→4 | Yes | III→I | 4 | |
| 19 | Ch, Pl | Z, B, C | XI-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 1→4 | Yes | III→I | 4 | |
| 20 | Ch Pl | Z, B, C | XI-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 1→4 | Yes | III→I | 4 | |
| 21 | Ch Pl | Z, B, C | CFNG-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 1→4 | Yes | III→I | 4 | |
| 22 | Ch Pl | Z, B, C | XI-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 1→3 | Yes | III→I | 5 | |
| 23 | Ch Pl | Z, B, C | CFNG-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 1→3 | Yes | III→I | 4 | |
| 24 | Ch Pl | Z, B, C | CFNG-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 1→1 | Yes | III→I | 3 | |
| 25 | Ch Pl | Z, B, C | XI-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 1→4 | Yes | III→I | 4 | |
| 26 | Ch Pl | Z, B, C | XI-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 1→4 | Yes | III→I | 5 | |
| 27 | Ch Pl | Z, B, C | CFNG-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 1→3 | Yes | III→I | 4 | |
| 28 | Ch Pl | Z, B, C | XI-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 2→4 | Yes | III→I | 4 | |
| 29* (Fig. 7) | Ch Pl | Z, B, C | masseter-gracilis (CFNG-gracilis failed) | Yes | Yes | Yes | Yes (lip adhesion) | 1→4 | Yes | III→I | 4 | |
| 30 | Ch Pl | Z, B, C | CFNG-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 1→4 | Yes | III→I | 5 | |
| 31 | Ch Pl | Z, B, C | CFNG-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 1→4 | Yes | III→I | 4 | |
| 32 | Ch Pl | Z, B, C | XI-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 1→4 | Yes | III→I | 4 | |
| 33 | Ch Pl | Z, B, C | CFNG-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 1→4 | Yes | III→I | 4 | |
| 34 | Ch Pl | Z, B, C | XI-gracilis | Yes | Yes | Yes | Yes (lip adhesion) | 1→4 | Yes | III→I | 4 | |

B, buccal branch; C, cervical branch; Ch, cheek muscles; Co, corrugator muscle; NLF, nasolabial fold; Pl, platysma muscle; TFL, tensor fasciae latae; Z, zygomatic branch.
 * Patient shown in figures or supplemental videos.

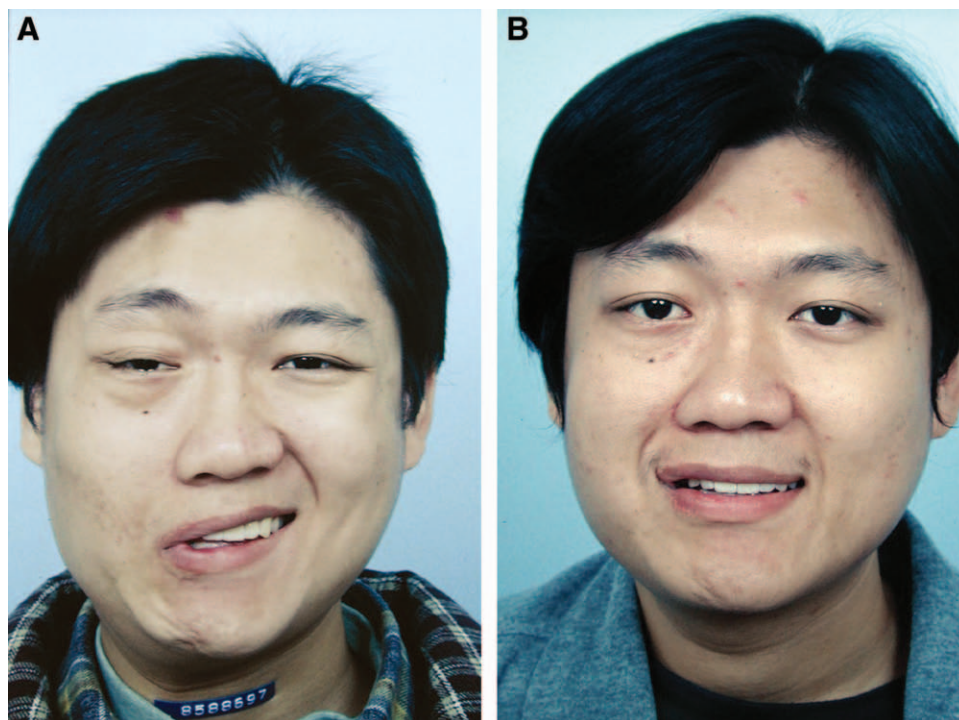


Fig. 5. A, An 18-year-old man (patient 1, Table 6) had Bell's palsy for 14 years and developed right PPFPS, pattern III. He received extensive myectomy and neurectomy and reconstruction by CFNG-innervated gracilis, a 2-stage procedure. B, Results at 2 years after showed excellence.

