Sultan Qaboos University Med J, November 2024, Vol. 24, Iss. 4, pp. 534–539, Epub. 27 Nov 24
Submitted 1 May 24
Revision Req. 1 Jul 24; Revision Recd. 20 Jul 24
Accepted 8 Aug 24
https://doi.org/10.18295/squmj.11.2024.074

CLINICAL & BASIC RESEARCH

Dynamic Facial Reanimation for Facial Palsy

The Oman experience

*Sony P. Varghese, Shaikhan N.M. Al Hashmi, Al Anood Al Hadhrami

abstract: ***Objectives:*** The goal of facial reanimation for facial palsy is to restore resting facial symmetry and dynamic facial motion that mirrors the opposite side as closely as possible. This study aimed to evaluate the restoration of oral commissure symmetry at rest and during excursion among patients with facial paralysis treated with free *gracilis* muscle transfer. ***Methods:*** This study included 9 patients who underwent facial reanimation with free *gracilis* muscle transfer at Khoula Hospital, Muscat, Oman, from 2019 to 2022. Children under 14 underwent a 2-stage surgery, while those above 14 underwent single-stage reconstruction. ***Results:*** The average age among the cohorts was 24 years. Overall, 5 cases underwent a 2-stage facial animation, 4 underwent single-stage reconstruction and 1 patient had free flap loss following the free *gracilis* muscle transfer. The mean time for noticing recovery was 3 months postoperatively. Early recovery was noted in patients who underwent single-stage free *gracilis* muscle transfer with motor innervation from the ipsilateral nerve to the masseter compared to the cross-facial nerve transfer. Good patient satisfaction (88.9%) was observed following the procedure. ***Conclusion:*** This study observed earlier recovery in patients who had undergone single-stage free *gracilis* muscle transfer with motor innervation from the ipsilateral nerve to the masseter compared to the cross-facial nerve transfer. The oral commissure symmetry at rest and during excursion among patients with facial paralysis treated with free *gracilis* muscle transfer in Oman was found to be near normal.

Keywords: Facial Palsy; Facial Nerve; Facial Asymmetry; Gracilis Muscle; Free Flap; Oman.

Advances in Knowledge

- *Early recovery was noted in patients who underwent single-stage free gracilis muscle transfer with motor innervation from the ipsilateral nerve to the masseter.*
- *Oral commissure symmetry at rest and during excursion among patients treated with free gracilis muscle transfer in Oman was found to be near normal.*
- *Good patient satisfaction was observed following facial reanimation with free gracilis muscle transfer.*

Applications to Patient Care

- *Adult patients with facial palsy can undergo single-stage facial reanimation surgery.*
- *Free gracilis muscle transfer improves the overall outcome in patients undergoing facial reanimation surgery.*

Facial expressions are an integral part of human emotional expression and social well-being.[1,2] Facial palsy can be caused by infectious, neurologic, congenital, neoplastic, traumatic, systemic and iatrogenic causes.[3] Based on the muscles affected, facial palsy may be categorised as upper motor neuron (UMN) or lower motor neuron (LMN) [Figure 1]. Patients with LMN facial palsy suffer from an ipsilateral inability to elevate the forehead, drooping of the eyebrow, inability to completely close eyelids, loss of nasolabial fold and deviation of angle of mouth to the contralateral side. Patients with partial or complete recovery may have synkinesis, which may involve oral–ocular synkinesis, ocular–oral synkinesis and involuntary mouth movements during voluntary eye closure. Facial nerve regeneration lacks a reliable prognostic indicator for spontaneous recovery.[4] In UMN facial palsy, the forehead muscles are spared due to the bicortical representation, whereas in LMN facial palsy, all the facial muscles are paralysed on the affected side. The extent of the facial palsy can be graded based on the House–Brackmann score, which is graded based on the severity of the facial palsy from 1 to 6, ranging from mild dysfunction to complete paralysis.[5]

Facial paralysis can be categorised based on the duration of facial paralysis as acute facial paralysis (<3 weeks), intermediate duration facial paralysis (3 weeks to 2 years) and chronic facial paralysis (>2 years).[6] Management of facial paralysis entails a combination of pharmacologic therapy, physical therapy for facial neuromuscular retraining and surgical intervention via dynamic and static techniques for facial reanimation.

