OPEN

PRS GLOBAL OPEN

ORIGINAL ARTICLE

Pediatric/Craniofacial

Blink Restoration in Long-standing Facial Paralysis: Use of Free Neurovascular Platysma Transfer

Paul J. Guelinckx, MD, PhD

Background: Since 2004, microneurovascular platysma transfer has been used for dynamic eye closure in long-standing facial palsy. The idea was initially presented by Lee and Terzis in 1984 but abandoned owing to its transfer difficulty. This muscle transfer allows forceful closure and blink restoration.

Methods: This study included 24 patients operated between 2004 and 2014 for long-standing facial palsy. In the first step of the procedure, a cross-facial nerve graft was employed to transfer the motor nerve fibers from the normal side to the paralyzed side responsible for eye closure. Simultaneously, a dynamic reanimation of the mouth was conducted. After 9 months, a 4×9-cm platysma was transferred on its neurovascular pedicle. Revascularization was performed on the temporal vessels. Nerve coaptation between the cross-facial nerve graft and motor nerve of the platysma was also performed.

Results: Twenty-one (88%) newly reconstructed orbicularis oculis displayed a good to excellent function. In 62% of the patients, a natural appearance and closure of the previously paralyzed eye and a return of spontaneous blinking were observed.

Conclusions: Compared with classical techniques (eg, gold weight implantation and temporalis transfer), platysma transfer is the only feasible method of restoring eye closure because of its special architecture and fiber-type distribution. *(Plast Reconstr Surg Glob Open 2018;6:e1939; doi: 10.1097/GOX.0000000000001939; Published online 22 October 2018.)*

INTRODUCTION

The principal rule of "like with like" has been a gold standard in plastic surgery and continues to be an important guide. Therefore, the damaged and atrophied muscles in long-standing facial paralysis should be replaced by a transfer that has a similar structure and function as the original muscles. Lee and Terzis[1] understood this principle in 1984 when they first described the reconstruction of the paralyzed eye sphincter using the contralateral platysma as a neurovascular transfer in combination with a cross-facial nerve graft (CFNG). This concept was revolutionary at that time but was not followed by many surgeons because of its difficult surgical technique.[2,3] Three muscles in the face were proposed to replace the orbicularis sphincter muscle, that is, frontalis, occipitalis, and platysma. Their same embryological origin, fine motor unit organization, and thin parallel-fibered architecture made all of them the most suitable for eye sphincter reconstruction.

The functional outcomes of the microneurovascular platysma in combination with a CFNG to restore eye closure and blink are rarely reported; only 4 cases were reported by Terzis and Karypidis.[4] The anatomical dissection in the procedure is complex, and the great effort to restore blink frightened many surgeons and patients. Biglioli et al.[5] reported the use of an avascular piece of the platysma in combination with a CFNG to restore blink. Only the upper eyelid sphincter was restored, and spontaneous revascularization was essential. No other study is available to support the initial report of Terzis and to highlight the unique qualities of the platysma as a neosphincter of the eye. The aim of this study was to describe the functional outcomes of the first 24 surgeries performed by the author between 2004 and 2014 and to suggest some simplifications of the different surgical steps.

From the Department of Plastic and Reconstructive Surgery, Jezza ZH, Hasselt, Belgium.

Received for publication April 12, 2018; accepted July 18, 2018.

DOI: 10.1097/GOX.0000000000001939

Disclosure: *The author has no financial interest to declare in relation to the content of this article. The Article Processing Charge was paid for by the author.*

Supplemental digital content is available for this article. Clickable URL citations appear in the text.

METHODS

Since 2004, 24 cases of facial paralysis were selected for dynamic eye blink reconstruction. Both developmental and long-standing palsies were included. More female than male patients were considered for surgery (Table 1). During the first consultation, the patients were generally informed that the ultimate goal was a natural, dynamic, emotional reanimation of the total face. Information regarding the concept of "simple eye closure" and "blink restoration" was also provided. Blink is defined as the rapid eyelid movement to moisturize the globe and to clean the eyeball surface and is usually involuntary; eye closure is generally voluntary and forceful. The patients or their parents provided informed consent concerning the applied method of reconstruction, amount of interventions, complications, and possibility that the transplanted muscle may not contract. Guarantees were not provided, and 100% symmetry was excluded from the possible outcomes. The etiology of the patients' condition and demographics are presented in Table 1. There was no limitation in age, and the oldest patient included was aged 63 years. Nearly all of the patients with acquired facial palsy had a previous surgery in other units (Table 1).