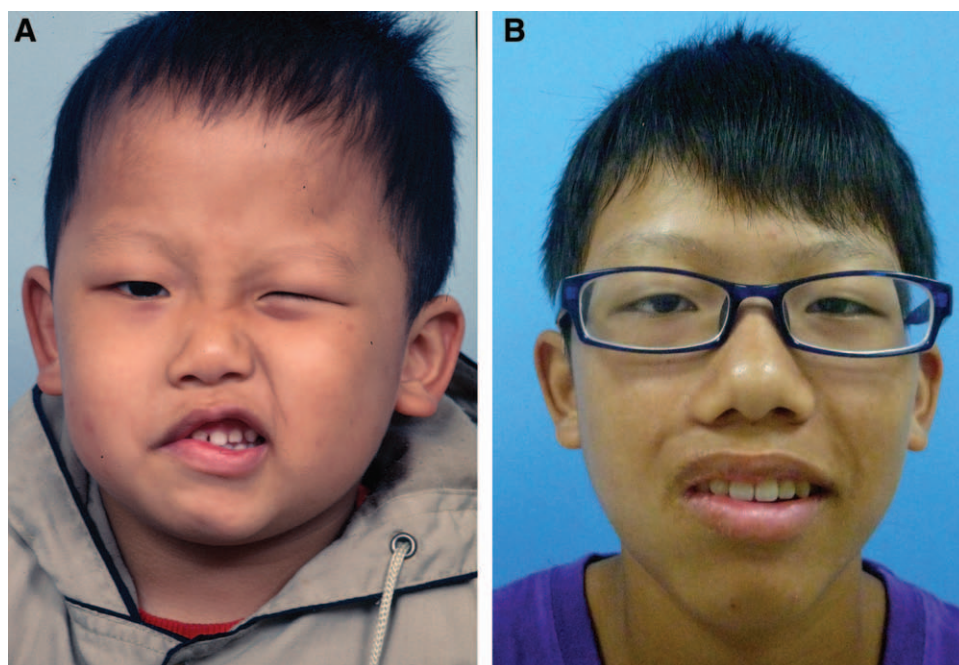


Fig. 6. A, A 5-year-old boy (patient 8, Table 6), who suffered a dog bite to the face and received facial nerve repair, developed right PPFPS for 1 year, pattern III. He received extensive myectomy and neurectomy and reconstruction by CFNG-innervated gracilis in a 2-stage procedure. B, Results at 9 years after showed excellence. He had lip adhesion for 1 year when developed contracture.