In acute facial palsy due to traumatic injury, primary tension-free neurorrhaphy provides the best return of facial nerve function. This necessitates the mobilisation of the adjacent facial nerve segments to provide tension-free anastomosis. When the motor

Department of Plastic and Reconstructive Surgery, Khoula Hospital, Muscat, Oman
**Corresponding Author's E-mail: sonypvarghese98@gmail.com*

Figure 1: Preoperative image of a child showing lower motor neuron facial palsy.

end plate on the facial muscle is still viable for patients with facial paralysis of intermediate duration, nerve transfer or cross-facial nerve grafting is performed from the opposite side facial nerve to enhance the activity of the affected muscle.[7] Popular choices for donor nerve grafts include the great auricular nerve, the sural nerve, the medial and lateral antebrachial cutaneous nerves, the thoracodorsal nerve and the superficial radial nerve.[8] The 2-stage babysitter approach introduced by Terzis and Tzafetta involves the coaptation of 40% of the ipsilateral hypoglossal nerve to the facial nerve on the paralysed side with concomitant cross facial nerve graft and subsequent micro-coaptation 8–15 months later.[9] Ipsilateral masseteric nerve can innervate the affected facial nerve from the same side.[10] However, this must be done within 18 months of the initial injury as the motor end plates are degenerated after this time.[11,12]

For patients with longstanding facial paralysis who are not candidates for reinnervation or nerve transfer procedures, the primary surgical options to restore a dynamic smile are temporalis tendon transfer or free *gracilis* muscle transfer using a cross-facial nerve graft or ipsilateral motor branch of masseter muscle as the motor nerve.[13–17] The goal of facial reanimation is to restore resting facial symmetry and dynamic facial motion that mirrors the opposite side as closely as possible. Much focus is directed towards restoring the ability to smile given the documented effects of a smile on emotional expression, facial attractiveness and psychosocial function.[18]

This study aimed to evaluate the restoration of oral commissure symmetry at rest and dynamic commissure excursion among patients with longstanding facial paralysis treated with free *gracilis* muscle transfer at a tertiary care centre in Oman.

Methods

This retrospective study included all the patients treated for congenital or longstanding unilateral facial paralysis with free *gracilis* muscle transfer from August 2019 to December 2022 at Khoula Hospital, Muscat, Oman. The patients underwent a preoperative evaluation including history, physical examination, standardised photography and ancillary testing comprising nerve testing or imaging as indicated. The severity of paralysis was graded according to the House–Brackmann facial grading scale (from I to VI, with VI indicating total paralysis).[5,19] Each of the patients and their families were counselled preoperatively about the procedure, expected duration of time, possible complications, need for re-exploration in the event of vessel thrombosis, recovery period, need for post-surgical muscle stimulation and re-training physiotherapy. All the patients were followed for at least 12 months postoperatively in the facial palsy clinic at Khoula Hospital, Muscat, Oman.

Patients under 14 years of age underwent a 2-stage procedure. Initially, a cross-facial nerve graft was placed from the normal side of the face (sural nerve graft coapted to the buccal branch on the normal side after mapping out other facial nerve branches using intraoperative nerve stimulation) to the affected side, using a sural nerve graft tunnelled through the upper lip. Eye-loading procedure (using gold weight) was also performed at this stage. After 8–10 months, dynamic facial reanimation with free *gracilis* muscle was performed during which the obturator nerve of the *gracilis* muscle was coapted to the cross facial nerve graft.

Patients above 14 years of age underwent single-stage dynamic facial reanimation, where the obturator nerve of the *gracilis* muscle is coapted to the masseteric nerve, which was identified by intraoperative nerve stimulation.

