

Effect of Weakening of Ipsilateral Depressor Anguli Oris on Smile Symmetry in Postparalysis Facial Palsy

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IMPORTANCE Aberrant depressor anguli oris (DAO) activity may arise after recovery from acute facial paralysis and restrict movement of the oral commissure.

OBJECTIVE To quantify the degree to which DAO inhibition affects smile dynamics and perceived emotional state.

DESIGN, SETTING, AND PARTICIPANTS In this prospective, pretest-posttest study performed at an academic tertiary referral hospital, patients with unilateral postparalysis facial palsy were studied from January 16 through April 30, 2016.

INTERVENTIONS Local anesthetic injection into the ipsilateral DAO.

MAIN OUTCOMES AND MEASURES Healthy- and paretic-side commissure displacements from the midline lower vermilion border referenced to the horizontal plane were calculated from random-ordered photographs of full-effort smile before and after injection, and random-ordered hemifacial photographs of the paretic side were assessed as expressing positive, negative, or indiscernible emotion.

RESULTS Twenty patients were identified as having unilateral postparalysis facial palsy with marked synkinesis of the ipsilateral DAO. Patient mean age was 46 years (range, 24-67 years), with a male to female ratio of 1:3. Mean paretic-side commissure displacement increased from 27.45 mm at 21.65° above the horizontal plane to 29.35 mm at 23.58° after DAO weakening (mean difference, 1.90 mm; 95% CI, 1.26-2.54 mm; and 1.93°; 95% CI, 0.34°-3.51°; $P < .001$ and $P = .20$, respectively). Symmetry of excursion between sides improved by 2.00 mm (95% CI, 1.16-2.83 mm; $P < .001$) and 2.71° (95% CI, 1.38°-4.03°; $P < .001$). At baseline, observers assessed 7 of 20 paretic hemifaces (35%) as expressing positive emotion; this proportion increased to 13 of 20 (65%) after DAO weakening ($P = .03$).

CONCLUSIONS AND RELEVANCE Ipsilateral DAO weakening results in significant improvements in smile dynamics and perceived expression of positive emotion on the paretic hemiface in postparalysis facial palsy. A trial of DAO weakening should be offered to patients with this disfiguring complication of Bell palsy and similar facial nerve insults.

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Facial nerve insult that results in dense facial paralysis may result in aberrant neural regeneration.¹ A hallmark of this condition, known as postparalysis facial palsy (PPFP), is abnormal coactivation of facial muscles with expression, known as synkinesis. Restriction of facial movement occurs when antagonistic muscles coactivate. At the modiolus, the superoposterolateral pull of the zygomaticus major may be antagonized by the inferolateral pull of the depressor anguli oris (DAO), resulting in restriction of oral commissure excursion and subsequent blunting of smile on the affected side. Labbé et al² first reported how chemodenervation or surgical resection of the ipsilateral DAO may improve smile dynamics in PPFP. The purpose of this study was to prospectively quantify to what degree inhibition of DAO activity affects smile dynamics and naive-observer perception of expressed emotion.

Methods

Inclusion criteria included unilateral PPFP with marked synkinesis of the ipsilateral DAO as determined by the presence of an asymmetric marionette line on observation (Figure 1) and forceful contraction of the muscle on palpation with full-effort smile. Patients were identified and enrolled from January 16 through April 30, 2016. Age of patient and cause and duration of facial palsy were documented. All patients received injection of 1 mL of 1% lidocaine into the DAO, using the method described by Choi et al.³ Briefly, a fan-shaped region of the DAO lateral to a vertical line through the modiolus was injected with lidocaine to avoid weakening of the adjacent ipsilateral depressor labii inferioris (DLI) (Video). Healthy- and paretic-side commissure displacements from the midline lower vermilion border referenced to the horizontal plane were calculated from random-ordered photographs of full-effort smile before and after injection using FaceGram software, version 1.0 (Massachusetts Eye and Ear Infirmary) (Figure 2), by 2 authors masked to the intervention (N.J. and R.M.). Displacement distances and angles were compared between sides (before and after DAO weakening) using paired-samples, 2-tailed *t* tests. Interrater reliability was assessed using the intraclass correlation coefficient (2-way, random consistency, single measures). This study obtained approval from the institutional review board of the Massachusetts Eye and Ear for human trials. All patients provided written informed consent.

