Masseteric cooptation and cross-facial nerve grafting: Is it still applicable 22 months after the onset of facial palsy?

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Short Title: Facial nerve cooptation for longstanding palsies.

Abstract

Background. Eighteen months is usually considered the cutoff time within which recovery of the mimic muscle remains possible using facial nerve cooptation. Few reports on the use of cooptation after this interval have appeared. Purpose of this study is to investigate the feasibility of this procedure also after 22 months.

Methods. Six patients treated via cross-facial nerve grafting between healthy and paralyzed middle and middle-upper facial nerve branches and masseteric cooptation of the main trunk of the paralyzed facial nerve between 20-24 months after the onset of palsy were analyzed. Population consisted of two males and four females ages 8–42 years (mean 24 years). Facial palsy developed after acoustic neuroma resection in three patients, after the removal of a cerebellopontine angle astrocytoma in one, and as a consequence of Bell's palsy or cerebral hemorrhage in the other two (one each). House-Brackman and Sunnybrook clinical evaluation systems and FDI questionnaire were used to assess results.

Results. House-Brackman scores changed from VI before the operation for all patients to II for two patients and III for four patients. Sunnybrook scores were 0–10 before the operation but 62–84 at the last visit. Mean FDI scores moved from 24 to 38.5 meaning a statistical high significant improvement ($p < 0.01$).

Conclusions. Masseteric/cross-facial nerve grafting is feasible for patients with palsies 20–24 months in duration, affording satisfactory functional and esthetic results and a dramatic improvement in quality of life.

Key Words: Facial palsy, Masseteric nerve cooptation, Cross-facial nerve grafting, Facial animation, Facial nerve

Introduction

Facial palsy is severely disabling, and the associated functional, psychological, and esthetic impairments deeply impact quality of life. Palsies may be classified by the involved side (unilateral or bilateral), by severity (complete or incomplete), or by etiology (congenital or acquired). However, from a clinical viewpoint, the most important factor is the duration of the condition. Palsies are usually divided into recent palsies (0–18 months in duration) and established palsies (>18 months in duration or congenital palsies)[1]. Duration is critical because treatment options differ greatly by time. In those with recent palsies, recovery of the facial mimic muscles is possible, and facial nerve cooptation techniques are used to this end. Conversely, in patients with congenital or established palsies, muscle recovery may not be possible because of muscle atrophy and denervation. Neuromuscular transplants or temporalis muscle transfers are usually performed on such patients to reanimate the impaired side of the face[2].

Although it is widely recognized that palsy duration greatly affects treatment choices, the exact cutoff between cooptation and muscle substitution remains unclear. In particular, the interval 18–24 months after the onset of palsy is considered a gray area, and to the best of our knowledge no reports that focus on this time have yet appeared. This interval is thus of great interest to surgeons doing facial palsy reconstruction. The surgical choices made have major implications for patients in terms of procedural burden, morbidity, expected results, and postoperative recovery and rehabilitation[3,4]. Thus, we explored whether facial cooptation, which usually affords good results after a rather gentle procedure and which is associated with easy postoperative rehabilitation because the native facial mimic structures recover, remains possible in this interval. We explored whether the extent of recovery and improvement in quality of life justify the use of this approach at such a late time.

Patients and Methods

Patients treated between January 2009 and May 2016 at the Facial Nerve Center (Maxillo-Facial Surgery Division) of the University Hospital of Parma were retrospectively reviewed. All included patients had unilateral facial palsy and underwent single-stage cross-facial nerve grafting with masseteric nerve cooptation >20 months after the onset of palsy. As the work was retrospective in nature, institutional review board approval was not required. Our report is written in accordance with the relevant guidelines of the Helsinki Declaration.

Our study population consisted of two males and four females ages 8–42 years (mean 24 years). Table 1 shows patient's info. Facial palsy developed after acoustic neuroma resection in three patients, after the removal of a cerebellopontine angle astrocytoma in one, and as a consequence of Bell's palsy or cerebral hemorrhage in the other two (one each). The time elapsed between the onset of palsy and surgery was 20–24 months (mean 22.8 months).