Surgical Procedure

The procedure is always performed in 2 steps. The first step is the CFNG for the eye, which is conducted at the same site of the muscle transfer for smile reconstruction in adults or during the CFNG for the mini-gracilis in children to elevate the modiolus of the mouth.

All procedures were performed through a facelift incision with extension in the temporal hair and submandibular crease to reach the facial vessels. The most critical and demanding part in the entire procedure was the selection of the donor branches for the CFNG for the eye. As any downgrading of normal eye function would be unacceptable, we selected one branch for forceful closure of the upper eyelid together with one-half branch of the preseptal portion of the upper eyelid for blink (Fig. 1). Intraoperative stimulation was mandatory, and leaving at least 60% of the branches for normal eye closure and blink was a golden rule. End-to-end or end-to-side coaptation using 11-0 nylon may occur owing to the small size of the facial nerve fascicles.[6,7] The sural nerve graft was placed supraorbitally in an orthodromic manner. This was performed early in the procedure while the surgeon was focused and the facial nerve has not yet been undercooled. The rest of the procedure for reanimation of the mouth was continued afterward, which was less demanding (Fig. 1).

Table 1. Patient Demographics and Cause of Facial Palsy

Patient demographics	
Sample size, N	24
Male, N (%)	6 (25)
Age, mean ± SD (minimum–maximum)	29.6±5.4 (4–63)
Cause of facial palsy	
Develpmental, N (%)	10 (42)
Posttumorextirpation, N (%)	11 (46)
Bell palsy, N (%)	2 (8)
Traumatic, N (%)	1 (4)

The second part of the operation is performed at least 9 months later and involves the platysma transfer. The ingrowth of the axons to the CFNG of the eye was followed up clinically with the Tinel's sign and confirmed at 9–12 months via nerve conduction studies, if possible. In children, this examination remains difficult. Before planning the platysma transfer, its function was tested on the normal side via clinical inspection. Under general anesthesia, and while the patients were in the supine position, we started dissecting the temporal vessels on the paralyzed side through the previous facelift incision. The CFNG for the eye, which was marked using a blue 6-0 nylon, was easily found at the back on the temporal area. The plane of the facelift incision was continued until the lateral canthus and then joined with the eyelid incisions. A careful dissection under the skin in the pretarsal plane was performed to receive the muscle transplant. Medially, the canthal ligament was identified to fix the neosphincter (Fig. 1).

In the neck area, a 6-cm incision 2 cm below the mandibular border allowed the full dissection of the platysma until the clavicle. The anterior surface was freed from the skin from the mandibular border until the clavicle using a light retractor. The distal insertion was sharply transected using scissors, and hemostasis was achieved using a bipolar pincet. Two transfixing sutures helped elevate the thin platysma from the underlying tissues from caudally to cranially. The facial artery and vein were clipped off above the mandibular border and followed downwards until the branches to the platysma were identified.[1] No attempt was made to isolate the perforating artery and vein; instead, the facial vessels were followed towards their origin to lengthen the pedicle. The submandibular salivary gland was pushed aside, and the motor nerve to the platysma was isolated on the lateral border using electrical stimulation. This small nerve was followed until it branched off from the marginal mandibular branch of the facial nerve. Depression in the lower lip was preserved, except when its ablation helped restore better symmetry in the lower lip region. Before dividing the pedicle, the motor endplate zone was determined in the muscle, and bleeding from the distal end of the platysma was checked; the parallel-fibered architecture allowed splitting of the distal part of the muscle without impairing the blood supply or neural input. Thereafter, the vascular pedicle was divided close to its origin in such a way that it was long enough to reach the receptor temporal vessels with a decent diameter of ≥ 1 mm.[8,9]

The platysma was transferred from the normal side to the paralyzed eye and revascularized. The 2 muscle slips were trimmed down to a width of 9 mm to fit into the preseptal portion of the upper and lower eyelids and then anchored to the medial canthal ligament. Care was taken to place the neosphincter in a flat position around the eye as in the original orbicularis muscle. It was essential to avoid too much muscle bulking in the upper eyelid to hamper normal levator function. One large piece of the normal platysma was sent for histochemistry and fiber-type identification.[10]

