34 Free Muscle Transfer in Partial Facial Palsy

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34.1 Introduction

Facial paralysis ranges from complete to varying degrees of incomplete paralysis [1]. Patients with incomplete paralysis are characterized by some degree of facial mimetic function in the affected hemiface and can be subdivided according to etiology, duration of paralysis, anatomical distribution and the degree of atrophy and synkinesis [1–3]. Bell's palsy remains the most common cause for acquired facial paralysis and in approximately 10–30% results in incomplete unilateral facial paralysis [4–6].

The main goals of facial paralysis reanimation procedures are to improve static and/or dynamic symmetry and function, specifically in the midface zone thus enhancing the symmetry of the smile [7, 8]. Spontaneity of facial mimetic function is a highly important aspect of the reconstruction goal.

The main risk in performing dynamic reanimation in incomplete paralysis cannot be stressed enough as it can result in damaging the existing facial mimetic function on the affected side [3, 4, 7–9]. The clinically evident facial movement in the incompletely paretic hemiface indicates some active facial nerve axons and the presence of viable facial muscle. Surgical manipulation of these anatomical structures may lead to worsening of the paralysis by injuring facial nerve branches and/or facial musculature. With that said, it has been reported that cross-face nerve grafting (CFNG) with end-to-end coaptation to the paretic facial nerve may be performed with minimal damage to the existing motor function [4]. A distal end-to-side coaptation was also presented in order to address this issue exactly with good results [7]. A one-stage mini-latissimus dorsi free muscle transfer with neural coaptation to a contralateral facial nerve branch has also been reported [8].

We have recently published our experience with a one-stage free gracilis muscle transfer that involves neural coaptation to an ipsilateral buccozygomatic residual branch of the paretic facial nerve [9]. According to this series of patients we recommend to consider using this method in patients with incomplete facial paralysis that present with any degree, even if minimal, of preoperative spontaneous ipsilateral mimetic function in the buccozygomatic region.

34.2 Etiology and Epidemiology

Etiologies for incomplete facial paralysis are mainly acquired. The causes include idiopathic causes, infection, trauma, iatrogenic injury, and neoplasms.

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Bell's palsy remains the most common cause for acquired facial paralysis. Approximately one half of all acquired cases qualify for the diagnosis of "Bell's palsy." The annual incidence rate of Bell's palsy is between 13 and 34 cases per 100,000 population. There is no race, geographic, or gender predilection, but the risk is three times greater during pregnancy, especially in the third trimester or in the first postpartum week. Diabetes is present in about 5–10% of patients. On presentation approximately one-third have an incomplete paralysis, and two-thirds have complete paralysis. The prognosis of Bell's palsy is related to the severity of the lesion. A simple rule is that clinically incomplete lesions tend to recover: with regard to the House-Brackmann grading system, grades I and II have good outcomes, grades III and IV characterize moderate dysfunction, and grades V and VI portend a poor result. Approximately 10–30% results in incomplete unilateral facial paralysis.

Several other disorders should be considered in the differential diagnosis of incomplete acquired facial nerve palsy. Cholesteatoma or a neoplasm should be suspected if the onset of facial palsy is gradual. Neoplasms can either compress or invade the facial nerve along its course from the cerebellopontine angle to the parotid gland. The Melkersson–Rosenthal syndrome is characterized by facial paralysis, episodic facial swelling, and a fissured tongue, typically beginning in adolescence but with recurrent episodes of facial palsy. Sarcoidosis should be considered, especially in patients with bilateral facial palsy. Severe systemic hypertension has been linked to unilateral primary facial nerve palsy in children and adolescents and rarely in adults. Hypertension should be suspected in a pediatric patient, if facial palsy is associated with headache, altered level of consciousness, vomiting, convulsions, or focal central nervous system deficit.

