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Novel anatomical proposal for botulinum neurotoxin injection targeting depressor anguli oris for treating drooping mouth corner

Kyu-Ho Yi[1,2,*], Ji-Hyun Lee[3,*], Hye-Won Hu[2], You-Jin Choi[4], Kangwoo Lee[2], Hyung-Jin Lee[5], Hee-Jin Kim[2]

[1]Wonju Public Health Center, Wonju, [2]Division in Anatomy and Developmental Biology, Department of Oral Biology, Human Identification Research Institute, BK21 PLUS Project, Yonsei University College of Dentistry, Seoul, [3]Department of Anatomy and Acupoint, College of Korean Medicine, Gachon University, Seongnam, [4]Department of Anatomy, Research Institute of Medical Science, Konkuk University School of Medicine, Seoul, [5]Department of Anatomy, Catholic Institute for Applied Anatomy, College of Medicine, The Catholic University of Korea, Seoul, Korea

Abstract: The depressor anguli oris (DAO) muscle is a thin, superficial muscle located below the corner of the mouth. It is the target for botulinum neurotoxin (BoNT) injection therapy, aimed at treating drooping mouth corners. Hyperactivity of the DAO muscle can lead to a sad, tired, or angry appearance in some patients. However, it is difficult to inject BoNT into the DAO muscle because its medial border overlaps with the depressor labii inferioris and its lateral border is adjacent to the risorius, zygomaticus major, and platysma muscles. Moreover, a lack of knowledge of the anatomy of the DAO muscle and the properties of BoNT can lead to side effects, such as asymmetrical smiles. Anatomical-based injection sites were provided for the DAO muscle, and the proper injection technique was reviewed. We proposed optimal injection sites based on the external anatomical landmarks of the face. The aim of these guidelines is to standardize the procedure and maximize the effects of BoNT injections while minimizing adverse events, all by reducing the dose unit and injection points.

Key words: Botulinum toxins, Depressor anguli oris, Drooping mouth corner, Dermotoxin, Anatomy

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Introduction

The depressor anguli oris (DAO) muscle is situated in the most superficial muscle layer of the perioral region [1, 2] The hyperactivity of DAO on both sides can cause the mouth corner to pull inferiorly and laterally, resulting in a droopy appearance. Unilateral contraction of DAO can cause asymmetry of the mouth [3]. The droopy appearance makes one look gloomy and is frequently treated using an injection of botulinum neurotoxin (BoNT), which relaxes the muscle [4]. BoNT prevents DAO contraction when injected into neuromuscular junctions, and hinders the release of acetylcholine from the presynaptic membrane [5]. Since the DAO, depressor labii ineferioris (DLI), and other perioral muscles partially overlap, an injection into the improper depth and location might cause undesirable facial animation [3, 6].

Therefore, consideration of anatomical factors with respect to the DAO and starting the primary treatment with a low dose of BoNT are important. In addition, knowledge of individual muscle variations is crucial for diagnosis [5]. Recent studies on BoNT injections in specific locations have been conducted as part of anatomical assessments of partic-

Corresponding author:
Hee-Jin Kim
Division in Anatomy and Developmental Biology, Department of Oral Biology, Yonsei University College of Dentistry, Seoul 03722, Korea
E-mail: hjk776@yuhs.ac

*These two authors contributed equally to this work.

ular muscles on the basis of external anatomical landmarks (Fig. 1) [7-31].

Clinicians treating DAO need to have a thorough understanding of the facial anatomy; however, few anatomical findings in the DAO have been reviewed with clinical application (area, depth, and units). The study narratively reviewed recently published articles of clinical and anatomical perspectives.

Review

Anatomy of DAO

The DAO is a triangular-shaped facial expression muscle that originates from the mental tubercle. Its continuation forms an oblique line below and lateral to the DLI muscle, which converges to the narrow fasciculus, blends with the modiolus, and interlaces with the orbicularis oris and the risorius (Fig. 2) [32]. The inferior and medial borders are known to be located 1.5 cm lateral to the mandibular symphysis. The inferior width of the DAO is 3.6 cm on average [3]. The action of the muscle is balanced at the modiolus by other perioral muscles. It dilates the mouth and bilaterally depresses the labial commissures. The depth of the DAO was located 0.25 to 0.4 cm from the skin surface as of our measurement of 20 subjects.

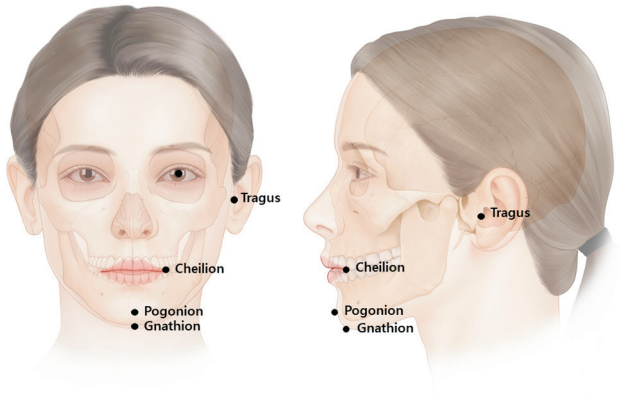

Fig. 1. Anatomical landmarks of soft tissue of the lower face.