Reinnervation of the transferred platysma was critical; the distal end of the CFNG was sent for frozen section

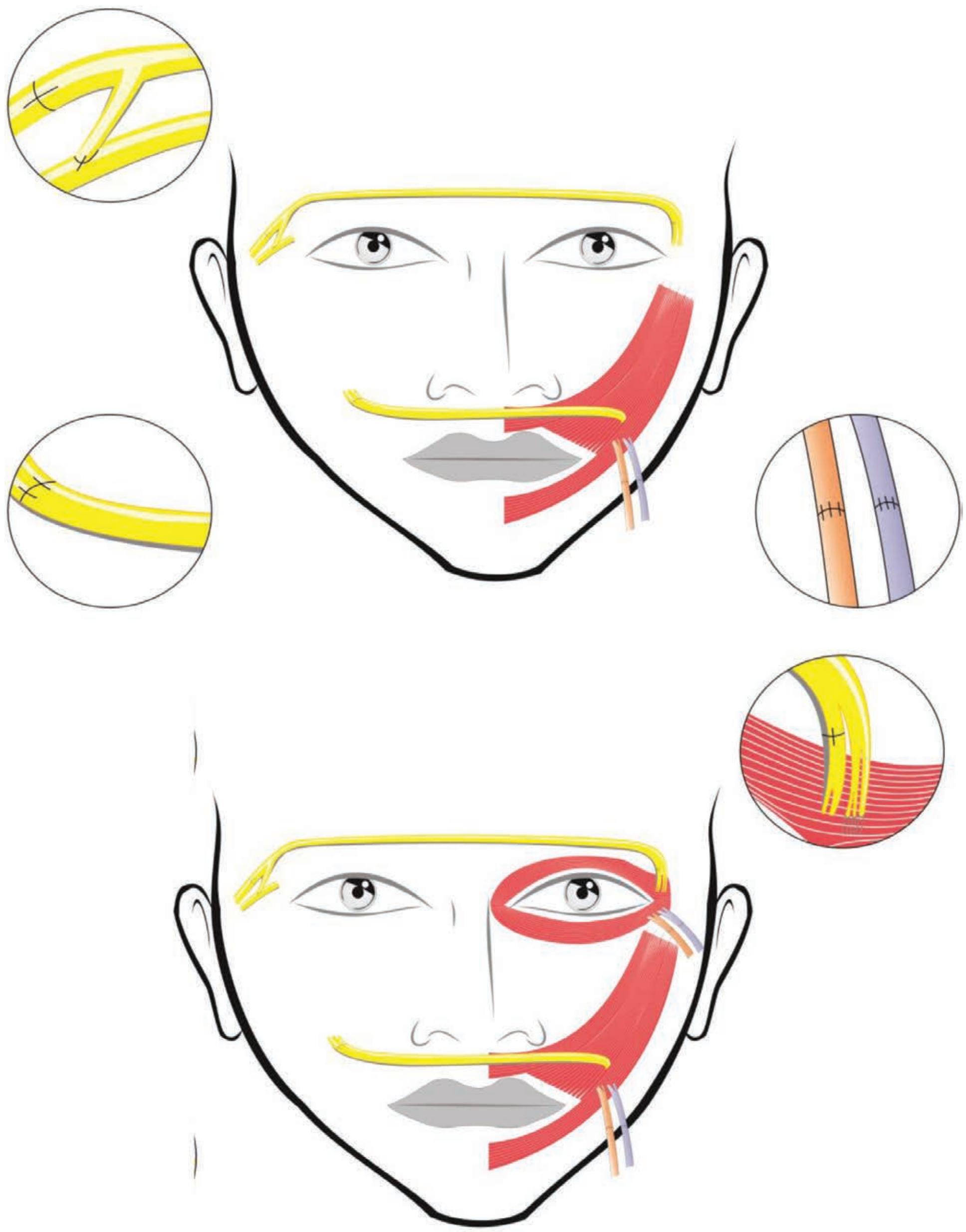

Fig. 1. Illustration of our current emotional dynamic facial reanimation concept. In the first phase (A), a cross-facial nerve grafting for the eye was performed with a mini-gracilis transfer using the long obturator nerve to the normal contralateral zygomaticus branch of the facial nerve. In the second phase (B), the microneurovascular platysma was transplanted and revascularized on the temporal vessels. Direct nerve coaptation between the CFNG and the motor branch of the platysma was performed with direct muscle neurotization.