Photographs were then cropped to display only the paretic-side smile (Figure 3). Two additional observers naive to the attempted expression and presence of an intervention viewed the cropped images in random order at a rate of 3 seconds per image, while assessing each expression as communicating positive emotion (such as joy, happiness, pride, and serenity), negative emotion (such as anger, sadness, grief, aversion, and disgust), or indiscernible emotion. Interrater reliability was assessed by the percentage of absolute agreement. The proportion of expressions perceived to communicate positive as opposed to negative or indiscernible emotion before and after DAO weakening was compared

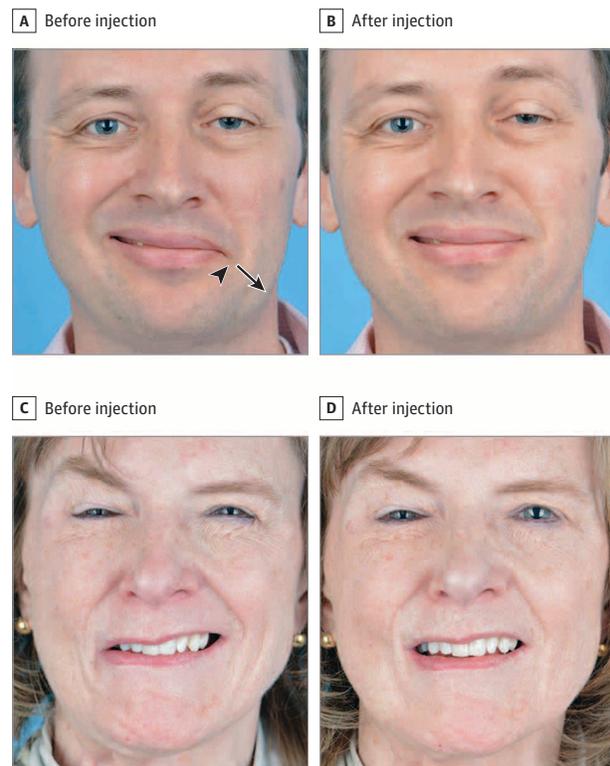
Key Points

Question How does weakening of the ipsilateral depressor anguli oris (DAO) muscle affect smile dynamics in the setting of postparalysis facial palsy (facial synkinesis)?

Findings This prospective, pretest-posttest study found that weakening of the ipsilateral DAO by simple injection of lidocaine significantly improved smile dynamics and communication of positive emotion on the paretic hemiface to observers naive to the attempted expression.

Meaning Ipsilateral DAO weakening is a simple yet powerful means of improving smile quality in patients with postparalysis facial palsy and may be of great benefit to patients who develop this disfiguring complication of Bell palsy and other facial nerve insults.

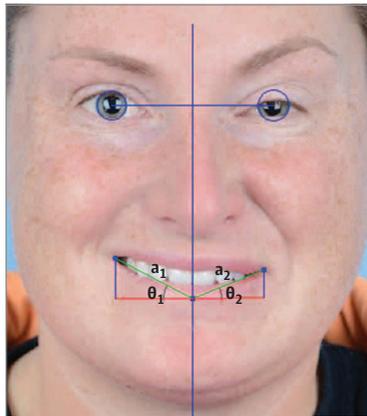
Figure 1. Preweakening and Postweakening of the Depressor Anguli Oris (DAO) in Postparalysis Facial Palsy



Full-effort smiles are shown for 2 of the patients in this study before (A and C) injection of the affected-side DAO and after (B and D) injection. Note the prominent asymmetric marionette line (lonely marionette) with full-effort smile attempt on the paretic side (A, black arrowhead) with direction of pull of the aberrantly innervated DAO (A, black arrow). The inciting episode of facial paralysis occurred 16 months earlier for the patient shown in A and B (paretic left side) and 38 years earlier for the patient shown in C and D (paretic right side).

using the McNemar test. Statistical tests were performed using SPSS statistical software, version 22 (SPSS Inc), with a set at .05 (2-way).

Figure 2. Calculated Oral Commissure Displacements From Photographic Documentation Using FaceGram Software



The mean iris diameter of 12 mm is used for pixel scaling to determine distance and angle with respect to the horizontal plane for vectors joining the midpoint of the lower vermilion border to the oral commissure on the healthy side (a_1 and θ_1) and paretic side (a_2 and θ_2).