Congenital incomplete facial paralysis is rare. It may be isolated with the involvement of the facial nerve and its musculature only, or it may be part of a syndrome. It may be the result of developmental defects or of traumatic etiology (mainly forceps delivery). It is estimated that facial paralysis occurs in 2% of live births. In distinguishing developmental from traumatic facial palsies in the perinatal period, some or complete recovery of function favors traumatic lesions.

34.3 Diagnosis and Patient Presentation

Incomplete facial paralysis is defined as a state of facial paralysis that involves any degree of voluntary and/or spontaneous movement of the affected hemiface [3, 9]. This movement may be secondary to native axons that were uninjured in the previous facial nerve insult or may represent partial and unorganized axonal regeneration that takes place in the recovery of the injured facial nerve. Patients with incomplete facial paralysis are usually characterized by fair static symmetry and tone however with obvious dynamic asymmetry and in some patients, synkinesis and facial spasms (Fig. 34.1a, b) [6, 7, 8, 10]. Pattern and extent of dynamic asymmetry is determined by the etiology and mechanism of facial nerve injury as well as duration of paralysis and many other factors. Thus the clinical presentation is highly variable.

A thorough medical interview and physical examination is performed. Age, general medical condition and comorbidities, etiology of paralysis and duration, specific facial paralysis complaints (i.e., dry eye symptoms or epiphora, difficulty in mastication and intra-oral food propulsion, drooling, etc.) all have a roll in the reconstructive decision-making. Patient's chief complaint and expectations are discussed. Physical examination involves assessment of the five divisions of the paretic facial nerve as well as the muscles of mastication and possible donor muscles. At physical assessment one should notice is there is a major hypertonicity or hyper spasticity in the affected side a phenomena that may impair the reconstructive end point.

Fig. 34.1 4 year-old male patient with congenital right incomplete facial paralysis. Note fair symmetry at rest (**a**) and mild ipsilateral nasolabial fold and lateral lip elevation on attempt to smile (**b**). The ipsilateral facial nerve branch responsible for this residual movement (**a**, **b**) was used and coapted to the gracilis motor nerve. Note improved symmetry at rest and while smiling (**c**, **d**)

34.4 Patient Selection

Patients suitable for reanimation using the ipsilateral buccozygomatic residual facial nerve branch are those who present with incomplete facial paralysis characterized by any degree of *spontaneous movement*, even if minimal, in the ipsilateral buccozygomatic region. This may include mild nasolabial fold motion, movement of the muscle over the zygomatic arch with no motion of any perioral structure, minimal commissure excursion, mild upper lateral lip elevation or twitch of the modiolus. We hypothesize that this movement is due to the presence of some active native axons of the facial nerve and active facial muscle/s. The movement they produce may be clinically ineffective, probably due to unorganized and partial regeneration and the fact that they innervate small and atrophic motor units. Spastic or hypertonic incomplete facial paralysis patients may benefit from this procedure as well as long as adjunct procedures are performed such as botulinum toxin injections and/or selective neurectomy or myomectomy.

34.5 Operative Techniques

Various authors have presented their experience with treating patients with complete and incomplete paralysis that were treated as a single cohort. Thus there are many publications in which patients with incomplete paralysis were treated with the wide range of reconstructive options used for treating complete facial paralysis. These include static procedures as well as dynamic reanimation procedures including temporalis muscle transfer, masseteric-to-facial and hypoglossal-to-facial nerve transposition and autogeneous fascia lata transfer [5, 6, 9, 11, 12]. Cross-face nerve grafting, with or without the use of a free muscle transfer, has been reported as a safe and reliable method for facial reanimation in incomplete facial paralysis [3, 4, 7, 9, 10, 13–15].