to check for viable axons. One nerve fascicle with good mushrooming was coapted to the single nerve fascicle of the platysma; the rest of the CFNG was split in its different fascicles and directly implanted to the motor point of the platysma to maximize direct muscle neurotization (Fig. 2). The surgical area was rinsed using warm saline solution, and a drain was left in place with a safe distance to the vessels. Antibiotics were administrated for 24 hours according to the patients' body weight. Doppler examination was routinely performed once a day to evaluate the vascular anastomoses.

The patients stayed ~2 days in our hospital for controlling swelling and relieving pain and were clinically followed up at 3 weeks and 3, 6, 9, and 12 months for eye closure and blink restoration. As soon as reinnervation started, the patients were encouraged to exercise their neosphincter every day. At 16 months, the final outcomes of all platysma were evaluated by an independent group of four individuals who scored the videos recorded preoperatively and postoperatively according to the protocol of Terzis and Bruno.[11] Normal opening and full closure of both eyes of all patients were video-

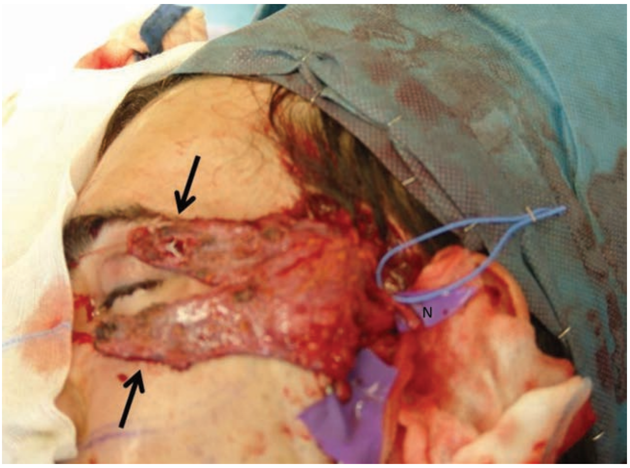

Fig. 2. The platysma was revascularized on the temporal vessels deep into the parotid gland to obtain an adequate diameter of the donor vessels. The parallel-fibered platysma was split into 2 parts distally to the motor endplate zone and reduced to 9-mm muscle slips (see arrows). The thin motor branch was coapted to the CFNG conducted 9 months before. The volume of the platysma was 2.3 g.

taped using a digital camera. Thereafter, the patients were asked to blink their eyes deliberately for ≥ 5 times. The preoperative and postoperative images were scored by 3 independent evaluators; none of the reviewers were involved in the surgery or knew the surgical history of the patients. The mean scores were calculated using the scoring system of Terzis and Bruno[11] and statistically analyzed using a paired t test. Significance was accepted at P values of < 0.05.

RESULTS

Twenty-one (88%) newly reconstructed orbicularis oculis displayed a good (grade 4) to excellent (grade 5) function (Figs. 3, 4). One of the most striking outcomes of the platysma transfer was the natural appearance and closure of the previously paralyzed eye and the return of spontaneous blinking in 62% of the patients. These patients had disappearance of eye lubrication, possibility to walk under the sun without wearing sunglasses, and ability to run against the direction of the wind. Six patients were able to close their eyes nearly completely (grade 4), but did not regain the fast blink reflex. The eye sphincter muscles of only 3 patients did not function at all and were replaced by a mini-temporalis transfer. The donor-site morbidity was excellent.

From among the 24 microneurovascular platysma transfers, none required revision for vascular problems, except for 2 because of an excessive muscle bulk in the upper eyelid hampering normal levator function (Table 2). Only 1 improved following muscle volume reduction in the upper eyelid under local anesthesia.

The blink scores significantly increased from 1.8 ± 0.4 preoperatively to 3.75 ± 1.1 postoperatively ($P < 0.005$). None of the patients experienced any downgrading in their eye function on the normal side.