Surgical Technique

After a pre-auricular incision, dissection began in the subcutaneous plane of the healthy side, and facial nerve branches were identified after facial pocket harvesting in their terminal part, outside from the parotid gland that was not violated. In this dissection, extreme care must be taken to avoid damages to the healthy facial nerve and to identify multiple branches with synergic functions in order to preserve facial muscle activity after their section. Zygomatic-buccal and zygomatic-eye branches were selected for cross-facial nerve grafting using neuro-stimulator and magnification. On the paralyzed side, the facial nerve was dissected starting from the main trunk inside the parotid gland. It was dissected completely and was followed to identify the zygomatic-buccal and zygomatic-eye branches that were used for co-optation with cross-facial nerve grafting. Afterwards, the masseteric nerve was identified inside the masseter muscle by using as landmarks the zygomatic arch (about 1-2 cm below) and posterior margin of the muscle (about 1 cm medially) using neuro-stimulator. Once the masseteric nerve was identified, it was dissected and cut in order to increase its mobility. The main trunk of the facial nerve was then cut at its origin and rotated to reach the masseter nerve and and end-to-end neurorrhaphy was done (Figure 1). Meanwhile, a second equipe harvested and split the sural nerve from the leg (usually the right one, but patient's preferences can be taken into account) in order to obtain two long neural grafts. These two grafts were passed from the healthy side to the paralyzed one through the upper gingivo-buccal sulcus, with the nerve passing in the submucosal plane. Finally, neurorrhaphies of the two (middle and middle-upper) cross-facial nerve grafting were performed between the grafts and the facial nerve branches previously identified (Figure 2, Drawing 1). Pen-rose drainages were placed and suturing was performed.

At the first visit, clinical examination included specific facial palsy evaluation (using the House-Brackman and Sunnybrook facial grading systems) and administration of the Facial Disability Index (FDI) quality-of-life questionnaire[5,6]. Children were assisted by their parents when completing the questionnaire using methods previously described for the evaluation of child patients[7]. All patients underwent cross-facial nerve grafting combined with masseteric nerve cooptation in a single-stage operation[8], according to the previously described technique. All patients underwent rehabilitation of the periocular complex during the same surgery. This featured platinum eyelid loading and inferior palpebral suspension to prevent ocular complications[9,10]. All patients routinely received injections of botulinum toxin to improve facial symmetry, with the depressor labii and forehead being the most common target areas[11].

Retrospective evaluation featured a comparison of the pre- and postoperative scores on the FDI questionnaires and those on the House-Brackman and Sunnybrook facial grading systems. Results were assessed before administration of botox, but include peri-ocular rehabilitation that must be performed (as mentioned above) in the same time of main procedure in order to provide eye protection and prevent severe complications, especially in this subset of patients having a long lasting palsy. Of the 10 items on the FDI questionnaire, the first five explore physical function, while the other 5 investigate social function and well-being. We compared scores on the pre- and postoperative FDI questionnaires to assess whether quality of life improved. We present pure data (not percentages) because this renders the results more comparable. We used the t test in SPSS ver. 22.0 (IBM Inc., Armonk, NY, USA) to compare pre- and postoperative data. We considered $p < 0.05$ to reflect statistical significance and $p < 0.01$ high-level significance. We compared both overall outcomes and the answers to specific questions to identify the areas that were most and least affected.

Results

We recorded no major or minor complications. The clinical results are summarized in Table 1. Previously paralyzed muscles began to contract in response to voluntary masseteric nerve activation between 4 and 5 months (mean 4.83 months) after the operation. Release from biting (the ability to activate contraction without biting) developed between 6 and 8 months after the operation (mean 7.17 months), and spontaneity (impulses afforded by cross-facial nerve grafting) developed between 9 and 12 months after the operation (mean 10.17 months). The follow-up duration ranged from 12 to 72 months (mean 39 months). Figures 3 and 4 and videos 1 and 2 shows two clinical cases comparing pre and post-operative facial muscles contraction.

Results of FDI questionnarie are summarized in table 2. Preoperative overall scores on the six FDI questionnaires ranged from 17 to 37 (mean 24). After the surgery, the scores ranged from 33 to 44 (mean 38.5). The difference was highly significant resulting in a -14.5 of mean difference with a standard deviation of ± 6.8337 and a mean standard error of 2.7899. Ninety-five Confidence interval of the difference ranged between -21.6716 (lower) and -7.3284 (upper), with a $p < 0.01$. Statistical analysis is shown in table 3.