Preoperative images were taken and attached digitally to the patient file to evaluate the extent of postoperative recovery. The measurement was taken from the oral commissure to the temporal *fascia* on the affected site, and the vector of pull was decided for the proper anchorage of the muscle and effective muscle movement to ensure the best facial symmetry while smiling preoperatively. The required length of free *gracilis* muscle with the neurovascular pedicle was harvested from the contralateral thigh, and the flap donor site was closed [Figure 2].

The free *gracilis* muscle was first anchored to the angle of the affected lip at 4 points: 2 upper lips, 1 at the commissure and 1 at the lower lip angles using 1-0 vicryl. Care had to be taken to avoid breach of the

Table 1: Characterisitcs of patients who had dynamic facial reanimation for facial palsy (N = 9).

Gender	Age in years	Aetiology of facial palsy	Number of facial animation stages	Postoperative complications	Clinically noticeable muscle activity after surgery in months	Patient subjective satisfaction
Male	9	Congenital	2	None	4	Satisfied
Male	48	Bell's palsy	1	None	2	Satisfied
Male	35	Bell's palsy	1	None	4	Very satisfied
Female	9	Congenital	2	Wound dehiscence	2	Satisfied
Male	14	Congenital	2	None	3	Satisfied
Male	31	Traumatic	1	None	2	Satisfied
Male	16	Congenital	1	Flap loss	0	Unsatisfied
Female	7	Congenital	2	Wound dehiscence	3	Satisfied
Male	47	Bell's palsy	1	None	3	Satisfied

oral mucosal layer while placing the oral commissure anchorage sutures, as this prevents the spread of infection from the oral cavity to the facial plane. After vascular anastomosis between the recipient site facial artery and facial vein to the free *gracilis* vessels and nerve coaptation between the anterior division of obturator nerve to the recipient site cross facial nerve graft or the nerve to the masseter, the superior part of the *gracilis* muscle was anchored to the temporal fascia with absorbable sutures. The overlying skin was closed with a drain in the chin with absorbable sutures. An hourly Doppler study was conducted to rule out vascular compromise and enable early intervention if there were any features of vessel obstruction. Facial muscle physiotherapy and muscle stimulation were started from the 6th week postoperatively and continued until the 4th–6th month postoperatively. When the ipsilateral nerve to the masseter was used to reanimate the free *gracilis* muscle, retraining of the smile on clenching the teeth was started by the 6th–8th week postoperatively.

Figure 2: Intraoperative image of a harvested free *gracilis* muscle.

Ethical permission was obtained from the research committee of Khoula Hospital, Muscat, Oman (MOH/DGKH/REC/23/27411). Informed written consent was obtained for the collection of clinical data of patients, data analysis and publication of data and images from all participants and guardians.

Results

A total of 9 patients underwent free *gracilis* muscle transfer from 2019 to 2022; 4 were paediatric (44.4%) and the majority were males (77.8%). Congenital facial palsy was found in 5 cases (55.6%), 3 had Bell's palsy (33.3%) and 1 had traumatic facial palsy (11.1%) [Table 1]. Moreover, 5 patients (55.6%) had left-side facial palsy and 4 patients (44.4%) had right-sided facial palsy. None of the adult onset of facial palsy had received steroids after developing the facial palsy. A total of 2 of the adult patients (22.2%) had incomplete recovery after the start of facial palsy, which involves partial eye closure (*orbicularis oculi*) and minimal movement at the angle of the mouth (*orbicularis oris* and *zygomaticus major*). Ocular–oral synkinesis was documented in 1 patient after partial recovery of facial palsy. The mean period before these patients attended the plastic surgery clinic after facial palsy was 14.88 years, due to the high number of neglected cases. This is because many patients were unaware of the treatment options available and some adult patients decided to wait for spontaneous recovery following facial palsy.

