

기능적 해부학에 기초한 미간 주름 교정



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Functional Anatomy-Based Botulinum Toxin A Injection to Correct Glabellar Frown Lines

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Botulinum toxin A injection to reduce glabellar lines has become one of the most popular procedures in facial rejuvenation. 5-site injection is generally accepted: into the procerus muscle at the midline and each corrugator muscle at its inferomedial and superolateral aspects. The superolateral injection site is above the pupil and approximately 1cm above the bony orbital rim. According to our observation, corrugator muscles are not either symmetric or tightly related to the surface anatomical landmarks such as pupils and bony orbital rims. Therefore when glabellar lines were treated by surface anatomical landmarks, in the case of asymmetrical corrugator, it was not precisely targeted to obtain sufficient paralytic effects. Herein, we suggest functional anatomy-based Botulinum toxic A injection to correct glabellar frown lines and its theoretical backgrounds. Between 1999 and 2007, 329 patients were enrolled in the study. 86 patients between 1999 and February of 2001 were injected by the traditional injection method. Later 243 patients were treated by the functional anatomy-based injection. By the new method, injection points were determined by observing glabellar furrows and skin fine wrinkles after repetition of muscle contraction. By this method, we could enhance the cosmetic effects and heighten patients' satisfaction.

(J Korean Soc Aesthetic Plast Surg 17: 35, 2011)

Key words: Botulinum toxin, Aging, Rejuvenation

I. INTRODUCTION

Since the approval by the US Food and Drug Administration (FDA) in 2002, Botulinum toxin A injection has been one of the most commonly performed procedures to smooth facial hyperkinetic lines in glabella.^{1,2} Glabellar frown lines are divided

into vertical and horizontal lines and vertical rhytids originate from the muscle contraction of the corrugator supercilii,³ which is the main target for botulinum toxic A injection. In spite of various studies, the injection sites are still determined by the practitioners' experiences. In traditional method, botulinum toxin A is injected into the procerus muscle at the midline and each corrugator muscle at its inferomedial aspect and at its superolateral aspect. The superolateral injection site is above the pupil and approximately 1 cm above the bony orbital rim. However, results by traditional method were insufficient, because the location of the corrugator muscle differs in every individual and is not so strongly connected with the surface landmarks as we expected before.⁴ Therefore, to paralyze corrugator muscles properly, it is essential to locate the origin

Received November 10, 2009

Revised October 28, 2010

Accepted February 9, 2011

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and the insertion of the muscle and decide the superolateral injection points of corrugator muscles based on the functional anatomy. Herein, we introduce our functional anatomy-based botulinum toxic A injection to locate the superolateral injection point of the corrugator muscle and thus obtained the constant and satisfactory aesthetic outcomes and augmented patients' satisfaction.

II. MATERIALS

Between 1999 and 2007, 329 patients (86 males and 243 females), who wished to correct their glabellar frown lines by non-surgical methods and return to their daily lives promptly, were enrolled in the study. The mean age was 32.4 years. 86 patients between 1999 and February of 2001 were injected according to the traditional injection method: into the procerus muscle and each corrugator muscle at its inferomedial aspect and at its superolateral aspect. The superolateral injection site is above the pupil and approximately 1 cm above the bony orbital rim. Later 243 patients were treated by the functional anatomy-based injection. Other conditions than the injection points were the same between the two groups.

III. METHODS

One vial of BOTOX® (Allergan Inc., Irvine, CA), containing 100 U of Botulinum toxic A, was reconstituted with 2.5 mL of 0.9% sterile saline solution to a concentration of 40 U/mL of solution and injected using 0.5 cc insulin syringe with a 30-gauge Becton-Dickinson Ultra-Fine II short needle to minimize volume loss and heighten accuracy. 4 U of Botox was injected at the midline of the glabella where procerus muscles locate. 4 U was injected into corrugator muscle at its inferomedial aspect. The inferomedial injection site was in the middle of the strongest

vertical frown lines when eyebrows frown. Then, we observed the skin fine ripples on the middle third of the eyebrow when eyebrows frown strongly. 2 U was infiltrated into the skin fine ripples (Fig. 1). Considering diffusion, Botox was injected in the middle of the concentric circle and depth was intended just above the periosteum at its inferomedial aspect and just below the skin at its superolateral point to directly infiltrate into the corrugator muscle itself between the frontalis and the procerus (Fig. 2). After the occurrence of eyelid ptosis, we used digital