Several authors have addressed the subgroup of patients with incomplete facial paralysis only with the intention to produce specialized procedures for these patients. Hontanilla et al. [6] assessed the efficacy of masseteric to facial nerve transposition in patients with incomplete facial paralysis. A series of nine patients is presented. Coaptation in all cases was performed between the nerve to masseter and an ipsilateral buccozygomatic branch that intraoperatively produced commissure excursion. As stated by the authors, the main disadvantage of this approach is the issue of movement dissociation and lack of a spontaneous smile. Outcome was assessed using the FACIAL CLIMA software that showed improvement of both commissural excursion and velocity of greater than 75% in six patients, greater than 50% in two patients, and less than 50% in one patient. Patient satisfaction was positive in the majority of patients while two patients reported no apparent improvement following surgery. Frey et al. [7] presented their approach for treating incomplete facial paralysis by coapting a contralateral active buccozygomatic facial nerve branch to an ipsilateral partially active buccozygomatic facial nerve branch using a sural CFNG. This approach does not involve a free muscle transfer. The nerve graft is coapted end-to-end on the healthy side and end-to-side on the paretic side via an epineural window. Axons are thought to regenerate along the CFNG and enter the distal part of the partially paretic facial nerve branch. The partially active nerve's axons are left intact as coaptation is performed by an epineural window. Spontaneous facial mimetic function is therefore enhanced while damage of the axons on the partially paretic facial nerve branch is minimized. The series included seven patients; three of them underwent 3D video symmetry assessment and are presented in the chapter. Results showed improved static and dynamic symmetry with what the authors call a functional upgrade of facial mimetic function in the incompletely paralyzed hemiface. Takushima et al. [8] reported a one-stage free mini-latissimus dorsi muscle transfer with neural coaptation to a contralateral facial nerve branch in patients with incomplete paralysis. Ipsilateral facial nerve branches are left untouched in order to avoid damage to the existing motion. The authors present a series of 96 patients. Mild worsening of the paralysis was noted in three cases, all of which resolved back to baseline within several months. Clinical outcome was assessed using a local grading scale that includes subjective symmetry score combined with EMG results. The authors present good postoperative symmetry scores (grades 4 or 5 in the local evaluation criteria used) in the majority of patients of the cohort. There were no cases of long-term worsening of paralysis. Advantages of this method include that it is a one-stage procedure, low complication and revision rate and its use of a free muscle transfer that provides a muscle source for modiolus pull. Of note, the authors do not mention any input regarding spontaneity of movement.

We have recently published our experience with a novel facial reanimation approach designed for patients with incomplete facial paralysis that present with residual ineffective movement in the midface zone of the paralyzed hemiface [9]. This includes using an ipsilateral minimally active buccozygomatic facial nerve branch as the donor nerve in a one-stage free gracilis muscle transfer (Fig. 34.2). The gracilis muscle is harvested with its neurovascular pedicle through a longitudinal incision in the medial thigh. Approximately one-third of the muscle width is used. Length and bulk of the muscle is determined intraoperatively according to the patient's size and proportions. Simultaneously, a preauricular face-lift incision is performed in the partially paralyzed hemiface. Dissection is performed in the supra-SMAS plane and deepens to the masseter fascia at the anterior border of the parotid gland, directed medially until facial nerve branches are identified emerging from the gland under the masseter fascia. At this stage, a meticulous functional mapping of the ipsilateral FN branches is performed using a nerve stimulator. The buccozygomatic branches responsible for the preoperative movement are identified. It is critical to identify the branches that create the exact movement that was evident clinically to activate the gracilis flap that eventually will create a spontaneous smile.

It is important to stress that in many times the muscle excursion that will be created by a nerve stimulator will be stronger than clinically evident at pre op clinical assessment. There are usually more than one such buccozygomatic branch thus elimination of the original motion is avoided when one of these branches is chosen to become the donor nerve for the gracilis flap and is divided. This branch will undergo neural coaptation to the gracilis motor nerve.

