Anatomical Considerations Regarding the Location and Boundary of the Depressor Anguli Oris Muscle with Reference to Botulinum Toxin Injection

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Background: Hyperactivity of the depressor anguli oris muscle can lead to a drooping of the mouth corner, which can give a sad, tired, or almost angry look in some patients. Botulinum toxin type A has recently been used to relax these hyperactive muscles. However, it is difficult to inject botulinum toxin type A into the depressor anguli oris 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. The aims of this study were to determine the topography of the facial muscles at the mouth corner and to provide critical information for determining the safest and most effective depressor anguli oris muscle botulinum toxin type A injection site.
Methods: Forty-two hemifaces from Korean and Thai adult cadavers were dissected.
Results: The location of the modiolus was 11.0 ± 2.6 mm (mean ± SD) lateral and 8.9 ± 2.8 mm inferior to the cheilion. The angle formed by the sagittal line passing through the modiolus (L_V) and the line connecting the modiolus and the intersection point of the lateral border of the depressor anguli oris muscle and the mandibular border (L_{P2}) was 44.7 ± 13.7 degrees. The angle formed by L_V and the line connecting the modiolus and the most concave point of the medial border of the depressor anguli oris muscle (L_{P3}) was 31.8 ± 8.5 degrees.
Conclusion: These results suggest that the fan-shaped area bounded by L_{P2}, L_{P3}, and the mandibular border is the safest and most effective depressor anguli oris muscle injection site. (*Plast. Reconstr. Surg.* 134: 917, 2014.)

One of the many features that contribute to the aging appearance of the perioral region is drooping of the mouth corner. This appearance can generate a sad, tired, or almost angry appearance in some patients.[1] A common complaint when patients present for facial rejuvenation is an expression of sadness or discontent, which is made evident by drooping of the mouth corner.[2]

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Drooping of the mouth corner is usually attributable to hyperactivity of the depressor anguli oris muscle. The depressor anguli oris muscle arises from the oblique line of the mandible, inserts into the modiolus, and interlaces with the adjacent muscles. This muscle dilates the mouth and depresses the labial commissures bilaterally.

One of the minimally invasive methods for improving a droopy appearance of the mouth corner is botulinum toxin type A injection. Although this process requires readministration of the toxin after a given period for maintenance of its effect, it does not present the risks inherent in any surgical intervention. This procedure offers predictable and replicable outcomes with few risks and little discomfort.[2]

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Botulinum toxin type A is an established safe method for chemoimmobilization of the facial musculature. However, undesired outcomes are possible if the toxin is not used appropriately in the correct location and with the correct dosage. Inappropriate botulinum toxin type A injection can easily result in dysfunction of the perioral musculature, affecting facial expression, muscle movement, and articulation. Toxin injection within the depressor anguli oris muscle is particularly effective but also risky because of the proximity of the orbicularis oris and depressor labii inferioris muscles at this level. For safety purposes, injections should be carried out very superficially, more externally, and lower to avoid any effect on the depressor labii inferioris muscle.[3] Thus, physicians should have a detailed understanding of the facial anatomy before performing botulinum toxin type A injections. In addition, knowledge of the individual muscle variations is crucial for diagnosis.[4] The aim of this study was to determine the topographic facial muscle anatomy of the mouth corner (depressor anguli oris muscle, depressor labii inferioris, platysma, and risorius), thereby providing critical information for determining the safest and most effective depressor anguli oris muscle injection site for botulinum toxin type A.