The best improvements in the items investigating physical functions were associated with items 1 (“How much difficulty do you have keeping food in your mouth, moving food around in your mouth, or getting food stuck in your cheek while eating?”), 3 (“How much difficulty do you have saying specific sounds while speaking?”), and 4 (“How much difficulty do you have with your eyes tearing excessively or becoming dry?"; all $p < 0.01$; highly significant improvements). The other two questions (items 2 and 5) also revealed significant improvements ($p = 0.11$ and 0.17, respectively). Amongst those exploring social function and well-being, item 10 ("How often has your facial function prevented you from going out to eat, shop, or participate in family or social activities?") improved most: The mean score increased from 2 to 4.17 ($p = 0.015$). The least improved score was for item 6 ("How much of the time do you feel calm and peaceful?"): The mean score increased from 2.17 to 3.16 ($p = 0.041$). House-Brackman facial grading system scores changed from VI before the operation for all patients to III for four patients and II for two; the mean scores thus changed from 6 to 2.67. Sunnybrook Facial Grading System scores were 0–10 (mean 4.17) before the operation but 62–84 (mean 69.7) at the last visit.

Discussion

The rehabilitation of recent facial palsies has received a great deal of international attention and several approaches have been described, particularly over the past decade[12]. Facial nerve cooptation procedures are the surgical gold standard, allowing recovery of facial mimic muscles before atrophy and denervation render it impossible[13]. We are of the view that of the various therapeutic options proposed, combined masseteric/cross-facial nerve grafting represents the ideal solution; we published on this in detail in 2014. We found that masseteric/cross-facial cooptation ensured rapid, reliable, and powerful restoration of muscle activity with extremely low morbidity. Contemporaneous cross-facial nerve grafting delivers motor impulses from the contralateral healthy facial nerve, affording spontaneity and symmetry of activation and yielding very satisfactory results in the great majority of cases.

A major concern when planning surgery is the cutoff time before which mimic muscle cooptation remains possible; is a neuromuscular transplant the better option? This cutoff is generally considered 18 months, but we here report for the first time very satisfactory results obtained 22 months after the onset of palsy. This was possible in our present subset of patients because of rapid and powerful reinnervation provided by the masseteric nerve and probably thanks to the fact that neurotrophic factors were still possible due to intact VII nerve; muscle recovery was possible at even a mean of 22.8 months after the onset of palsy. Once the main trunk of the facial nerve has been coopted and the mimic muscles have been recruited once more by masseteric nerve activation, the time needed for activation after cross-facial nerve grafting is no longer an issue. Initial activation is reflected by voluntary biting (at 4–5 months in our present series, mean 4.83 months), and successful postoperative rehabilitation release activation from biting (usually after 2 months of treatment). Finally, when the cross-facial graft delivers impulses from the contralateral side (at 9–12 months in our current series, mean 10.17 months), activation becomes both spontaneous and synchronous and tone at rest is improved.

Our major concern is the quality of the results. The literature shows that the quality of recovery is strictly (negatively) correlated with the time that has elapsed since denervation of the mimic muscle; the best results are obtained in cases treated early[14-16]. However, the esthetic and functional outcomes of our patients were satisfactory, as demonstrated by their scores on the Sunnybrook Facial Grading System. This system was recently identified by the Sir Charles Bell Society as being the most reliable of the several alternatives[17]. Although better results could certainly have been achieved had the patients been treated earlier, the quality-of-life improvements were dramatic; the statistical significance was very high despite the fact that only six patients were analyzed. Note that the best improvements were in areas related to social interaction and daily functions such as speaking and eating. The patients were very satisfied. This was, of course, our primary goal.

It is very important to note that rehabilitation involved only a light procedure or superficial surgery. The mean operative time was about 3 h. We encountered no complications and no morbidity. All patients were discharged after 3 days in hospital. In addition, if facial nerve cooptation fails, the cross-facial nerve graft can be used to reinnervate the gracilis muscle in a two-step procedure (cross-grafting followed by a gracilis neuromuscular transplant reinnervated via the cross-graft)[18,19]. This is normally considered the gold-standard treatment for established or congenital unilateral palsy[20]. This option should be clearly explained to the patient: It is possible that cooptation may fail but the rehabilitation course will not be affected. If, however, cooptation is not possible, muscular substitution is indicated.

Another interesting finding is the absence of any correlation between age and outcome: The results in pediatric and adult patients were similar. Our small sample size limits the weight of this conclusion, but we have no evidence that cooptation is unreliable in elderly patients.