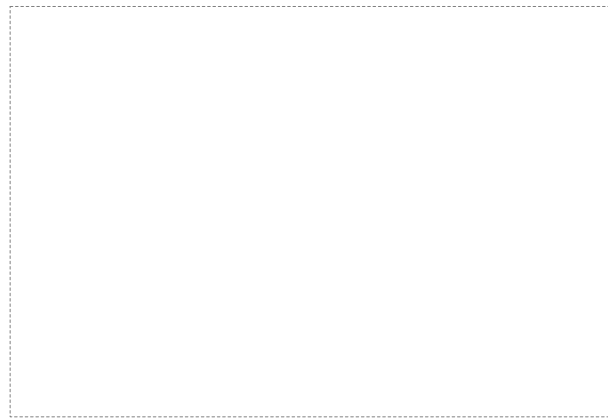


Fig. 1. Injection points. 4U of Botox was injected at the midline of the glabella (black circle), 4U at the strongest vertical frown lines on each sides (inferomedial injection point of corrugator; white circles) and 2U at the skin fine ripples near the middle 1/3 of eyebrow (superolateral injection point of corrugator; white diamonds) after the observation of muscle movements of frowning and squeezing eyebrows together toward the midline in sitting position to determine the location, size, and power of the muscles. The dotted circles are the imaginary boundaries of Botox diffusion on the horizontal plane. Note the asymmetry of the injection points. The insertion of right corrugator is located more laterally than that of left, and both insertions are more medial than the imaginary vertical lines from pupils.

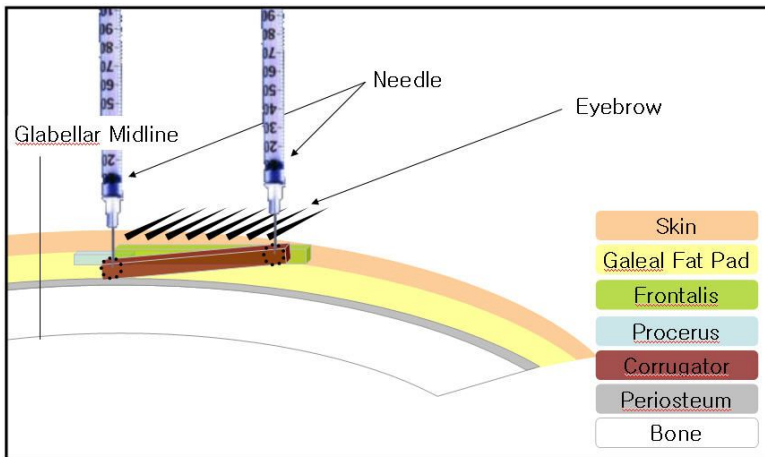


Fig. 2. Schematic transverse section of glabellar area. The inject points should be vertically in the middle of wrinkles in consideration of intramuscular diffusion of Botox. The dotted circles are the imaginary boundaries of Botox diffusion on the vertical plane.

compressions on the upper border of orbital rims to prevent the diffusion of Botox toward upper eyelids.

IV. RESULTS

Efficacy was evaluated on day 28 by the patient's subjective satisfaction and the physician's assessment based on the digital photography according to the glabellar line severity at maximum frown on a scale of 0 to 3 (0=none, 1=mild, 2=moderate, and 3=severe) (Table I, II). Any adverse events were recorded.

At day 0, the mean glabellar line severity scores at maximum frown were nearly identical (traditional=2.57; new=2.59) in the two treatment groups. At day 28, the mean glabellar line severity scores at maximum frown were 1.07 and 0.94 in each group. The change from the baseline was significantly greater ($p < 0.05$) for the new method group compared with the traditional group at day 28 (change for the traditional group=1.5; new group=1.65). Our method enhanced the cosmetic improvement of glabellar lines and heightened patient's satisfaction (Fig. 3). After the procedures, medial eyebrow ptosis occurred in 3 patients, and eyelid ptosis in 2 patients, but all of them were temporary and recovered without specific sequelae. After occurrence of ptosis, we started to use digital compressions and eyelid ptosis was effectively prevented by digital compressions on the upper border of orbital rims.

V. DISCUSSION

Glabellar frown lines negatively affect appearance, revealing

premature aging or giving false impressions of being angry or concentrating. Accordingly, botulinum toxin A injection to reduce these lines has become one of the most popular procedures in facial rejuvenation.