A total of 4 patients underwent physiotherapy and 2 patients received muscle stimulation therapy after the onset of facial palsy. Furthermore, 5 patients (55.6%) underwent single-stage facial animation in which the motor nerve of the masseter was used to innervate the free *gracilis* muscle; 4 patients underwent cross-facial nerve grafting followed by second-stage facial reanimation. In all 9 patients, facial reanimation was performed using a free *gracilis* muscle flap. All the patients who received single-stage facial animation were adult patients. There were 4 patients (44.4%) who received upper eyelid gold weight loading for protection of the eye. The average muscle ischaemia time intraoperatively was 117 minutes and the average hospital stay was 11 days. No postoperative complications were noted in most cases (66.7%); however, 1 patient (11.1%) among the single-stage facial reanimation group had flap loss due to infection because of an intra-oral anchoring stitch, which might have occurred during flap inset at the oral commissure. This was managed by debridement and was planned for free muscle transfer from the opposite thigh. In addition, 2 patients (22.2%) developed post-operative partial wound dehiscence that was managed by resuturing. The average follow-up was 13.4 months after surgery.

Muscle stimulation was initiated at 6 weeks postoperatively for all patients, and the mean time for noticing smile recovery was 3 months postoperatively. The postoperative clinical muscle exertion was noted to be better among 4 out of 5 patients (while 1 patient had flap loss) who underwent single-stage facial reanimation. A spontaneous synchronous smile was noted among the 4 patients who underwent the two-stage facial animation. Most of the patients (88.9%) were satisfied with the outcome of the surgery [Figure 3].

Figure 3: Postoperative image of a patient showing reanimated left side of the face.

Discussion

Patients with facial palsy avoid social interaction as their emotions cannot be expressed due to the loss of facial movement. Classification of facial palsy according to time has standardised the treatment in facial palsy patients with good outcomes and patient satisfaction after the procedure. Patients with partial or complete recovery may develop synkinesis, which may grossly interfere with their normal facial movements. Physiotherapy can improve functional recovery and increase the quality of life and psychological well-being of patients suffering from facial palsy.[20–22] Notable physiotherapy techniques include facial exercise, electric stimulation, biofeedback and neuromuscular retraining.[23]

Depending on the aetiology and severity of facial nerve palsy, a management plan is formulated, and ocular protection should be prioritised. Denervation of the *orbicularis oculi* muscle can cause dryness, irritation, a foreign body sensation, epiphora and the long-term risk of corneal ulceration, infections, exposure keratitis and possible vision loss. Lagophthalmos can be corrected by upper eyelid weight loading, lower lid ectropion can be corrected by a lateral or medial canthopexy and tarsal strip suspension and brow lift can be performed to treat brow ptosis.[24,25]

There are static and dynamic procedures to restore the facial function customised for individual patients.[26–29] In congenital facial nerve palsy, reconstruction is aimed at between 3 and 5 years of age. Staged reconstruction with initial cross-facial nerve graft followed by dynamic facial reanimation with free functioning muscle transfer (FFMT) is the procedure of choice.

In acute injuries to the facial nerve following facial trauma, early reconstruction of the facial nerve is warranted if the lacerated end can be identified at the time of debridement and suturing. Optimal results are obtained if the facial nerve is repaired within 3–4 weeks of the initial injury. Facial nerve reconstruction can be performed by direct nerve repair, nerve grafting or nerve transfer (babysitting procedure until the facial nerve graft is ready for coaptation).

In incomplete facial nerve recovery following facial nerve injury, the isolated facial nerve segment involved is reconstructed according to the region involved. For neglected facial palsy, delayed reconstruction is usually carried out with supportive therapy such as botulinum toxin injection to the contralateral (normal) side to reduce the disfigurement of the affected side, static slings or FFMT reconstruction.