Certain ancillary procedures are essential for successful rehabilitation. As we reported above, all patients underwent upper eyelid loading with platinum chain and botulinum toxin injections. Despite the evaluation of results that was assessed before botox administration, it is probable that palpebral rehabilitation with this ancillary procedure has partially biased our evaluation of results in this area: assessment of results without including upper eyelid evaluation is not possible without deep modification of the scores we used that would lead to loosening of their scientific validation. Therefore, we choose to include in our assessment this area, also with the intent to underline that all patients should receive both treatments, even if it is not possible to split "pure" assessment of the benefit of the main procedure from the one related to platinum chain loading. On the other hand, eyelid loading is essential because when palsies of such long duration are to be treated, lagophtalmos and eye discomfort become urgent issues and eyelid loading with platinum chain affords rapid and reliable results. Despite satisfactory recovery of facial mimicing, no patient required eyelid removal. Thus, after facial recovery, loading did not become an issue, as evidenced by the excellent improvement on item 4.

Botulinum toxin is commonly used as an aid to rehabilitate unilateral palsy, as in our patients. The depressor labii and frontalis regions usually exhibit the poorest recoveries, particularly when the palsy is of long duration, and none of our patients achieved perfect movement in these areas as measured using the Sunnybrook Facial Grading System. Thus, chemodenervation of the contralateral side optimally restores facial symmetry and is routine in such patients.

The principal limitations of our study are the small sample size and the retrospective nature of the work. However, facial nerve cooptation procedures are not routine, and we would have had even fewer patients had we restricted our analysis to patients treated 20–24 months after the onset of palsy. Future prospective multicenter studies would certainly strengthen our findings. Meanwhile, we approached a neglected subset of patients for whom surgical decision making is difficult and helped them.

Conclusions

Our pilot study supports the idea that masseteric/cross-facial nerve grafting may be used to treat palsies 20–24 months in duration, affording satisfactory functional and esthetic outcomes and dramatically improving quality of life using a relatively light procedure. The English in this document has been checked by at least two professional editors, both native speakers of English. For a certificate, please see:

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Tables legend.

Table 1. Patients data and clinical evaluation. Abbreviations: HBFGS, House-Brackmann Facial Grading; SFGS, Sunnybrook Facial Grading System; CPAA, cerebellopontine angle astrocytoma; CH, Cerebral Hemorrhage; AN, Acoustic Neuroma.

Table 2. Results of FDI questionnaire. Table shows scores for each patient and overall results.

Table 3. Statistical evaluation of the FDI questionnaire results. Abbreviations: df, degrees of freedom; Std, standard. “Item”: refers to items on the Facial Disability Index (FDI) questionnaire. “Mean” refers to the mean difference between the pre and post operative scores in the item.

Figure Legend.

Figure 1. Intra-operative picture showing masseteric-facial cooptation.

Figure 2. Intra-operative picture showing cooptation of middle and upper branches of facial nerve with sural nerve used for cross-facial nerve grafting. Masseteric-facial cooptation was still visible in the deeper plane.

Figure 3. Results of the procedure comparing pre-operative (a) and post-operative (b) picture of a 42 yo patient treated 24 months after right Bell's palsy.

Figure 4. Results of the procedure comparing pre-operative (a) and post-operative (b) picture of a 22 yo patient treated 24 months after right palsy resulted from an acoustic neuroma resection.

Drawing 1. Scheme of the procedure. S1: sural nerve graft 1; S2: sural nerve graft 2; M: masseteric nerve; T: main trunk of the facial nerve. Proximal stump of masseteric nerve (M, black bold line) was rotated and cooptation of distal stump of main trunk of facial nerve (T) was performed to provide a full masseteric-facial cooptation.

Table 1. Patients data and clinical evaluation.