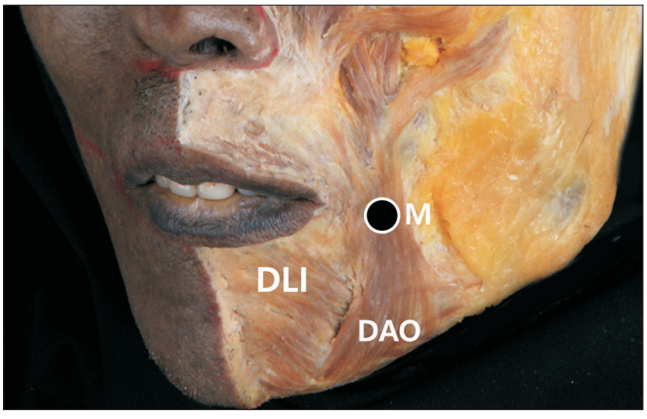

Fig. 2. The dissected image of the lower face representing depressor levator inferioris (DLI) and depressor anguli oris (DAO). The DAO originates from the mental tubercle and converges to the narrow fasciculus, blends with the modiolus (M) and interlaces with the orbicularis oris.

Anatomy of the modiolus

The modiolus is an important anatomical structure in the perioral area. Its thick muscular band is intermingled with the converging fibers around the cheilion, which consists of the zygomaticus major, DAO, levator anguli oris, buccinators, orbicularis oris, and risorius muscles. In the study of histologic sections, the modiolus was observed as a dense tissue with collagen and muscle fibers [33]. The modiolus is the insertion point of the perioral muscles and is heavily involved in lower facial expressions. Contrary to the case of Caucasians, the location of the modiolus in Asians is below the intercheilion line in 58.4% [34].

Injection points and methods

The injection points can be created by drawing crossing points using two lines: one vertical and one transverse. The

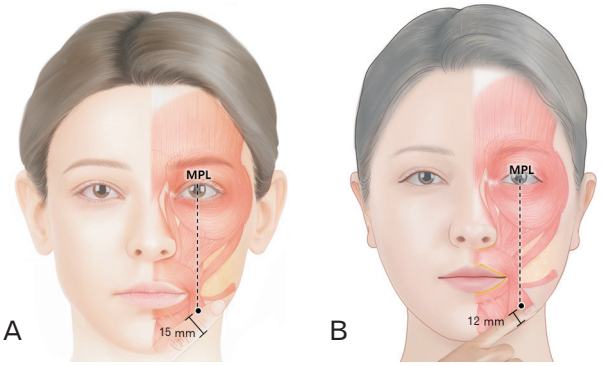

Fig. 3. Injection points of botulinum neurotoxin for targeting depressor angulii oris muscle. The dotted line is drawn vertically at mid-pupil point, mid-pupillary line (MPL), and the transverse dotted line is drawn in middle of line crossing the cheilion and tragus and the mandibular border. The intersection point of dotted lines is injection point (orange colored dot) for the muscle with 2–3 U. This would be easily applied by placing index finger (15 mm width) for caucasions (A) and little finger (12 mm width) for Asians (B) along the lower margin of the mandible.

vertical line is the line crossing the mid-pupil, and the transverse line is located in the middle of the lower mandibular border and the line that crosses the cheilion and tragus. One-point injection bilaterally, intradermally or subdermally, is proposed with 2–3 units (U) at each point. Since the modiolus is located below intercheilion line in most of the Asian population, the injection point is about the width of the index finger (1.5 cm) in the Caucasians and little finger (1.2 cm) in the Asian population (Fig. 3).

The injection should not be administered medially to the vertical line crossing the cheilion, which might affect inadvertent diffusion of the DLI muscle, leading to an asymmetric smile. If the patient does not have a sufficient effect, additional treatment should be conducted after primary treatment.

Conclusion

The diffusion of BoNT with 2–3 U per point is sufficient for any individual. Because BoNT spreads 1 cm from the injection point, injection into a minimum of three points with 1–2 U of BoNT, totaling 4–6 U, is recommended. Borodic et al. [35] demonstrated that BoNT diffuses up to 4.5 cm from the point of injection in case of 10 U administration into the rabbit longissimus dorsi muscle, and the diffusion gradient of 1 U injection is 1.5 cm to 3 cm.

Choi et al. [2] conducted cadaveric research on 43 hemifaces and discovered that the morphological angle of the DAO (from the modiolus to the lateral border of DAO had a mean of 44.7°±13.7° and that to the medial border was 31.8°±8.5°.