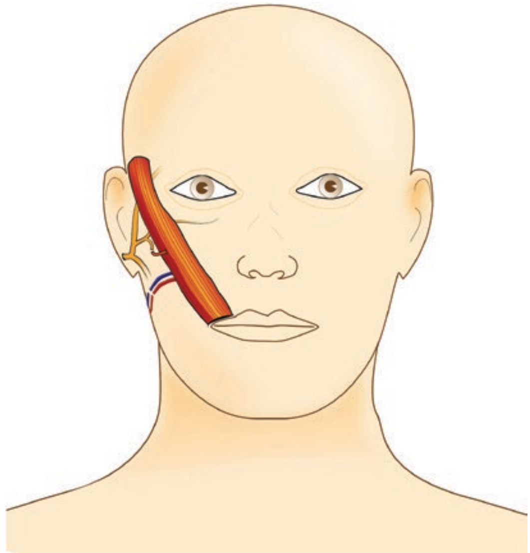

Fig. 34.2 Illustration of the one-stage free gracilis muscle transfer with neural coaptation to an ipsilateral residual buccozygomatic facial nerve branch in right sided incomplete facial paralysis. One of the residual branches is utilized leaving at least one branch intact. The gracilis's vascular pedicle is preferably anastomosed to the superficial temporal artery and vein. Used with permission from Wolters Kluwer Health, Inc.: Gur E, Zuker RM, Zaretski A, Leshem D, Barnea Y, Arad E, Yanko R, Meilik B, Kedar DJ, Fliss E. Incomplete facial paralysis: The use of the ipsilateral residual facial nerve as a donor nerve for facial reanimation. *Plast Reconstr Surg*, 2018 Jul;142(1):202-214. doi: https://doi.org/10.1097/PRS.0000000000004536

It is of utmost importance to make all efforts in order to identify more than one residual buccozygomatic branch in order to leave at least one intact branch thus the chance of worsening the preoperative residual function is minimized. In cases when only one residual buccozygomatic branch is identified, efforts are made to preserve its function on the native facial musculature by splitting it longitudinally and one half will be used as a donor nerve for the gracilis flap. The reminder of the fascicles is left uninterrupted in the native nerve sheath. In this case, the gracilis motor nerve is incised longitudinally leaving two split ends. End-to-end coaptation is then performed between the split end of the donor nerve and one of the free split ends of the gracilis motor nerve. The other split end of the gracilis motor nerve is coapted by end-to-side to the remaining fascicles of the buccozygomatic nerve that was left uninterrupted.

The gracilis flap is inset according to the standard procedure from the modiolus to the superficial temporal fascia. Vascular anastomoses are preferably performed between the flap pedicle and the ipsilateral superficial temporal vessels however the facial vessels may also be used. Chosing the superficial temporal system is suggested in order to avoid dissection of the lower facial zone if it not necessary and thus reduce buccal or marginal mandibular nerve injury (if still present). The face-lift incision is sutured and a penrose drain is left, the donor area is closed and a drain is left. Elastic bandage is placed on the donor leg. Postoperative care includes avoiding pressure on the operated cheek from the bed or pillow or from staff or patient manipulation by placing a curved hard splint from the oral commissure to the temporal scalp, pain management, regular hydration and diet, early mobilization, and respiratory physiotherapy. The penrose drain is removed prior to discharge and the thigh drain is removed according to amount of discharge. First follow-up visit is set to 1 week following discharge where the cheek splint is removed.

34.6 Outcome and Complications

We have published our experience with the above-described method in a series of 16 patients [9]. Our cohort included a majority of women with a mean age of 26.2 years (range 5–59 years). Patients were heterogeneous regarding the etiology of paralysis with the most common cause being iatrogenic paralysis following resection of head and neck tumors or other facial surgery. Mean interval between palsy onset and surgery was 11.2 years (range 1–49 years) and patients were followed for a mean period of 88.3 months (range 16–132 months). Following surgery, mean interval to first muscle flap motion was documented in seven patients and was 2.8 months (range 1–6 months).