Patient	Sex	Age (Years)	Side	Etiology	Time from palsy to intervention (Months)	Contraction (Months from surgery to first contraction)	Release from biting (Months required)	Spontaneity (Months elapsed to achieve spontanous movements)	HBFGS pre	HBFGS post	SFGS pre	SFGS post
1	F	42	R	Bell's Palsy	24	5	7	11	6	2	0	62
2	M	8	L	CPAA	24	5	6	9	6	3	10	70
3	F	22	R	AN	24	4	7	11	6	2	5	72
4	F	40	L	AN	20	5	8	12	6	3	0	63
5	M	16	L	CH	21	5	8	9	6	3	5	84
6	F	16	L	AN	24	5	7	9	6	3	5	67
Mean	-	24	-	-	22.8	4.83	7.17	10.17	6	2.67	4.17	69.7

Abbreviations: HBFGS, House-Brackmann Facial Grading; SFGS, Sunnybrook Facial Grading System; CPAA, cerebellopontine angle astrocytoma; CH, Cerebral Hemorrhage; AN, Acoustic Neuroma.

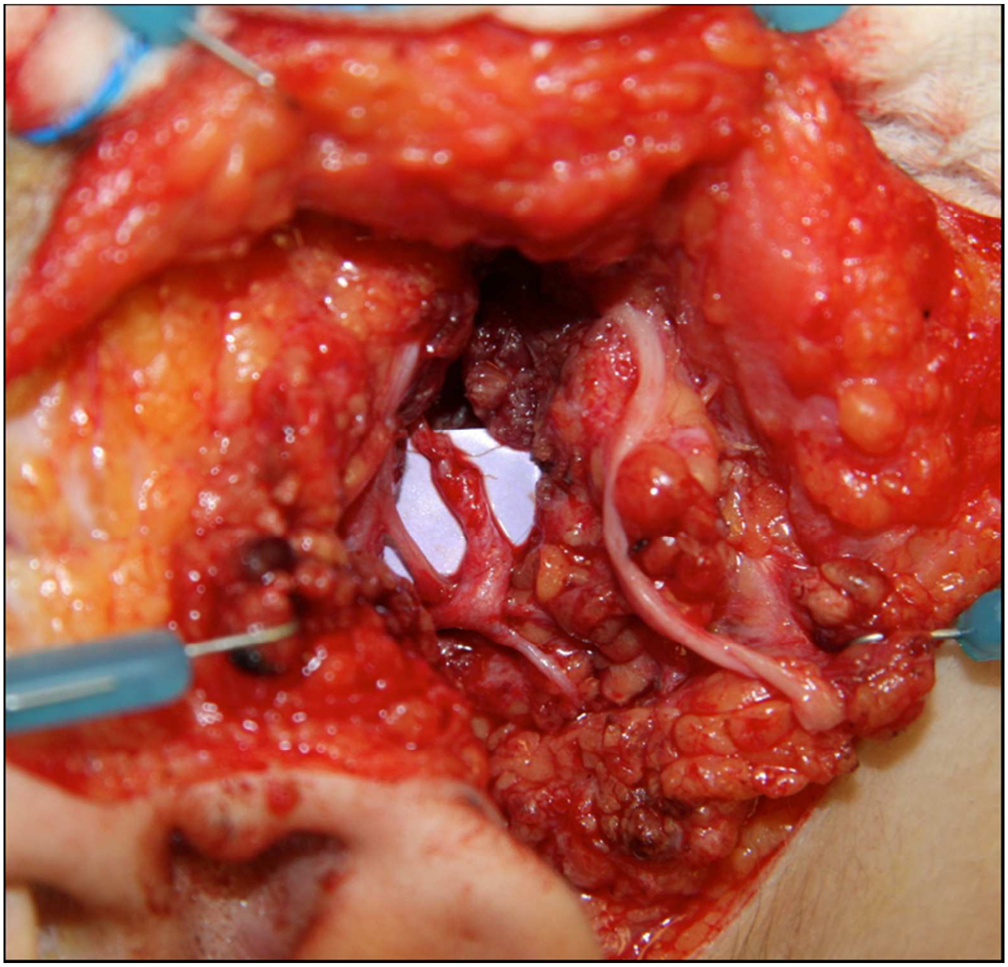
Table 3. FDI Items and scores

	Item 1 Eating Function		Item 2 Drinking Function		Item 3 Speaking Function		Item 4 Eye Comfort		Item 5 Brushing Teeth ability		Item 6 Feeling Calm and Peaceful		Item 7 Feeling Isolate		Item 8 Getting Irritable		Item 9 Sleep Comfort		Item 10 Social Interaction		Scores	
Patients	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post
1	2	4	2	5	2	5	2	4	2	5	1	3	1	4	2	4	2	4	1	5	17	43
2	2	4	2	4	2	3	2	3	2	4	2	3	2	3	2	3	2	3	2	3	20	33
3	3	4	3	5	2	3	2	4	3	5	1	3	3	3	0	3	2	4	1	4	20	38
4	2	3	4	5	3	4	3	4	4	5	2	3	2	4	1	2	4	4	5	5	30	39
5	5	5	5	5	3	4	3	5	5	5	5	5	4	5	5	5	0	0	2	5	37	44
6	2	4	2	4	3	4	4	4	3	4	2	2	1	3	1	3	1	3	1	3	20	34