Results

Twenty patients were identified as having unilateral PFP with marked synkinesis of the ipsilateral DAO. Patient mean age was 46 years (range, 24-67 years), with a male to female ratio of 1:3. The mean time to presentation from the date of acute facial palsy onset was 115 months (range, 8-757 months). The cause of the acute facial palsy was as follows: 6 presented with a prior history of a single episode of Bell palsy, 5 with a single episode of pregnancy-associated Bell palsy, 2 with multiple episodes of Bell palsy, 1 with a single episode of Ramsay Hunt syndrome, 1 with a single episode of Lyme disease-associated facial palsy, 1 with acute otitis media requiring mastoidectomy as a child, and 4 with PFP after resection of benign tumors (an ossifying venous vascular malformation of the geniculate ganglion, a vestibular schwannoma, a meningioma that involved the internal auditory canal, and a recurrent pleomorphic adenoma of the parotid gland).

Before DAO weakening, full-effort smile in most patients appeared as a lazy S with downward pulling of the affected-side commissure into a markedly pronounced asymmetric marionette line (Figure 1). The mean difference between healthy- and paretic-side commissure excursions was greater than 6 mm, with the healthy-side commissure rising a mean of 6.5° higher than the paretic-side commissure above the horizontal plane (Table 1). Interrater reliability for measurements of commissure displacement was excellent, with all measures having an intraclass correlation coefficient greater than 0.8 (Table 2). Naive-observer perception of emotion being expressed on the paretic side yielded negative or indiscernible emotion in 13 of 20 patients (65%) (Table 3).

After weakening of the ipsilateral DAO, affected-side commissure excursion increased by a mean of 1.90 mm (range, 0.35-5.23 mm) and rose a mean of 1.93° higher than the preinjection position relative to the horizontal plane (Table 1).

Figure 3. Paretic-Side Smile Appearance With Full-Effort Smile Before and After Weakening of the Depressor Anguli Oris (DAO) in Patients With Postparalysis Facial Palsy



A-C, Before weakening, these hemifaces were perceived by naive observers as expressing negative or indiscernible emotion. D-F, Images from the same patients after ipsilateral DAO weakening were interpreted by the same observers as expressing positive emotion.

Asymmetry between sides decreased to 4.09 mm and 3.81° after injection (Table 1). Clinical improvements were immediately obvious for most patients (Figure 2). A significant increase was demonstrated in the proportion of hemifaces perceived as expressing positive emotion by naive observers, increasing from 35% to 65% ($P = .03$) (Table 3). Absolute agreement between observer assessments was 70%. Among patients whose perceived emotional state changed from negative or indiscernible to positive after DAO weakening (Table 3), the mean increase in paretic-side commissure excursion with full-effort smile was 2.22 mm and 4.8° higher above the horizontal plane.

Discussion

Balancing the need to maintain facial tone and function with the desire to eliminate undesirable hyperactivity is the principle challenge of PFP management.⁴ In this study, we found that smile function may be improved by weakening the DAO in cases where it is noted to be hyperactive. When present, such hyperactivity is readily observed by noting an asymmetric marionette line, which we colloquially referred to as the lonely marionette sign, on the affected side with attempts at smile. Weakening of the DAO in such cases may be advantageous not only for enhancing expression of positive emotion but also for blunting of the negative emotions conveyed by DAO activation, which include anger, sadness, grief, aversion, and disgust. This

Table 1. Paretic- and Healthy-Side Oral Commissure Displacement With Full-Effort Smile Before and After Local Anesthetic Injection Into the Paretic-Side Depressor Anguli Oris

Measure	Injection, Mean (SD)		Difference, Mean (95% CI)	P Value ^a
	Pretest	Posttest		
Paretic hemiface				
Distance, mm ^b	27.45 (1.95)	29.35 (1.68)	1.90 (1.26 to 2.54)	<.001
Angle, degrees ^c	21.65 (6.71)	23.58 (7.26)	1.93 (0.34 to 3.51)	.02
Healthy hemiface				
Distance, mm	33.54 (2.82)	33.44 (3.10)	-0.10 (-0.87 to 0.67)	.78
Angle, degrees	28.17 (6.05)	27.39 (5.89)	-0.78 (-1.86 to 0.30)	.15
Asymmetry between sides^d				
Distance, mm	6.09 (2.99)	4.09 (3.13)	-2.00 (-2.83 to -1.16)	<.001
Angle, degrees	6.52 (3.23)	3.81 (2.67)	-2.71 (-4.03 to -1.38)	<.001

^a Paired-samples, 2-tailed t test; bold font indicates significant at an α of .05.
^b From the midpoint of the lower vermilion.
^c Above the horizontal plane.
^d Healthy-side minus paretic-side values.