In order to assess the procedures efficacy, we have conducted a subjective analysis of static and dynamic symmetry following surgery in 11 of the 16 patients of the cohort. This included a group of 21 reviewers who gave symmetry scores for three facial zones (eye region, nasolabial fold region, mouth region) at rest and while smiling and another score for global symmetry of the face while smiling. The former were assessed according to still photos and the latter according to videos of the patients smiling. All scores were given for pre- and postoperative photos and videos. These scores were later subtracted (postoperative score–preoperative score) in order to produce a *delta* value that represents the clinical change following surgery for the various anatomical zones at rest and while smiling. Statistically significant results demonstrated that in the majority of observations, no clinical apparent change was seen following surgery in the eye region at rest and while smiling and in the nasolabial fold region at rest. Improved symmetry was noted in the majority of observations in the nasolabial fold while smiling and in the mouth region at rest and while smiling. These findings demonstrate that this procedure positively affects the midface zone while not harming other facial zones (Figs. 34.1, 34.3 and 34.4). Global symmetry of the face on dynamic video assessment was also improved in the majority of patients (Table 34.1).

There were a minority of observations that demonstrated downgrading of symmetry following surgery. After reviewing the photos and videos of the cases we concluded that symmetry was interrupted mainly at rest but also in a small percentage of dynamic assessments. It seems this is mainly secondary to the gracilis flap's presence in the affected hemiface which may produce an abnormal appearing bulkiness. Moreover, in some cases the pulling vector of the gracilis flap produced some lateral movement that may by itself impair dynamic symmetry at the midface. These findings can be improved with secondary static procedures.

Fig. 34.3 Pre- and postoperative photos at rest and while smiling of a 43 year-old patient who presented with incomplete left facial paralysis secondary to Bell's palsy (**a**, **b**). Surgery was performed 25 years following palsy onset. Note mild upward and lateral movement of the ipsilateral lateral lip on attempt to smile (**c**, **d**). Used with permission from Wolters Kluwer Health, Inc.: Gur E, Zuker RM, Zaretski A, Leshem D, Barnea Y, Arad E, Yanko R, Meilik B, Kedar DJ, Fliss E. Incomplete facial paralysis: The use of the ipsilateral residual facial nerve as a donor nerve for facial reanimation. *Plast Reconstr Surg*, 2018 Jul;142(1):202-214. https://doi.org/10.1097/PRS.0000000000004536

Fig. 34.4 Pre- and postoperative photos at rest and while smiling of a 19 year-old with left incomplete right facial paralysis secondary to traumatic injury at early childhood. Surgery was performed 16 years palsy onset. Note minimal movement of the nasolabial fold on attempt to smile (**b**)

In our series, there were no cases of major complications (partial or complete flap necrosis, flap loss, flap congestion, hemorrhage, or any complication requiring urgent revision surgery). In four patients, minor complications were noted (mild surgical site infection with mild wound dehiscence), all of which resolved with conservative measures. There were no cases of marginal mandibular nerve injury. Ten patients (62%) underwent secondary static procedures for fine-tuning of the aesthetic result. These included scar revision, fat injection, fat suction, adhesiolysis,

Table 34.1 Comparison of mean pre- and postoperative facial symmetry scores for all observations, according to media category and anatomical zone[a]

	Preoperative mean facial symmetry score (± Std. deviation)	Postoperative mean facial symmetry score (± Std. deviation)	*P* value	Mean delta (post-op to pre-op)
Static symmetry, eye At rest	4.02 (±0.96)	4.27 (±0.77)	< 0.001	+0.24
Static symmetry, NLF[b] At rest	3.32 (±1.03)	3.77 (±0.88)	< 0.001	+0.44
Static symmetry, mouth At rest	2.78 (±1.13)	3.90 (±0.92)	< 0.001	+1.12
Static symmetry, eye While smiling	3.42 (±1.22)	3.93 (±0.91)	< 0.001	+0.51
Static symmetry, NLF[b] While smiling	2.90 (±0.86)	3.68 (0.82)	< 0.001	+0.78
Static symmetry, mouth While smiling	2.13 (±0.80)	3.73 (±0.84)	< 0.001	+1.60
Dynamic symmetry While smiling	1.93 (±0.78)	3.61 (±0.85)	< 0.001	+1.68