Mean	2,67	4	3	4,67	2,5	3,83	2,67	4	3,17	4,67	2,17	3,16	2,17	3,67	1,83	3,33	1,83	3	2	4,17	24	38,5

Table 2. Statistical evaluation of the FDI questionnaire results

Items of FDI questionnaire (#pre - #post)		Paired differences: Mean and Std. deviation	Std error mean	95% Confidence interval of the difference: Lower	Upper	t-test	df	P value
Item 1	#1.1-#2.1	-1.3333 ± 0.8165	0.3333	-2.1902	-0.4765	-4.000	5	<0.01
Item 2	#1.2-#2.2	-1.6667 ± 1.0328	0.4216	-2.7505	-0.5828	-3.953	5	0.011
Item 3	#1.3-#2.3	-1.3333 ± 0.8165	0.3333	-2.1902	-0.4765	-4.000	5	<0.01
Item 4	#1.4-#2.4	-1.3333 ± 0.8165	0.3333	-2.1902	-0.4765	-4.000	5	<0.01
Item 5	#1.5-#2.5	-1.5000 ± 1.0488	0.4282	-2.6007	-0.3993	-3.503	5	0.017
Item 6	#1.6-#2.6	-1.0000 ± 0.8944	0.3651	-1.9386	-0.0614	-2.739	5	0.041
Item 7	#1.7-#2.7	-1.5000 ± 1.0488	0.4282	-2.6007	-0.3993	-3.503	5	0.017
Item 8	#1.8-#2.8	-1.5000 ± 1.0488	0.4282	-2.6007	-0.3993	-3.503	5	0.017
Item 9	#1.9-#2.9	-1.1667 ± 0.9832	0.4014	-2.1985	-0.1349	-2.907	5	0.034
Item 10	#1.10-#2.10	-2.1667 ± 1.4720	0.6009	-3.7114	-0.6219	-3.606	5	0.015
Score tot	TOT 1-TOT 2	-14.5000 ± 6.8337	2.7899	-21.6716	-7.3284	-5.197	5	<0.01

Abbreviations: df, degrees of freedom; Std, standard.
"Item": refers to items on the Facial Disability Index (FDI) questionnaire.
"Mean" refers to the mean difference between the pre and post operative scores in the item.