DISCUSSION

Microneurovascular platysma transfer, as originally described by Lee and Terzis[1] in 1984, is the only possible dynamic method of restoring eye closure and blink. Eye blink is emotionally linked to the brain as it is driven by the contralateral side of the facial nerve. The platysma is similar to the orbicularis oculi in terms of the fiber-type distribution (Fig. 5) and embryological origin; the principle of "like with like" can be applied herein.[12]

This study is the first and largest case series on the systematic use of the microneurovascular platysma as a neosphincter for eye closure and blink restoration in long-standing or developmental facial palsy.[13] The results support those of Lee and Terzis[1] that this small microneurovascular unit functions in 85% of cases in combination with a CFNG of the eye; this is probably the only possible method of restoring a dynamic emotional blink. Although it is a complex reconstruction method and requires a great surgical effort and long surgical time, it is the only technique that allows restoration of a natural physiological eye sphincter, which can withstand wind, sunlight, and other weather conditions. Neither the temporalis transfer nor gold weight implant or any other muscle transfer is at par to this type of reconstruction because of the lack of spontaneity.[14,15] The secret lies in the small motor unit organization typical for all facial expression muscles. The similar embryological origin of the platysma and orbicularis oculi[12] is the most plausible explanation together with the innervation source of the contralateral eye. Both eyes adapt to the degree of aperture and closure to each other owing to the CFNG.

This platysma neosphincter technique presents a complex challenge for reconstructive surgeons and includes several difficult steps. The most critical part remains the selection and sacrifice of the ocular branches of the facial nerve to reinnervate the CFNG. No patients had a downgrading of the normal blink after the initial step of the CFNG, indicating that we used the optimal quantity of donor nerves to allow growth across the face. No previous data on the amount of nerve fascicles to be sacrificed and the functional outcome of muscle transplants are available.[16] Another surgical challenge is to avoid damaging the small arterial and venous branches of the facial vessels towards the platysma. This is overcome by dissecting the facial vessels above the mandibular border and dividing them there. The facial vessels are then followed proximally as long as possible without searching for the small perforating branches, leaving the submandibular gland in place and facilitating the anastomosis with temporal vessels with a sufficient diameter. Terzis and Anesti[17] performed the transfer based on the perforator vessels, which make the transfer riskier for vascular thrombosis; this was not observed in our 24 subjects. Another problem is the discrepancy in size between the CFNG and the small motor branch to the platysma. This size difference is overcome by coapting only 1 fascicle to the motor branch of the platysma and by directly implanting the rest of the CFNG to the eye neosphincter; this so-called direct muscle neurotization was frequently applied in improving facial movements.[18,19]