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[a]Static symmetry refers to still photograph assessment; Dynamic symmetry refers to video assessment

[b]NLF—Nasolabial fold

and gracilis flap re-anchoring. One patient (6%) showed mainly static improvement of facial symmetry with only minimal dynamic improvement after 14 months of follow-up. On clinical examination, the gracilis flap did contract however the facial movement it produced was weak and non-significant. Revision surgery was decided upon and during surgery the gracilis flap seemed viable however its motor nerve underwent atrophy. After retrospective inspection of the case, we could not find the reason for this course. During surgery, cross-face nerve grafting was performed with direct neurotization of the gracilis flap.

34.7 Conclusions and Future Study

Incomplete facial paralysis is the common form of facial paralysis. It includes a wide range of facial static and dynamic abnormalities with a highly heterogeneous clinical picture. According to current literature, incomplete paralysis is generally treated with the same treatment algorithm as complete facial paralysis. Several publications however did address this entity with the aim of refining the reconstructive approach. Here we present our experience with a one stage procedure designed specifically for patients with incomplete facial paralysis who present with any degree of spontaneous movement in the midface. This involves a one-stage free gracilis muscle transfer with neural coaptation to an ipsilateral, residually, partially active buccozygomatic branch of the paretic facial nerve. It is under debate whether the facial motion weakness is to be attributed to defective facial nerve growth or to facial muscle weakness and atrophy. The suggested procedure overcomes those two options by using the remaining normal facial nerve axons to stimulate a whole new and strong muscle that is transferred to the paralyzed face. Advantages of this procedure are that it is a safe and effective one-stage procedure, coaptation to an ipsilateral facial nerve branch allows for a spontaneous smile, using the gracilis flap provides a strong source for commissure excursion and in case no movement is identified postoperatively, salvage procedures are still possible with cross-face nerve grafting. Results in our cohort are promising and the procedure has proved to be safe and efficacious in this specific sub-group of patients.

34.8 Pearls and Pitfalls

- Contraindications.
  - Non-spontaneous–*only intentional* facial motion or residual smile production.
  - Severely spastic incomplete facial paralysis.
  - Recent progression of the paresis or a history of a recent gradual onset of facial paralysis.
  - Incomplete resection of a brain tumor (as cause of paralysis), with an evidence of slow progression of the tumor.
  - Medical status not permitting long anesthesia.
  - Major depression and/or doubt that the patient understands the nature of the procedure and its targets.
  - Unrealistic expectations.
- Special preoperative considerations
  - Be sure that there is a residual facial motion that is spontaneous (not an eye closure motion).
  - Assess whether there is synkinesis or hypertonicity on the affected side.
  - Assure that the patient understands the nature of those long procedures and the long time lag until the final result shows. Assure reasonable expectations of the final results.
- Special intraoperative considerations:
- Assure that the selected branch does not play a major role in orbicularis oculi action.
- Identify more than one residual buccozygomatic branch in order to leave at least one intact branch thus the chance of worsening the preoperative residual function is minimized.
- In cases when only one residual buccozygomatic branch is identified, the nerve is not divided but first dissected longitudinally, split and followed by partial transection leaving a free end that includes part of the nerve fascicles. The reminder of the fascicles is left uninterrupted in the native nerve sheath. The gracilis motor nerve is also split and an end-to-end coaptation is performed between the split end of the donor nerve and one of the free split ends of the gracilis motor nerve. The other split end of the gracilis motor nerve is coapted by end-to-side coaptation to the remaining fascicles of the buccozygomatic nerve that were left uninterrupted.
- Regarding the gracilis muscle—treat the muscle gently and preserve its epimysium. Tailor the muscle to be transferred, to make it as thin, gentle, and long as possible and needed, while not compromising the neurovascular pedicle that penetrates it. Verify muscle contraction after nerve transection, by nerve stimulation on the side table.
- Place the muscle obliquely from the modiolus to the superficial temporal fascia superior to the auricle.
- Vascular anastomoses are preferably performed between the flap pedicle and the ipsilateral superficial temporal vessels. This is in order to avoid dissection of the lower facial zone and thus reduce other residual nerves injury.
- Special postoperative considerations:
  - Immediate extubation, de-catheterization, and operated cheek stenting for protection.
  - Admit the patient to a step down unit for 24 h after surgery.
  - Protect the operated cheek by attaching worning sticker to the cheek and place the designated splint.
  - When motion starts, several months after the procedure, the patient should practice daily, in front of a mirror, to strengthen the muscle action and create more symmetry with the healthy side smile.