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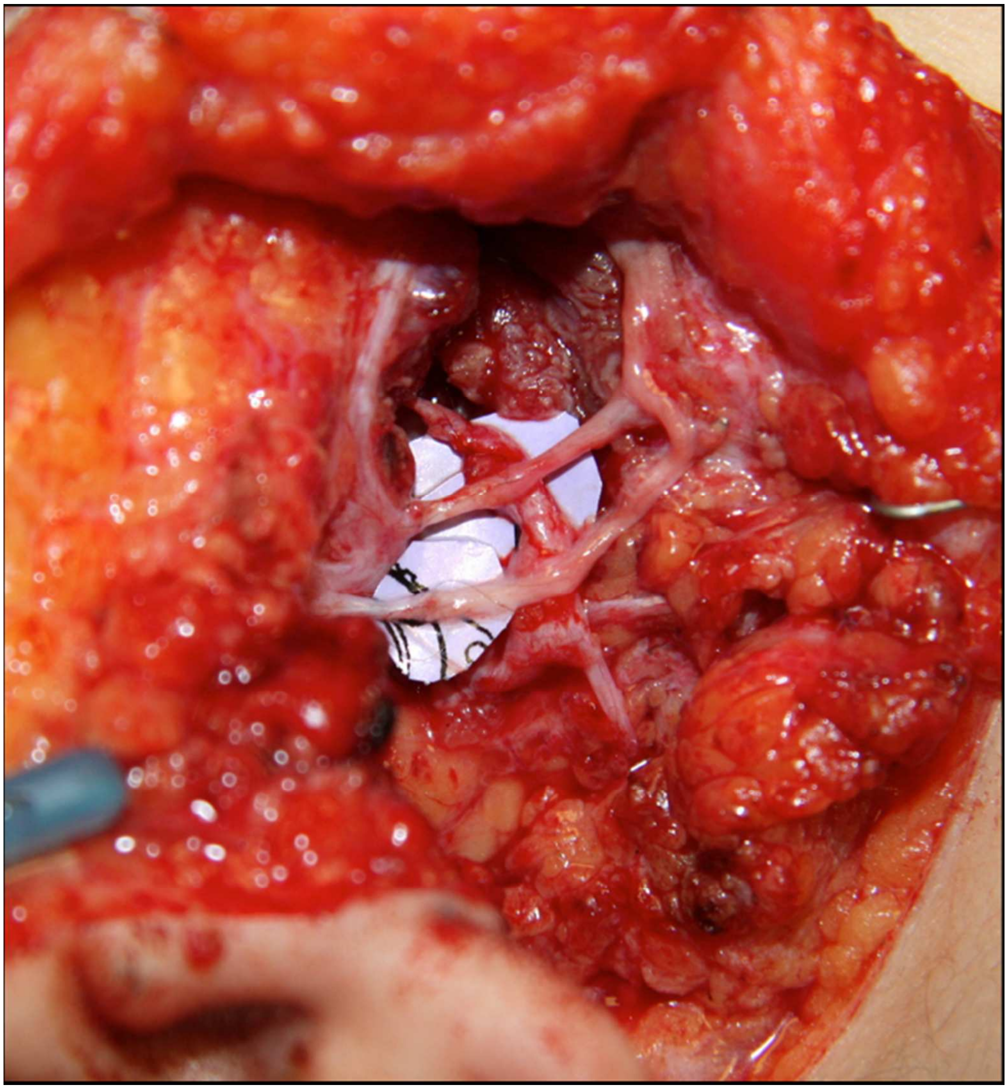

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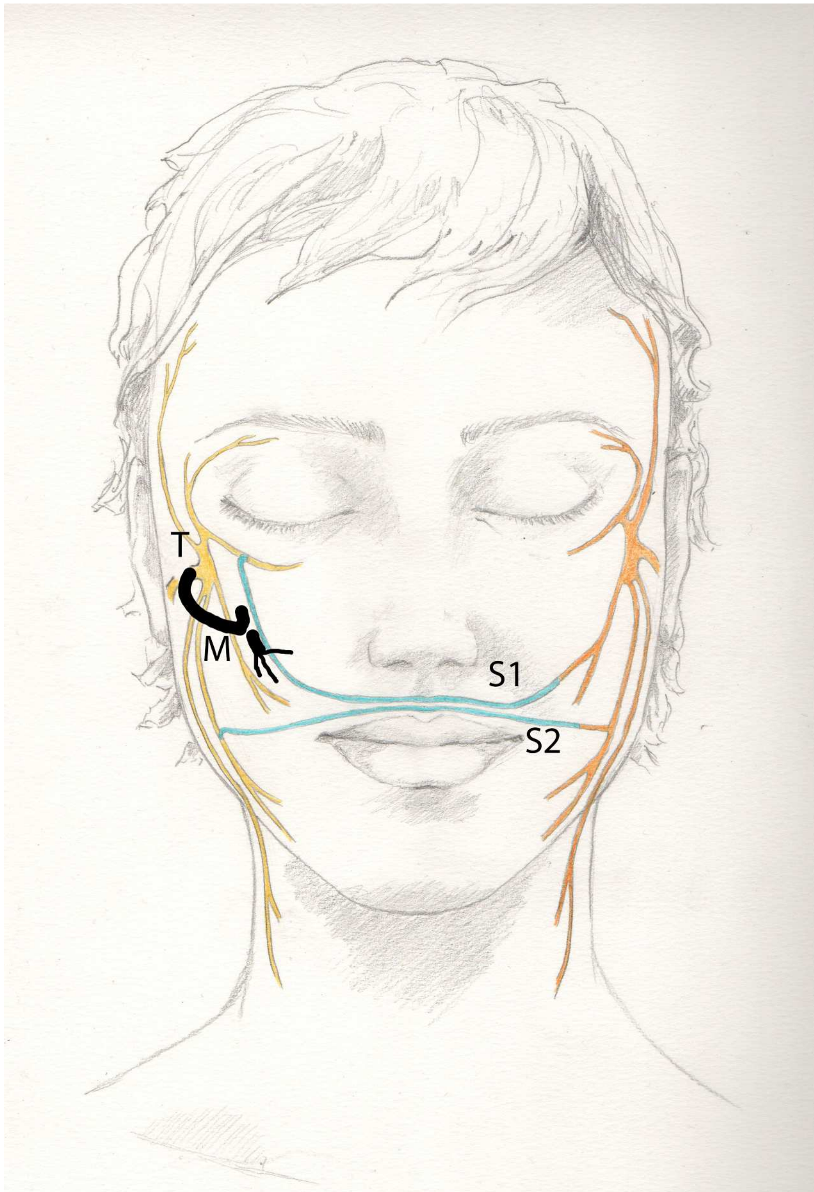