Mechanism of Botulinum Neurotoxin Action and Distribution of Motor End Plate

Botulinum toxin A is a neurotoxin which exert a paralytic effect on muscles by inhibiting acetylcholine release from the motor end plates at the neuromuscular junction (NMJ).^{5,6} A few studies reported the existence of a zone where motor end plates concentrate.^{7,8} Saitou et al. discovered a close relationship between motor end plates and muscle morphology (arrangement of the muscle fibers).⁹ Now, it is generally accepted that in muscles with a simple parallel arrangement of muscle fibers, the motor end plates are equidistant from the poles of their respective muscle fibers, or within the midbelly of the muscle.^{7,8} Therefore, precise knowledge about the structure of target muscles and the distribution of end plates might maximize injection efficiency and minimize doses and side effects due to local or systemic diffusion.

Anatomy and Structure of the Corrugator Supercilii

Glabellar frown lines are created by the complex movements of frontalis, orbicularis oculi, corrugator supercilii, procerus and depressor supercilii muscles. Since corrugators play the main role to induce vertical glabellar lines, Botox was frequently utilized to paralyze this muscle.

The corrugator supercilii is a rectangular panel-like muscle.¹⁰⁻¹³

Table I. Patient's Satisfaction on Day 28

	Traditional injection No. (%)	Functional anatomy-based injection No. (%)
Very satisfied	12 (14.0)	43 (17.7)
Satisfied	64 (74.4)	176 (72.4)
No effect	7 (8.1)	17 (7.0)
Dissatisfied	3 (3.5)	7 (2.9)

Table II. Physician's Assessment of Glabellar Line Severity at Maximum Frown on Day 28

	Traditional injection No. (%)	Functional anatomy-based injection No. (%)
0 (none)	9 (10.5)	41 (16.9)
1 (mild)	65 (75.6)	180 (74.1)
2 (moderate)	9 (10.5)	17 (7.0)
3 (severe)	3 (3.5)	5 (2.1)