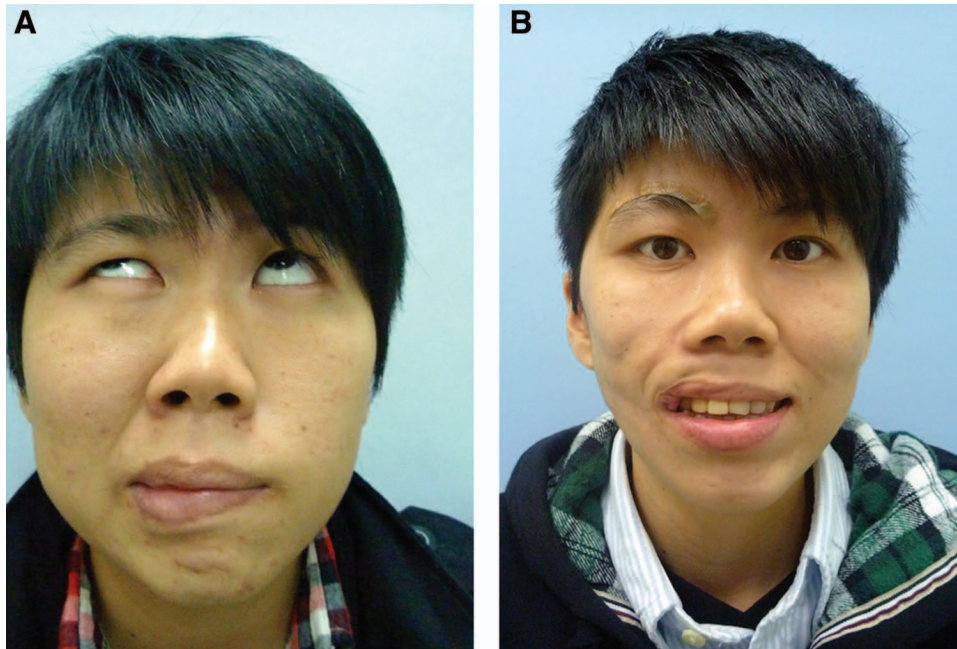


Fig. 7. A, A 25-year-old solidier (patient 29, Table 6) had right facial palsy for 1 year due to a falling accident and developed right PPFS, pattern III. She had failed CFNG-innervated gracilis (left gracilis) 1 year ago due to infection and muscle necrosis. After 11 months, she had masseter-innervated second gracilis (right gracilis) for facial reanimation. B, Good facial smile score with mild synkinesis was achieved. She needs rigotomy and fat grafts for uneven surface of the reconstructed face later for refined surgery.

Table 7. Improvement of Synkinesis Grading and Smile Score after Aggressive Surgical Procedures

| | Pattern II (14 Patients) | Pattern III (34 Patients) | Improvement |
|----------------------------|--|--|--|
| Synkinesis grading (I–III) | Before operation III, 7 patients II, 7 patients After operation I, 14 patients | Before operation II, 0 patients III, 34 patients After operation I, 34 patients | Synkinesis grading ≤ 1 Pattern II, 14/14 ($P < 0.001$) Pattern III, 34/34 ($P < 0.001$) |
| Smile score (0–4) | Before operation Score 2, 6 patients Score 3, 5 patients Score 4, 3 patients After operation Score 4, 14 patients | Before operation Score 0, 4 patients Score 1, 29 patients Score 2, 1 patients After operation Score 1, 1 patient Score 3, 9 patients Score 4, 24 patients | Smile score ≥ 2 Pattern II, 14/14 ($P < 0.001$) Pattern III, 33/34 ($P < 0.001$) |

Pattern IV (n = 5)

In pattern IV, all 5 patients underwent CFNG-innervated gracilis, a classic 2-stage procedure for reconstruction. Four patients had good results, but 2 developed upper lip contracture, requiring lip revision. The cortical adaptation stage was \geq stage III in all, and the smile score improved from average 0.65 preoperatively to 3.0 postoperatively.

DISCUSSION

Aberrant reinnervation, for motor it is synkinesis, may occur after nerve injury and repair, such as cases of obstetric brachial plexus palsy.^{31,32} Deformities at

shoulder and elbow after recovery are seen quite often. The major treatment is surgical intervention^{31,32} not BTX-A and/or rehabilitation.

The philosophy of surgical treatment of PPFS is similar to the treatment of scars. PPFS is a healing process of facial nerve injury, similar to scar, a healing process of wound. Scars have many different clinical presentations. Not all scars can be treated simply by injection, massage, and pressure. Some scars, hypertrophic scars and keloids, should be treated aggressively, such as radical excision and resurface by free tissue transfer. Similarly, not all PPFS can be treated effectively and permanently by BTX-A and/

or rehabilitation. The goal of PPFS treatment is not only to decrease synkinesis but also to achieve a natural and symmetric smile permanently.

Rehabilitation therapy is attempting to inhibit the trigger movement or change the intended voluntary movements to decrease synkinesis.⁹⁻¹² It has involved exercises (eg, mirror exercises, electromyography feedback training), learning (neuromuscular reeducation), relaxation training, mime therapy, electric stimulation, and BTX-A injection. However, there has been little support showing it could significantly and permanently reduce synkinesis.