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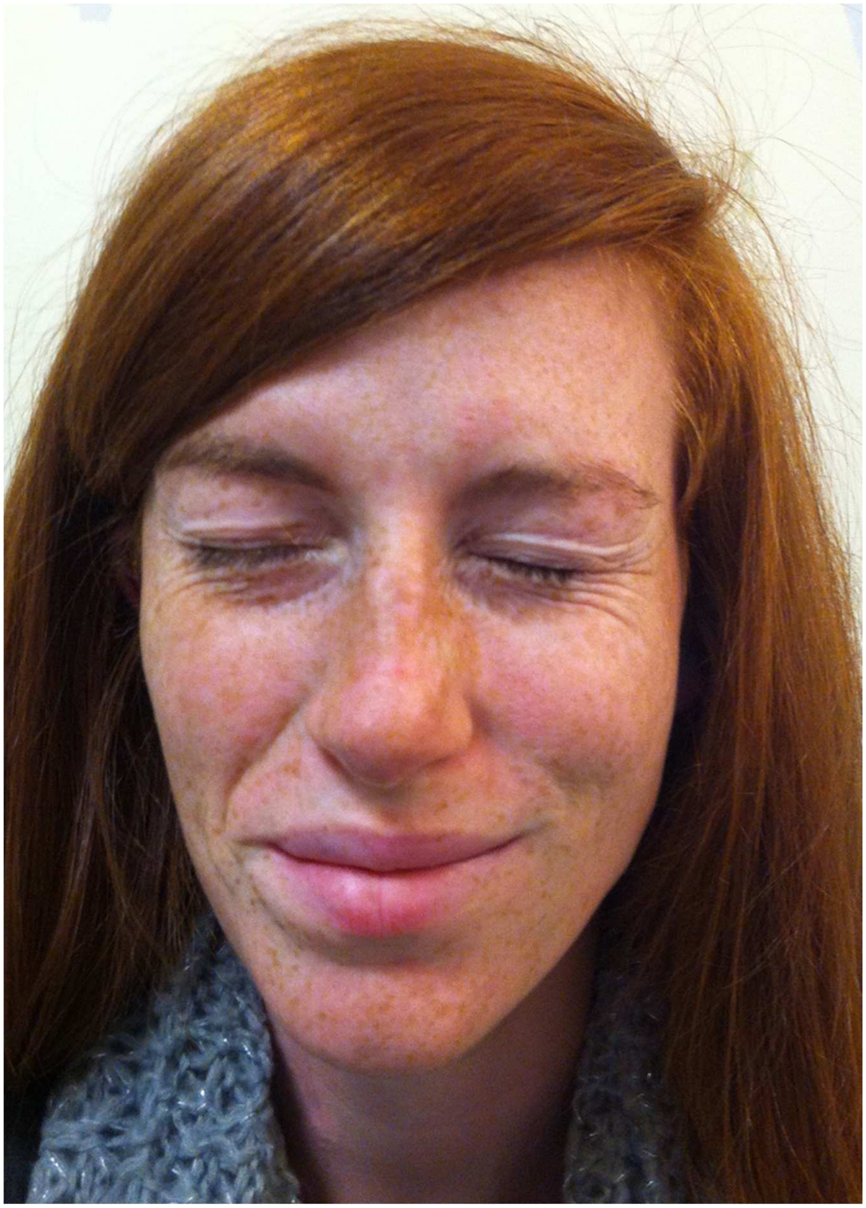

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