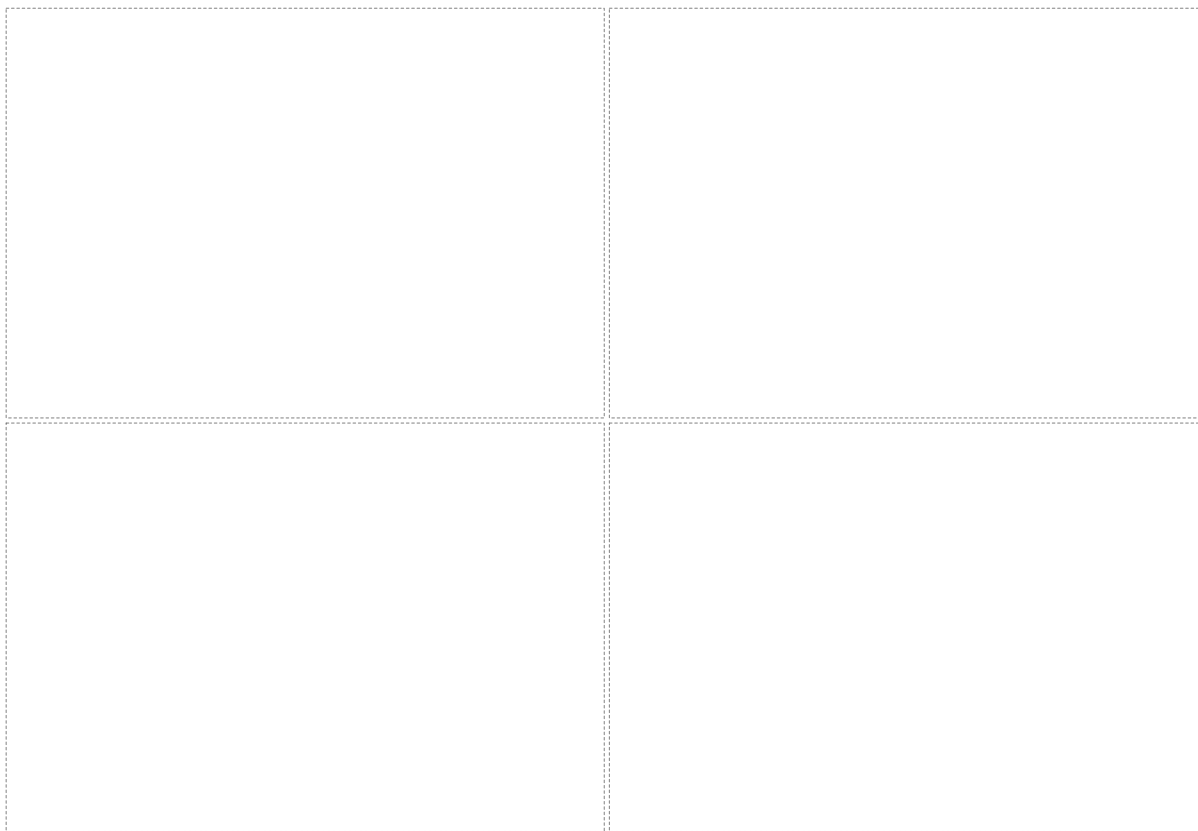


Fig 3. before (Above, left and Below, left) and 1 month (Above, right), 2 weeks (Below, right) after the Botox injection.

It arises from the frontal bone, near the superior and medial portion of the orbital rim¹⁴ and lies deep to both the frontalis and the procerus muscles.⁴ Then it passes through the galeal fat pad upwards and outwards to insert into the dermis superior to the middle third of the eyebrow.¹⁵ The corrugator is located closer to the skin near its insertion than its origin (Fig. 2). When it approaches its origin, it releases the skin just lateral to the medial frowning line.

The muscle is a brow adductor, moving the eyebrow downward and inward and, with repetitive contraction, produces vertical creases.^{1,15} The motion range of the corrugator is greater at insertion than origin, the medial one thirds of both eyebrows is pulled toward the glabellar central region, and the vertical lines appear mainly on it. This muscle movement is innervated by the temporal branch of the facial nerve, and the nerve enters it from the lateral side.¹⁰⁻¹² Kim et al. described the entry point of facial nerve as the inferolateral part of the corrugator averagely 35.8 mm distant from median plane.¹² Ellis et al. reported that the temporal branch of the facial nerve is consisted of 3 rami and the middle ramus enters into the superolateral portion of the corrugator muscle.¹¹ Choi et al. said that the plexus mainly from the inferior ramus of the temporal branch of the facial nerve

entered into the lateral portion of corrugator supercilii muscle.¹⁰

Paralysis of Corrugator Supercilii Muscles with Botulinum Toxin A

Corrugator is a small muscle about 5 cm long, but plays a main role to create glabellar vertical lines. Therefore, it is essential to paralyze the muscle completely with minimal dose of botulinum toxin to maximize effect and minimize side-effects. Still, there exist few studies about the distribution of NMJ on corrugators, but we can expect that the NMJ concentrate on the midbelly or rather lateral portion of the corrugator where the innervating nerves enter because of the rectangular panel-like anatomy and parallel arrangement of the muscle fibers. Consequently, Botox injection should be more precise near its insertion than its origin to obtain sufficient paralytic effects. While the origin of the corrugator muscle is obvious, the insertion is not distinct and the motion range of the corrugator is greater near its insertion than its origin. Therefore, many practitioners experienced difficulties to locate superolateral injection points. In our study, we could find the insertion of the muscle more accurately by observing the skin fine wrinkles (Fig. 4). By functional anatomy-based injection, we could obtain more predictable and desirable cosmetic