For those who undergo a single staged facial reanimation surgery, where the motor nerve to

masseter is coapted to the motor branch of the free *gracilis* on the ipsilateral affected side, teeth clenching is required to initiate a smile on the affected side. Usually, children aged 14 years or above are compliant and can be taught to initiate a smile with teeth clenching on the affected side. In 2-stage facial reanimation surgery, the use of a cross-facial nerve graft for facial reanimation enables the patient to have a spontaneous and synchronous smile. Faria *et al*. found that the presence of 2 nerve coaptations in 2-stage procedures leads to low predictability and consistency of muscle contraction.[30] This finding is consistent with that of the current study, where the strength of muscle exertion is better in the single-stage procedure than in the 2-stage procedure. This can be attributed to the masseter nerve having a greater axonal load than cross-face nerve grafts, resulting in stronger motor innervation.[14,31]

The initial bulk of the free *gracilis* muscle following surgery was found to reduce over 4–6 months following surgery to an acceptable size with good facial symmetry and ample movement of the angle of the mouth during a smile. The vector of pull and the elevation in the angle of the mouth remain unchanged once the initial facial oedema has subsided following surgery. Double innervation of the free *gracilis* muscle can be performed by coapting the motor nerve of the free *gracilis* to the ipsilateral nerve to the masseter till the cross-facial nerve is ready for coaptation.[32] A 2-stage approach is used to reconstruct the facial smile in children, where initially a cross facial sural nerve graft is placed from the normal side to the affected side tunnelled through the upper lip, followed by free *gracilis* muscle transfer once the nerve growth through the tunnelled sural nerve is complete. On the other hand, children above 14 years of age and adults with facial palsy are treated by a single staged surgery.

This study was subject to some limitations. One of the limitations of this study was the small sample size. The results of this study may not be generalisable to all cases of facial palsy. Future studies should include larger sample sizes from multiple centres.

Conclusion

Dynamic facial reanimation following facial nerve palsy remains a challenge as the patients are emotionally affected following facial palsy and the need for complex surgery to restore the facial function adds to their trauma. Classification of facial palsy according to time has standardised the treatment in facial palsy patients with good outcomes and patient satisfaction after the procedure. The use of cross-facial sural nerve graft for facial reanimation or direct coaptation of the motor branch of the free *gracilis* to the nerve to the masseter on the affected side has drastically changed the outcome in restoring smiles. Protection of the eye on the affected side remains the priority in facial palsy as this can avoid vision loss on the affected side. Partial involvement of the nerve or incomplete recovery can be addressed by nerve transfers or patient-specific treatment. In this study, earlier recovery was observed in patients who underwent single-stage free *gracilis* muscle transfer with motor innervation from the ipsilateral nerve to the masseter compared to the cross-facial nerve transfer. The oral commissure symmetry at rest and dynamic commissure excursion among patients with longstanding facial paralysis treated with free *gracilis* muscle transfer in Oman was found to be near normal with good patient satisfaction following the procedure.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

FUNDING

No funding was received for this study.

AUTHORS' CONTRIBUTION

SNMAH conceptualised the study and supervised the work. AAAH collected the data and contacted the patients and their families. SPV designed the study, analysed the data and drafted the manuscript. All authors approved the final version of the manuscript.

ACKNOWLEDGEMENT

We are grateful to all the patients and their families who participated in this study and those who were willing to spread awareness about treatment options for facial palsy in Oman.

References

1. Ishii LE, Godoy A, Encarnacion CO, Byrne PJ, Boahene KDO, Ishii M. What faces reveal: Impaired affect display in facial paralysis. Laryngoscope 2011; 121:e1138–43. https://doi.org/10.1002/lary.21764.
2. VanSwearingen JM, Cohn JF, Turnbull J, Mrzai T, Johnson P. Psychological distress: Linking impairment with disability in facial neuromotor disorders. Otolaryngol Head Neck Surg 1998; 118:e790–6. https://doi.org/10.1016/S0194-5998(98)70270-0.
3. Melvin TA, Limb CJ. Overview of facial paralysis: Current concepts. Facial Plast Surg 2008; 24:e155–63. https://doi.org/10.1055/s-2008-1075830.
4. Hadlock TA, Greenfield LJ, Wernick-Robinson M, Cheney ML. Multimodality approach to management of the paralyzed face. Laryngoscope 2006; 116:e1385–9. https://doi.org/10.1097/01.mlg.0000225980.38147.c6.