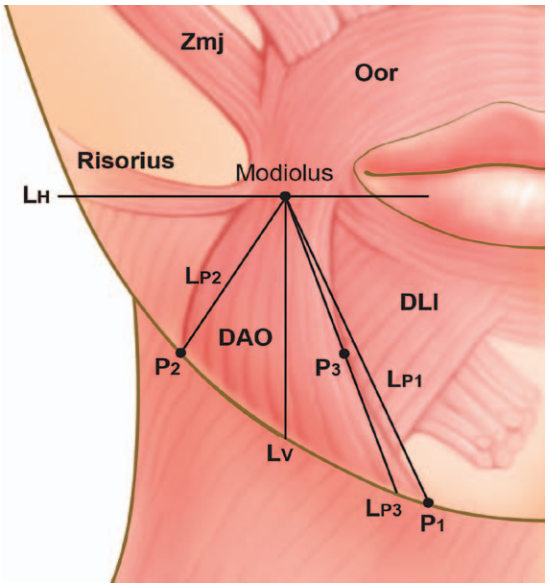


Fig. 1. Reference points and lines centered from the modiolus. *P1*, point at which the medial border of the depressor anguli oris muscle and the mandibular border meet; *P2*, point at which the lateral border of the depressor anguli oris muscle and the mandibular border meet; *P3*, most concave point of the medial border of the depressor anguli oris muscle; L_H, horizontal line passing through the modiolus; L_V, vertical line passing through the modiolus; L_{P1}, line connecting the modiolus and P1; L_{P2}, line connecting the modiolus and P2; L_{P3}, line from the modiolus to the point of the mandibular border passing P3.

MATERIALS AND METHODS

Forty-two hemifaces from Korean (20 hemifaces, nine left and 11 right; mean age, 69.1 years) and Thai (22 hemifaces, 11 left and 11 right; mean age, 78.4 years) adult cadavers (in total, 20 left and 22 right; mean age, 73.9 years) were dissected. In all specimens, the skin and subcutaneous tissues of the lower face were removed to expose the facial expression muscles, focusing on the modiolar region and lower lip. All authors were well informed regarding the World Medical Association Declaration of Helsinki, Ethical Principles for Medical Research Involving Human Subjects, and confirmed that the present study firmly fulfilled the declaration. All cadaveric objects in this study were legally donated to Yonsei Medical Center and Chulalongkorn University.

The relationships among the modiolus, the medial and lateral borders of the depressor anguli oris muscle, and the most concave point of the medial border of the depressor anguli oris muscle were noted. Reference points and lines were established before the following measurements were obtained (Fig. 1):

P1: point at which the medial border of the depressor anguli oris muscle and the mandibular border meet.
P2: point at which the lateral border of the depressor anguli oris muscle and the mandibular border meet.
P3: most concave point of the medial border of the depressor anguli oris muscle.
L_H: horizontal line passing through the modiolus.
L_V: vertical line passing through the modiolus.
L_{P1}: line connecting the modiolus and P1.
L_{P2}: line connecting the modiolus and P2.
L_{P3}: line from the modiolus to the point of the mandibular border passing P3.

The following dimensions were also measured using a protractor and digital caliper (CD-15CP; Mitutoyo, Kawasaki, Japan) capable of measuring to the nearest 0.01 mm:

1. Location of the modiolus (the horizontal distance between the cheilion and the modiolus/the vertical distance from the intercheilion line to the modiolus).

2. A_{HP1}: angle formed by L_H and L_{P1}.
3. A_{HP2}: angle formed by L_H and L_{P2}.
4. A_{VP3}: angle formed by L_V and L_{P3}.
5. A_{VP2}: angle formed by L_V and L_{P2}.

RESULTS

The modiolus in Asians (Koreans and Thais) was located 11.0 ± 2.6 mm (mean ± SD) lateral and 8.9 ± 2.8 mm inferior to the cheilion. There was no statistically significant difference in the location of the modiolus between the left and right sides ($p > 0.05$).

P1 was located 23.5 ± 6.4 mm medial and 30.9 ± 6.1 mm inferior to the modiolus; P2 was positioned 22.6 ± 8.6 mm lateral and 20.8 ± 8.3 mm inferior to the modiolus; and P3 was 10.6 ± 3.6 mm lateral and 17.9 ± 5.1 mm inferior to the modiolus (Table 1). There were no significant differences in the locations of P1, P2, and P3 between the right and left sides ($p > 0.05$).