Table 2. Interrater Reliability of Oral Commissure Displacement Measurements

Measure	Injection, ICC (95% CI)	
	Pretest ^a	Posttest
Paretic hemiface		
Distance, mm ^b	0.844 (0.648-0.935)	0.883 (0.729-0.952)
Angle, degrees ^c	0.938 (0.850-0.975)	0.987 (0.984-0.997)
Healthy hemiface		
Distance, mm	0.879 (0.719-0.950)	0.936 (0.846-0.974)
Angle, degrees	0.973 (0.933-0.989)	0.964 (0.954-0.993)

Abbreviation: ICC, intraclass correlation coefficient.

^a Two-way, random consistency, single measures.
^b From the midpoint of the lower vermilion.
^c Above the horizontal plane.

Table 3. Mean Masked Naive-Observer Assessment of Expressed Emotion on Paretic Hemiface With Full-Effort Smile Attempt Before and After Weakening of the Ipsilateral Depressor Anguli Oris^a

Emotion Being Expressed	No. (%) of Patients (N = 20)		
	Injection Rating		
	Pretest	Posttest	Change
Positive ^b	7 (35)	13 (65)	6 (30)
Negative ^c	8 (40)	4 (20)	-4 (-20)
Indiscernible	5 (25)	3 (15)	-2 (-10)

^a McNemar test (positive vs negative or indiscernible) $P = .03$, significant at an α of .05.
^b Positive emotion, such as joy, happiness, pride, and serenity.
^c Negative emotion, such as anger, sadness, grief, aversion, and disgust.

study found that significant improvements in naive-observer interpretation of positive emotional expression on the paretic side may be achieved through this simple technique. Of note, although a 1.9-mm mean improvement in commissure excursion is modest, some patients in this study demonstrated up to 5 mm of increased excursion. As such, a trial of local anesthetic weakening of the ipsilateral DAO should be offered to all patients with PFP-associated smile restriction who have hyperactivity of the muscle.

Most patients with hyperactivity of the ipsilateral DAO in PFP also have impairment in ipsilateral DLI function, for which weakening of the contralateral DLI improves lower lip symmetry.^{5,6} For patients hesitant to use botulinum toxin, we have found targeted lidocaine injection of these facial regions to be extremely useful in demonstrating the aesthetic and functional benefits achievable through chemodenervation. When a lidocaine trial is performed, botulinum toxin injection should be delayed by at least 1 day to avoid dilution of the drug and facilitate muscle targeting.

In addition, many patients with PFP manifest unsightly hyperactivity of the mentalis that is responsive to chemodenervation. The challenge is to adequately weaken the ipsilateral DAO, mentalis, and contralateral DLI without overweakening the lower lip, which may result in impairment of articulation, oral competence, and food bolus manipulation.

Conclusions

Weakening of the DAO results in significant improvements in smile dynamics and perceived expression of positive emotion on the paretic hemiface in PFP. A trial of DAO weakening should be offered to patients with this disfiguring complication of Bell palsy and similar facial nerve insults. In addition, further studies should seek to determine the efficacy of long-term concurrent tailored weakening of the ipsilateral DAO, mentalis, and contralateral DLI in improving facial symmetry while maintaining adequate lower lip tone and function.

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Concept and design: Jowett, Hadlock.

Acquisition, analysis, or interpretation of data: All authors.

Drafting of the manuscript: Jowett, Hadlock.

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REFERENCES

1. Wetzig P. Aberrant regeneration of oculomotor and facial nerves. *Rocky Mt Med J.* 1957;54(4):347-348.
2. Labbé D, Bénichou L, Iodice A, Giot JP. Depressor anguli oris sign (DAO) in facial paresis: how to search it and release the smile (technical note) [in French]. *Ann Chir Plast Esthet.* 2012;57(3):281-285.
3. Choi YJ, Kim JS, Gil YC, et al. Anatomical considerations regarding the location and boundary of the depressor anguli oris muscle with reference to botulinum toxin injection. *Plast Reconstr Surg.* 2014;134(5):917-921.
4. Jowett N, Hadlock TA. A contemporary approach to facial reanimation. *JAMA Facial Plast Surg.* 2015;17(4):293-300.
5. Godwin Y, Tomat L, Manktelow R. The use of local anesthetic motor block to demonstrate the potential outcome of depressor labii inferioris resection in patients with facial paralysis. *Plast Reconstr Surg.* 2005;116(4):957-961.
6. Hussain G, Manktelow RT, Tomat LR. Depressor labii inferioris resection: an effective treatment for marginal mandibular nerve paralysis. *Br J Plast Surg.* 2004;57(6):502-510.