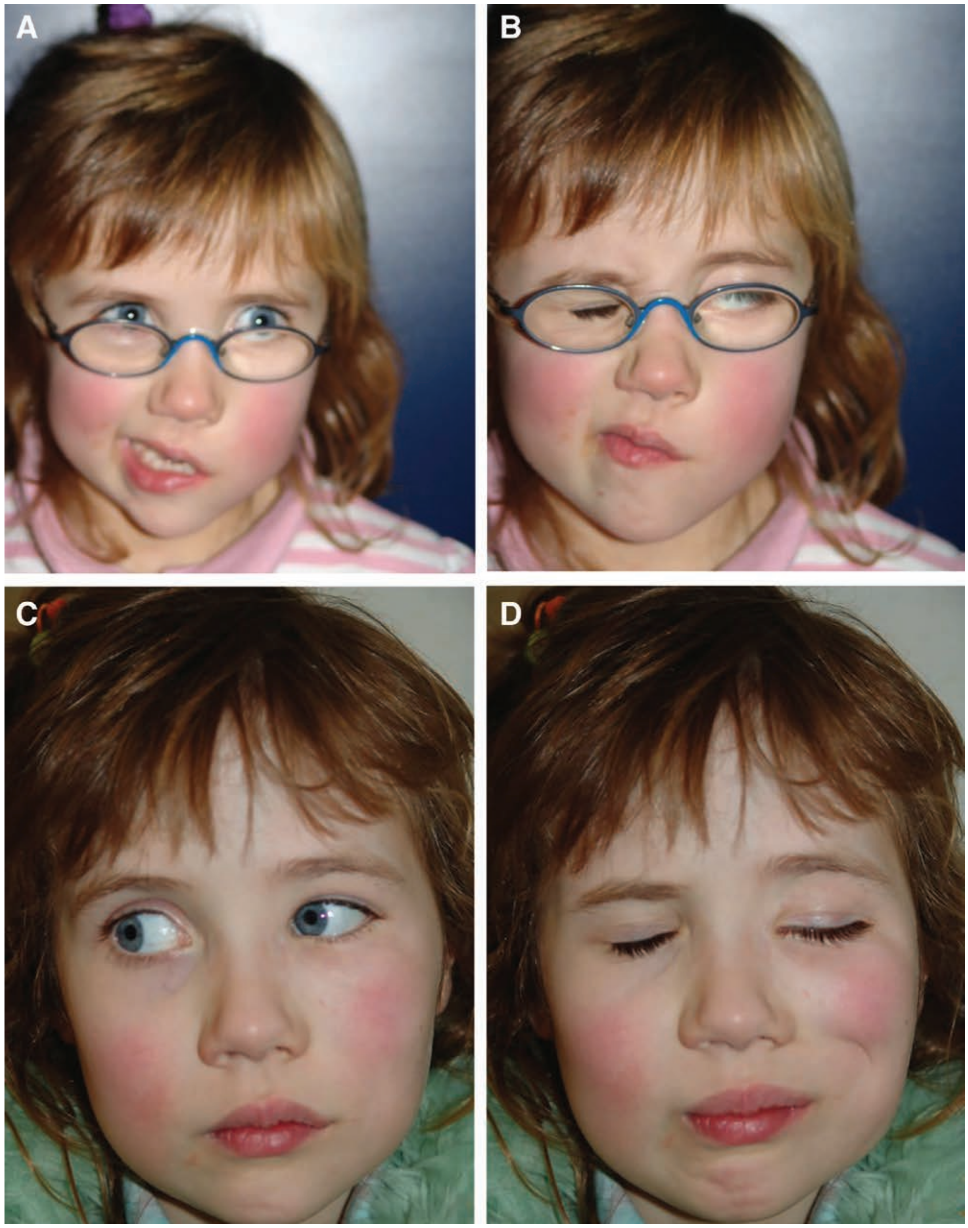

Fig. 3. Pre- (A and B) and postoperative (C and D) images of a young girl with developmental facial palsy. She was operated at the age of 5 years, and the outcomes 2 years later are shown in C and D. The pre- and postoperative scores for blinking were 2 and 5, respectively. There were restoration of symmetry in the mouth at rest and small dimpling in the cheek during eye closure.

If the microneurovascular platysma fails, it constitutes a great disappointment for the patient and surgeon. Three patients showed no clinical and electromyographical improvement in their eye sphincter after 18 months. The major reason was the lack of reinnervation by the CFNG; this should not be attributed to revascularization problems as Doppler signs were present in all cases. Biglioli et al.[5] even grafted nonvascularized rectangles of the platysma around the eye and claimed that neovascularization would take place within a few days. Although the face provides the ideal vascular bed for the platysma as a free graft, we believe that muscle transplants above 1 g should be used with microneurovascular repair.[20,21] Muscle regeneration from satellite cells is poor in human beings, and better reinnervation of the muscle occurs via nerve coaptation than direct muscle neurotization.[21,22]

Although we used the platysma for restoring eye closure in patients aged 5–64 years, we believe that this complex technique should preferably be reserved for patients aged < 40 years. Larger case series are needed to make stronger recommendations. However, owing to the rarity of this surgery and the short follow-up duration, building a large case series with a sufficient statistical power is a lengthy process.

The 2-step procedure is complex and stressful for microsurgeons but easily tolerated by patients. This last one considers it as a lifelong investment, and all patients would

Fig. 4. Pre- (A and B) and postoperative (C and D) images of a 39-year-old woman after acoustic neuroma resection. Before her platysma transfer, she underwent gold weight implantation (see arrow) and had a CFNG. She underwent surgery because of the visibility of the implant and a wish to have a blink. After 1.5 years, a good smile and a blink score of 4 were achieved as shown in C and D.