5. House JW, Brackmann DE. Facial nerve grading system. Otolaryngol Head Neck Surg 1985; 93:e146–7. https://doi.org/10.1177/019459988509300202.

6. Mehta RP. Surgical treatment of facial paralysis. Clin Exp Otorhinolaryngol 2009; 2:1–5. https://doi.org/10.3342/ceo.2009.2.1.1.

7. Gousheh J, Arasteh E. Treatment of facial paralysis: dynamic reanimation of spontaneous facial expression-apropos of 655 patients. Plast Reconstr Surg 2011; 128:e693–703. https://doi.org/10.1097/PRS.0b013e318230c58f.

8. Renkonen S, Sayed F, Keski-Säntti H, Ylä-Kotola T, Bäck L, Suominen S, et al. Reconstruction of facial nerve after radical parotidectomy. Acta Otolaryngol 2015; 135:e1065–9. https://doi.org/10.3109/00016489.2015.1050604.

9. Terzis JK, Tzafetta K. The "babysitter" procedure: minihypoglossal to facial nerve transfer and cross-facial nerve grafting. Plast Reconstr Surg 2009; 123:e865–76. https://doi.org/10.1097/prs.0b013e31819ba4bb.

10. Bianchi B, Ferri A, Ferrari S, Copelli C, Magri A, Ferri T, et al. Cross-facial nerve graft and masseteric nerve cooptation for one-stage facial reanimation: principles, indications, and surgical procedure. Head Neck 2014; 36:e235–40. https://doi.org/10.1002/hed.23300.

11. Garcia RM, Hadlock TA, Klebuc MJ, Simpson RL, Zenn MR, Marcus JR. Contemporary solutions for the treatment of facial nerve paralysis. Plast Reconstr Surg 2015; 135:1025e–46e. https://doi.org/10.1097/PRS.0000000000001273.

12. Harris BN, Tollefson TT. Facial reanimation: evolving from static procedures to free tissue transfer in head and neck surgery. Curr Opin Otolaryngol Head Neck Surg 2015; 23:e399–406. https://doi.org/10.1097/MOO.0000000000000193.

13. Biglioli F, Colombo V, Tarabbia F, Pedrazzoli M, Battista V, Giovanditto F, et al. Double innervation in free-flap surgery for long-standing facial paralysis. J Plast Reconstr Aesthet Surg 2012; 65:e1343–9. https://doi.org/10.1016/j.bjps.2012.04.030.

14. Klebuc MJA. Facial reanimation using the masseter-to-facial nerve transfer. Plast Reconstr Surg 2011; 127:1909–15. https://doi.org/10.1097/PRS.0b013e31820e9138.

15. Jandali D, Revenaugh PC. Facial reanimation: an update on nerve transfers in facial paralysis. Curr Opin Otolaryngol Head Neck Surg 2019; 27:e231–6. https://doi.org/10.1097/MOO.0000000000000543.

16. Roy M, Corkum JP, Shah PS, Borschel GH, Ho ES, Zuker RM, et al. Effectiveness and safety of the use of gracilis muscle for dynamic smile restoration in facial paralysis: A systematic review and meta-analysis. J Plast Reconstr Aesthet Surg 2019; 72:e1254–64. https://doi.org/10.1016/j.bjps.2019.05.027.

17. Lindsay RW, Bhama P, Hadlock TA. Quality-of-life improvement after free gracilis muscle transfer for smile restoration in patients with facial paralysis. JAMA Facial Plast Surg 2014; 16:e419–24. https://doi.org/10.1001/jamafacial.2014.679.

18. Dey JK, Ishii M, Boahene KD, Byrne PJ, Ishii LE. Changing perception: Facial reanimation surgery improves attractiveness and decreases negative facial perception. Laryngoscope 2013; 124:e84–90. https://doi.org/10.1002/lary.24262.