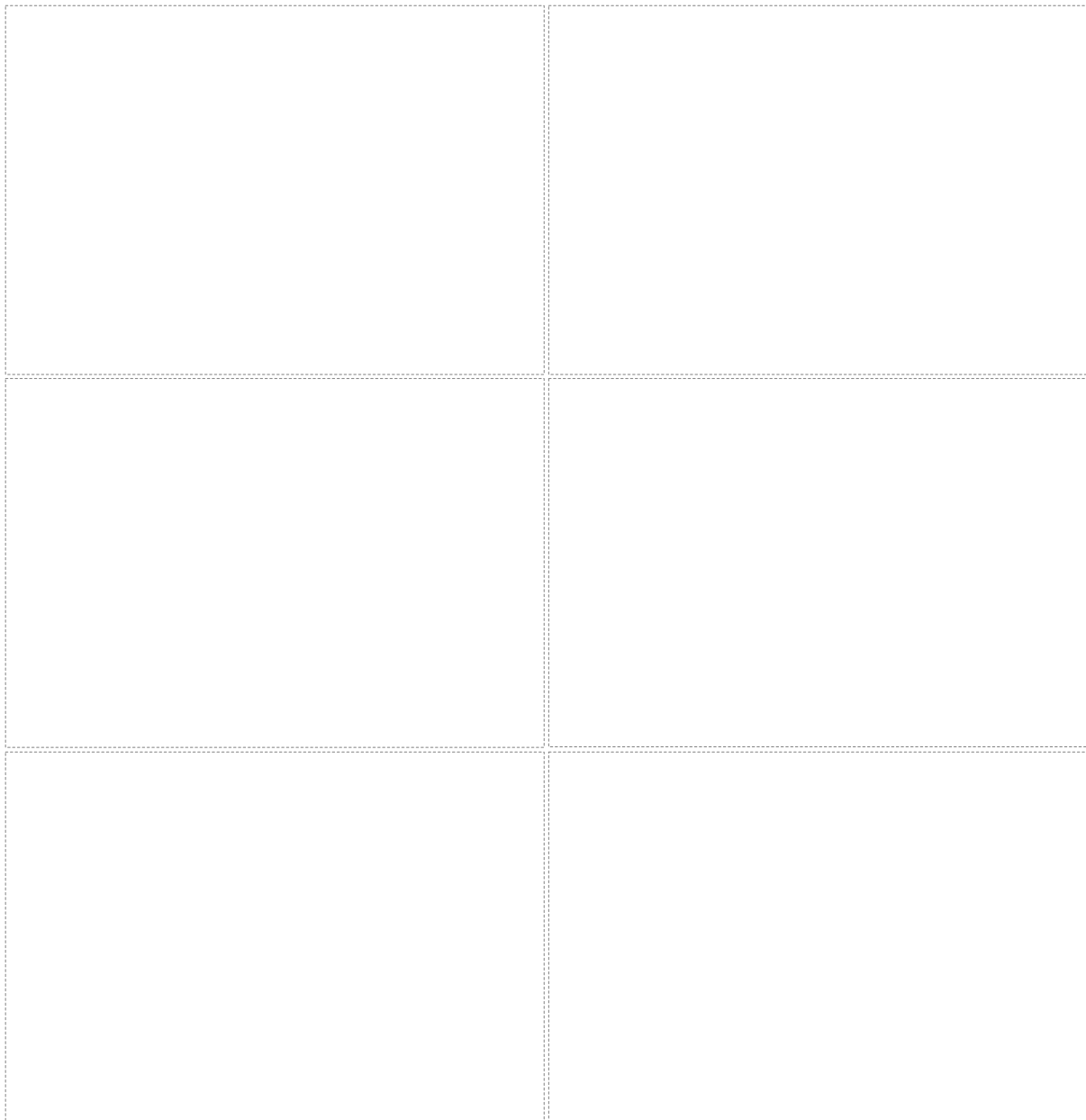


Fig. 4. Standardized photographs of a patient at maximal frowning at baseline (Above, left), 2 days (Above, right), 5 days (Center, left), 13 days (Center, right), 17 days (Below, left) and 1.5 months (Below, right) after Botox injection. 4 U of Botox was injected on the midline of the glabella (procerus; black dot), 4 U at the strongest vertical frown lines on each sides (origin of corrugator; white dots) (Above, left). Note the skin ripples (arrows) that imply the remaining muscle activity of the corrugator supercilii muscles (Center, left) which is interpreted as the over-contraction compensating the loss of contractile function and disappears in a week. Note eradication of glabellar frown lines (Center, right, Below, left). The insertion of right corrugator is located more laterally than that of left. After 1.5 months, glabellar lines begun to reappear but were still less prominent than at baseline (Below, right).

results and increase patients' satisfaction.

VI. CONCLUSION

In most patients of our study, the corrugator muscles are not

either symmetrical or tightly attached to the surface anatomical landmarks like eyebrows, pupils or supraorbital rims. Hence it is essential to locate the origin and the insertion of the muscle and decide the superolateral injection points of corrugator muscles based on the functional anatomy. We could map out the inser-

tion of corrugator muscles more accurately and determine the superolateral injection point more precisely by observing muscle movements and fine wrinkles on skin surface. Consequently, we could obtain more predictable and desirable cosmetic results and heighten patients' satisfaction.

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