Table 2. Results from Surgery

Different Outcomes	Cases of Total Sample (N = 24), N (%)	Comments
Eye closure (grade 4–5)	21 (87)	
Blink	15 (62)	
Microvascular revision	0 (0)	
Inadequate function of platysma as eye sphincter	3 (12.5)	Turned over to mini-temporalis transfer
Overweight of platysma muscle in upper eyelid	2 (8.3)	Corrected under local anesthesia
No need for eye lubrication after platysma transfer	12 (50)	

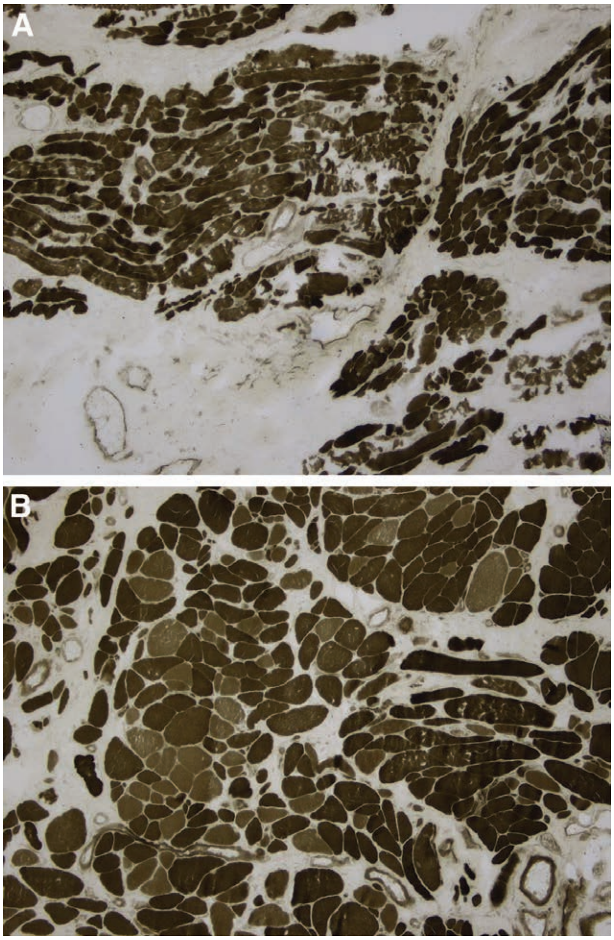

Fig. 5. Histochemistry (ATPase 9.4×100) of a cross-sectional biopsy of the normal orbicularis (A) and platysma (B) before transfer. The figure shows the predominance of type 2 fibers and similarity in the fiber-type composition.

Video Graphic 1. See video, Supplemental Digital Content 1, which displays the postoperative blink in a young girl with developmental facial palsy as presented in Fig. 3, ***http://links.lww.com/PRSGO/A868***.

Video Graphic 2. See video, Supplemental Digital Content 2, which displays the postoperative blink in an adult woman after acoustic neuroma resection as presented in Fig. 4, ***http://links.lww.com/PRSGO/A869***.

undergo the surgery again despite the uncertain outcome. Patients who have seen videos of the blink restoration are strongly motivated to undergo this procedure as the donor morbidity of the platysma is low, and it has an 80% success rate (**see video, Supplemental Digital Content 1**, which displays the postoperative blink in a young girl with developmental facial palsy as presented in Fig. 3, ***http://links.lww.com/PRSGO/A868***; **see video, Supplemental Digital Content 2**, which displays the postoperative blink in an adult woman after acoustic neuroma resection as presented in Fig. 4, ***http://links.lww.com/PRSGO/A869***). This mini-muscle transfer is a powerful tool in the armamentarium of reconstructive surgeons and should, therefore, be reserved for a dedicated and well-trained team.

CONCLUSIONS

In patients with facial palsy, absence of eye closure and blink markedly hampers their functioning. Therefore, one of the most important goals is to restore dynamic and emotional eye closure. This can only be achieved in long-standing facial palsy via newly inbring of the motor nerve and an adequate vascularized muscle. The platysma revascularized on the facial vessels and reinnervated by a CFNG can replace the denervated original orbicularis oculi. In this study, 87% of the patients had adequate eye closure, and 62% showed blink restoration, indicating that the platysma can optimally replace the sphincter muscle of the eye.