References

1. Zuker RM. Facial paralysis and the role of free muscle transplantation. Ann Chir Plast Esthet. 2015;60(5):420–9. https://doi.org/10.1016/j.anplas.2015.06.001.
2. Fattah A, Borschel GH, Zuker RM. Reconstruction of facial nerve injuries in children. J Craniofac Surg. 2011;22:782–8.
3. Fattah A, Borschel GH, Manktelow RT, Bezuhly M, Zuker RM. Facial palsy and reconstruction. Plast Reconstr Surg. 2012;129(2):340e–52e.
4. Hontanilla B, Marre D, Cabello A. Cross-face nerve grafting for reanimation of incomplete facial paralysis: quantitative outcomes using the facial clima system and patient satisfaction. J Reconstr Microsurg. 2014;30(1):25–30.
5. Hohman MH, Hadlock TA. Etiology, diagnosis, and management of facial palsy: 2000 patients at a facial nerve center. Laryngoscope. 2014; 124(7):E283–93.
6. Hontanilla B, Marre D. Masseteric-facial nerve transposition for reanimation of the smile in incomplete facial paralysis. Br J Oral Maxillofac Surg. 2015;53(10):943–8.
7. Frey M, Giovanoli P, Michaelidou M. Functional upgrading of partially recovered facial palsy by cross-face nerve grafting with distal end-to-side neurorrhaphy. Plast Reconstr Surg. 2006;117(2):597–608.
8. Takushima A, Harii K, Okazaki M, Ohura N, Asato H. Availability of latissimus dorsi minigraft in smile reconstruction for incomplete facial paralysis: quantitative assessment based on the optical flow method. Plast Reconstr Surg. 2009;123(4):1198–208.
9. Gur E, Zuker RM, Zaretski A, Leshem D, Barnea Y, Arad E, Yanko R, Meilik B, Kedar DJ, Fliss E. Incomplete facial paralysis: the use of the ipsilateral residual facial nerve as a donor nerve for facial reanimation. Plast Reconstr Surg. 2018;142(1):202–14. https://doi.org/10.1097/PRS.0000000000004536.
10. Lindsay RW, Bhama P, Weinberg J, Hadlock TA. The success of free gracilis muscle transfer to restore smile in patients with nonflaccid facial paralysis. Ann Plast Surg. 2014;73(2):177–82.
11. Wan H, Zhang L, Li D, et al. Hypoglossal-facial nerve "side"-to-side neurorrhaphy for persistent incomplete facial palsy. J Neurosurg. 2014;120(1):263–72.
12. Yoshioka N. Masseteric nerve as "baby sitter" procedure in incomplete facial paralysis. Plast Reconstr Surg Glob Open. 2016;4(4):e669.
13. Gur E, Stahl S, Barnea Y, et al. Comprehensive approach in surgical reconstruction of facial nerve paralysis: a 10-year perspective. J Reconstr Microsurg. 2010;26(3):171–804.
14. Jowett N, Hadlock TA. A contemporary approach to facial reanimation. JAMA Facial Plast Surg. 2015;17(4):293–300.
15. Terzis JK, Noah ME. Analysis of 100 cases of free-muscle transplantation for facial paralysis. Plast Reconstr Surg. 1997;99(7):1905–21.