19. Reitzen SD, Babb JS, Lalwani AK. Significance and reliability of the House-Brackmann grading system for regional facial nerve function. Otolaryngol Head Neck Surg 2009; 140:154–8. https://doi.org/10.1016/j.otohns.2008.11.021.

20. Vaughan A, Gardner D, Miles A, Copley A, Wenke R, Coulson S. A systematic review of physical rehabilitation of facial palsy. Front Neurol 2020; 11:222. https://doi.org/10.3389/fneur.2020.00222.

21. Volk GF, Steinerstauch A, Lorenz A, Modersohn L, Mothes O, Denzler J, et al. Facial motor and non-motor disabilities in patients with central facial paresis: A prospective cohort study. J Neurol 2019; 266:e46–56. https://doi.org/10.1007/s00415-018-9099-x.

22. Wamkpah NS, Jeanpierre L, Lieu JEC, Del Toro D, Simon LE, Chi JJ. Physical therapy for iatrogenic facial paralysis: A systematic review. JAMA Otolaryngol Head Neck Surg 2020; 146:1065–72. https://doi.org/10.1001/jamaoto.2020.3049.

23. Novak CB. Rehabilitation strategies for facial nerve injuries. Semin Plast Surg 2004; 18:47–52. https://doi.org/10.1055/s-2004-823123.

24. Crawford KL, Stramiello JA, Orosco RK, Greene JJ. Advances in facial nerve management in the head and neck cancer patient. Curr Opin Otolaryngol Head Neck Surg 2020; 28:235–40. https://doi.org/10.1097/MOO.0000000000000641.

25. Kim IA, Wu TJ, Byrne PJ. Paralytic Lagophthalmos: Comprehensive approach to management. Curr Otorhinolaryngol Rep 2018; 6:e311–17. https://doi.org/10.1007/s40136-018-0219-z.

26. Udagawa A, Arikawa K, Shimizu S, Suzuki H, Matsumoto H, Yoshimoto S, et al. A simple reconstruction for congenital unilateral lower lip palsy. Plast Reconstr Surg 2007; 120:238–44. https://doi.org/10.1097/01.prs.0000264062.64251.10.

27. Hayashi A, Yoshizawa H, Natori Y, Suda S, Mochizuki M, Nishimuta Y, et al. Assessment of T-shape double fascia graft for lower lip deformity from facial paralysis: A questionnaire survey. J Plast Reconstr Aesthet Surg 2016; 69:e427–35. https://doi.org/10.1016/j.bjps.2015.10.032.

28. Watanabe Y, Sasaki R, Agawa K, Akizuki T. Bidirectional/double fascia grafting for simple and semi-dynamic reconstruction of lower lip deformity in facial paralysis. J Plast Reconstr Aesthet Surg 2015; 68:321–8. https://doi.org/10.1016/j.bjps.2014.10.044.

29. Jowett N, Hadlock TA. Free gracilis transfer and static facial suspension for midfacial reanimation in long-standing flaccid facial palsy. Otolaryngol Clin North Am 2018; 51:129–39. https://doi.org/10.1016/j.otc.2018.07.009.

30. Faria JC, Scopel GP, Busnardo FF, Ferreira MC. Nerve sources for facial reanimation with muscle transplant in patients with unilateral facial palsy: clinical analysis of 3 techniques. Ann Plast Surg 2007; 59:87–91. https://doi.org/10.1097/01.sap.0000252042.58200.c3.

31. Coombs CJ, Ek EW, Wu T, Cleland H, Leung MK. Masseteric-facial nerve coaptation--an alternative technique for facial nerve reinnervation. J Plast Reconstr Aesthet Surg 2009; 62:1580–8. https://doi.org/10.1016/j.bjps.2008.05.046.

32. Cardenas-Mejia A, Covarrubias-Ramirez JV, Bello-Margolis A, Rozen S. Double innervated free functional muscle transfer for facial reanimation. J Plast Surg Hand Surg 2015; 49:183-8. https://doi.org/10.3109/2000656X.2014.988218.