Paul J. Guelinckx, MD, PhD
Department of Plastic and Reconstructive Surgery
Jessa ZH, Campus Salvator, Salvatorstraat 20
3500 Hasselt, Belgium
E-mail: pauljulien.guelinckx@jessazh.be

REFERENCES

1. Lee KK, Terzis JK. Reanimation of the eye sphincter. In: Portmann M, ed. *Proceedings of the Fifth International Symposium on the Facial Nerve*, Bordeaux, FRANCE; September 3–6, 1984. New York: Masson Publishing; 1985:119–131.
2. Hohman MH, Hadlock TA. Etiology, diagnosis, and management of facial palsy: 2000 patients at a facial nerve center. *Laryngoscope*. 2014;124:E283–E293.
3. Frigerio A, Heaton JT, Cavallari P, et al. Electrical stimulation of eye blink in individuals with acute facial palsy: progress toward a bionic blink. *Plast Reconstr Surg*. 2015;136:515e–523e.
4. Terzis JK, Karypidis D. Blink restoration in adult facial paralysis. *Plast Reconstr Surg*. 2010;126:126–139.

5. Biglioli F, Zago M, Allevi F, et al. Reanimation of the paralyzed lids by cross-face nerve graft and platysma transfer. *J Craniomaxillofac Surg*. 2017;S1010-5182:30454–30457.
6. Terzis JK, Tzafetta K. Outcomes of mini-hypoglossal nerve transfer and direct muscle neurotization for restoration of lower lip function in facial palsy. *Plast Reconstr Surg*. 2009;124:1891–1904.
7. Viterbo F, Romão A, Brock RS, et al. Facial reanimation utilizing combined orthodromic temporalis muscle flap and end-to-side cross-face nerve grafts. *Aesthetic Plast Surg*. 2014;38:788–795.
8. Terzis JK, Anesti K. Novel use of platysma for oral sphincter substitution or countering excessive pull of a free muscle. *J Plast Reconstr Aesthet Surg*. 2013;66:1045–1057.
9. Hurwitz DJ, Rabson JA, Futrell JW. The anatomic basis for the platysma skin flap. *Plast Reconstr Surg*. 1983;72:302–314.
10. Goodmurphy CW, Ovalle WK. Morphological study of two human facial muscles: orbicularis oculi and corrugator supercilii. *Clin Anat*. 1999;12:1–11.
11. Terzis JK, Bruno W. Outcomes with eye reanimation microsurgery. *Facial Plast Surg*. 2002;18:101–112.
12. Grenier J, Teillet MA, Grifone R, et al. Relationship between neural crest cells and cranial mesoderm during head muscle development. *PLoS One*. 2009;4:e4381.
13. Terzis JK, Karypidis D. The outcomes of dynamic procedures for blink restoration in pediatric facial paralysis. *Plast Reconstr Surg*. 2010;125:629–644.
14. Labbé D, Huault M. Lengthening temporalis myoplasty and lip reanimation. *Plast Reconstr Surg*. 2000;105:1289–97; discussion 1298.
15. Terzis JK, Olivares FS. Use of mini-temporalis transposition to improve free muscle outcomes for smile. *Plast Reconstr Surg*. 2008;122:1723–1732.
16. Terzis JK, Wang W, Zhao Y. Effect of axonal load on the functional and aesthetic outcomes of the cross-facial nerve graft procedure for facial reanimation. *Plast Reconstr Surg*. 2009;124:1499–1512.
17. Terzis JK, Anesti K. Developmental facial paralysis: a review. *J Plast Reconstr Aesthet Surg*. 2011;64:1318–1333.
18. Terzis JK, Karypidis D. Outcomes of direct muscle neurotisation in adult facial paralysis. *J Plast Reconstr Aesthet Surg*. 2011;64:174–184.
19. van Veen MM, Dijkstra PU, Werker PMN. A higher quality of life with cross-face-nerve-grafting as an adjunct to a hypoglossal-facial nerve jump graft in facial palsy treatment. *J Plast Reconstr Aesthet Surg*. 2017;70:1666–1674.
20. Guelinckx PJ, Dom R, Bex M, et al. Rectus femoris muscle grafts performed with and without vascular anastomosis: an experimental study in the rabbit. *Br J Plast Surg*. 1984;37:584–595.
21. Frey M, Gruber H, Holle J et al. Experimental an experimental comparison of the different kinds of muscle reinnervation: nerve suture, nerve implantation and muscular neurotisation. *Plast Reconstr Surg*. 1982;69:656–667.
22. Carlson BM, Faulkner JA. The regeneration of skeletal muscle fibers following injury: a review. *Med Sci Sports Exerc*. 1983;15:187–198.