BTX-A injection has been a well-established benefit in the control of facial hyperkinesis in the literatures,¹³⁻¹⁶ mostly due to lack of effective surgical treatment. The authors have been taught that BTX-A can treat the whole PPFS for years (1990–2000) and used it for treatment in the beginning. Quick effects have been noted, but with many variations in the procedure, including injection sites, injection dosage, timing of injection, frequency of injection, result evaluation, and follow-up period. In addition, the major disadvantages of BTX-A were many injection sites (on the paralyzed and healthy face), repeated injections, anaphylaxis, blepharoptosis, diplopia, and accelerating the paralysis. The effect of BTX-A will also be decreasing following the repeated injections. Those will usually exhaust patients. Most patients will lose their patience and finally disappear from clinic after a short follow-up period (usually less than 2 years), but they were not cured yet.

In PPFS, except pattern IV, 2 phenomena have been seen: less synkinesis will tend to be more symmetric in smile; more muscle paralysis is associated with less synkinesis. Our philosophy to treat PPFS is to remove the trigger and synkinetic muscles as much as possible to decrease the synkinesis and to remove the innervated nerves to avoid its recurrence. The effect is permanent. Our treatment protocol is based on patterns of PPFS and patient's desire. BT-A injection, rehabilitation, and other additional aesthetic surgeries were only our adjuvant therapy to improve the result.

VanSwearingen and Brach⁹ described the importance of treatment-based classification system for facial synkinesis. As PPFS has many presentations and patient expectations are usually high, pattern classification is necessary, which can be used for explanation and strategy of treatment. Narrow eye, dominant nasolabial fold, dominant lower lip pulled down, and dominant neck bands are all important signs for judging degree of synkinesis. Tooth exposure when smiling is a good sign for judging quality of facial palsy. Most patients with PPFS are more concerned with facial asymmetry than synkinesis. But to the physician, correction of synkinesis should always

be done before treatment of asymmetry. This is especially true in pattern II and III patients with PPFS.

Treatment for pattern I patients will be much closer to aesthetic surgery. BT-A injection, rehabilitation, and distraction procedures (hair style changes and eye glasses wearing), and minor facial contouring surgeries can be helpful. However, those conservative treatments cannot cure synkinesis. The best treatment for pattern II and pattern III patients is to treat synkinesis first and then aesthetics. Extensive removal of the involved muscles and nerves, followed by FFMT for facial reanimation, is our treatment of choice. All patients with PPFS who received such aggressive procedures should be aware that additional minor procedures such as blepharoplasty and fat grafts might be required later to enhance the results. The advantage of such extensive procedures is to avoid insufficient treatment and recurrence.

Performing aggressive surgical procedures to treat pattern II and III patients with PPFS is a challenging task. For a safe practice and to avoid potential law suit, some prerequisites are essentially necessary:

1. The surgeon should have experiences in facial palsy reconstruction and skills in aesthetic judgment and management.
2. Extensive preoperative explanation to both the patient and patient's family is required, including mechanism, 4 patterns of PPFS and their treatment options, and conservative vs surgical intervention. The patient should recognize that the disfiguring involved is due to synkinesis effects. Surgical risks, postoperative rehabilitation, potential sequelae, and further surgical procedures should be explained for decision making. Showing photographs or videos of results from previously treated patients are also helpful. The patient and parents should take the messages home and think about them. The final decision will be made by the patient not by a driven surgeon. The patient should be given enough time for consideration of such invasive surgery.
3. The patient should have close follow-up postoperatively.
4. Indication and contraindication: patient selection is also crucial. The age of the patient should not be too young (before 14 years old) or too old (after 60). Patients with low education level and high expectation for results or hesitation in decision making should not be considered for radical procedures.

Until now, for more than 25 years, the authors have never met 1 case with law suit, even though 1 fair result (patient 23, pattern III) and 1 failed first gracilis (patient 29, pattern III) were encountered. The patients did not need repeated BTX-A injection

or require a profound rehabilitation program during the follow-up period.

CONCLUSIONS

Treatment of PPFs remains a challenging problem. Aggressive surgical procedures for pattern II and III patients including myectomy, neurectomy, and functioning muscle transplantation showed more promising results than minor procedures. The 4 patterns of classification and treatment strategies mentioned above are still constantly followed.

David Chwei-Chin Chuang, MD

Department of Plastic Surgery
Chang Gung Memorial Hospital
199 Tun-Hwa North Road
Taipei, Taiwan 105
E-mail: micro.cgmh@gmail.com

PATIENT CONSENT

Patients or their parents or guardians provided written consent for the use of the patients' image

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