Another three-dimensional evaluation study in 90 hemifaces precisely located the outer landmark of DLI, at the point transversely between the cheilion and mid-sagittal line and vertically between the inferior mandibular border and inferior line of the vermilion border. The DAO was located vertically at the mid-pupillary line and transversely at the middle of the lower face. They described effective guidelines that only targeted DLI and DAO [36].

The anatomical location of the mental foramen has been evaluated by Hur et al. [3], alongside its variation within the DAO and DLI, depending on the individuals. Cadaveric dissection was conducted on 34 hemifaces; 67.7% were covered by DAO, and 22.3% were covered by DLI. Since the mental nerve spreads from the foramen, covered by these muscles, the injection should be administered superficially to avoid neural damage.

Lee et al. [37] discovered the facial artery runs beside the DAO along the lateral margin of the muscle and inferior labial artery running beneath the muscle. This indicates superficial injection is appropriate for not damaging the artery (Fig. 4). Additionally, we have observed the muscle with whole mount staining technique called Sihler's method. The intramuscular neural distribution was observed in evenly dispersed throughout the muscle (Fig. 5).

The DAO is a superficially located muscle near the mouth area that overlaps with nearby muscles. It is necessary to identify its detailed anatomical borders and depth when treating perioral asymmetry and a drooping appearance by injecting BoNT [38].

When correcting the depressed mouth corner, the platysma should also be targeted, as the muscle plays an important

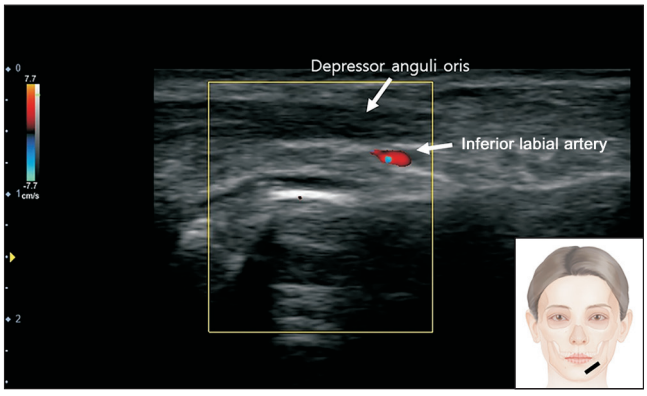

Fig. 4. The inferior labial artery runs beneath the depressor anguli oris muscle.

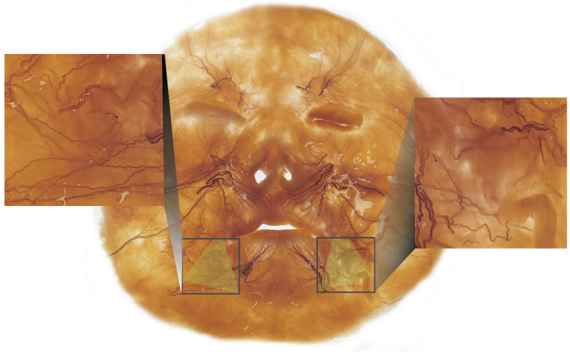

Fig. 5. Neural distribution of the face was revealed with whole mount staining method (Sihler's method) with motor and sensory distribution. The enlarged panel with depressor anguli oris (yellow shaded) demonstrates neural distribution of the muscle. The nerve distribution seems to evenly dispersed in the muscle region.

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role in pulling down the mouth corner [39]. The proposal based on anatomically dissected data would be sufficient to support blind injection into the DAO. However, it could be visualized with ultrasound-guided injection. The DAO and its virtual contraction can easily be observed on ultrasonography [40]. A limitation of this study was that it was not clinically applied. Further studies should be conducted in a clinical setting.

Overall, we propose that BoNT injections should be carried out intradermally or subdermally. They should be injected at the crossing point of the mid-pupillary line and at the middle of line crossing the cheilion and tragus and the mandibular border, with 2–3 U for each point.

ORCID

Kyu-Ho Yi: https://orcid.org/0000-0001-5572-1364
Ji-Hyun Lee: https://orcid.org/0000-0003-3732-2698
Hye-Won Hu: https://orcid.org/0000-0001-5460-6428
You-Jin Choi: https://orcid.org/0000-0003-3701-2200
Kangwoo Lee: https://orcid.org/0000-0001-8654-8306
Hyung-Jin Lee: https://orcid.org/0000-0002-3082-935X
Hee-Jin Kim: https://orcid.org/0000-0002-1139-6261

Author Contributions

Conceptualization: KHY, JHL. Data acquisition: HWH, YJC. Data analysis or interpretation: KL, HJL. Drafting of the manuscript: KHY. Critical revision of the manuscript: HJK. Approval of the final version of the manuscript: all authors.

Conflicts of Interest

I acknowledge that I have considered the Conflict of Interest statement included in the Author Guidelines. I hereby certify that to the best of my knowledge, no aspect of my current personal or professional situation might reasonably be expected to significantly affect my views on the subject I am presenting.

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