Angles A_{HP1} and A_{HP2} relative to the horizontal line passing through the modiolus were 51.5 ± 9.8 degrees and 45.2 ± 13.7 degrees, respectively; the corresponding values of A_{VP3} and A_{VP2} were 31.8 ± 8.5 degrees and 44.7 ± 13.7 degrees, respectively (Table 2). A_{HP1}, A_{HP2}, A_{VP2}, and A_{VP3} did not differ significantly between the left and right sides ($p > 0.05$).

DISCUSSION

The continuation of the depressor anguli oris muscle forms an oblique line below and lateral to the depressor labii inferioris muscle, and it converges into a narrow fasciculus that blends at the modiolus with the orbicularis oris and risorius muscles.[5] The modiolus is the mobile muscular mass located at the lateral border of the mouth corner, and is formed by a convergence of the muscle fibers from the depressor anguli oris muscle and the zygomaticus major, orbicularis oris, risorius, buccinators, and levator anguli oris muscles.[6] The location of the modiolus varies between individuals and races. Contrary to the case in Africans and Caucasians,[7,8] in Asians (including Koreans and Japanese) the modiolus is located below the intercheilion line in 58.4 percent[9] and 45.1 percent[7] of cases, respectively. This means that the modiolus generally lies lower in Asian populations than in Caucasian and black populations.

The modiolus is directly involved in all of the forces acting on the mouth corner. Therefore, hyperactivity of the depressor anguli oris muscle can pull down the modiolar position, leading to drooping of the mouth corner, which can manifest in a depressed and gloomy expression. Application of botulinum toxin type A to the depressor anguli oris muscle, causing its inactivation, may lead to elevation of the mouth corner by its antagonists, such as the levator anguli oris and zygomaticus major muscles, which insert into the modiolus.

If botulinum toxin type A is injected at a point lateral to the depressor anguli oris muscle, the zygomaticus major, risorius, and platysma muscles can be influenced. If botulinum toxin type A is injected at a point medial to the depressor anguli oris muscle, the orbicularis oris and depressor labii inferioris muscles can be influenced. In such cases, botulinum toxin type A injection can result in unwanted changes or difficulties related to facial animation.

The target of botulinum toxin type A injection in a muscle may be determined based on its individual morphology, topographic relationships with adjacent muscles, and corresponding facial wrinkles or folds. Hur et al. provided critical information for the safest and most effective site for botulinum toxin type A injection into the depressor anguli oris muscle based on the relationships between this muscle and the mental foramen.[10] However, they did not present clinical and surface anatomical information targeting the depressor anguli oris muscle.

The detailed facial animations at the lower face, including those reflecting determination, satisfaction, smiling, purposeful action, and sadness, are made possible by muscles that terminate at the modiolus. The modiolus can be palpated effectively in the patient by using the opposing thumb

Table 1. Distances (mean ± SD, in millimeters) from the Modiolus to P1, P2, and P3*

	P1		P2		P3	
	x_1	y	x_2	y	x_1	y
Left side	23.7 ± 6.0	31.4 ± 6.7	–22.6 ± 8.8	20.4 ± 8.9	9.7 ± 3.6	17.6 ± 4.5
Right side	23.3 ± 6.9	30.4 ± 5.7	–22.6 ± 8.6	21.1 ± 7.8	11.5 ± 3.4	18.1 ± 5.7
Overall	23.5 ± 6.4	30.9 ± 6.1	–22.6 ± 8.6	20.8 ± 8.3	10.6 ± 3.6	17.9 ± 5.1

*Positive values mean that the position is medial (x_1) or inferior (y) to the modiolus; negative values mean that the position is lateral to the modiolus (x_2).

Table 2. Values of A_{HP1}, A_{HP2}, A_{VP2}, and A_{VP3}*

	A_{HP1}	A_{HP2}	A_{VP3}	A_{VP2}
Left side	52.7 ± 8.2	44.2 ± 15.1	28.9 ± 9.0	45.7 ± 15.1
Right side	50.5 ± 11.0	46.0 ± 12.8	35.1 ± 6.8	43.9 ± 12.8
Overall	51.5 ± 9.8	45.2 ± 13.7	31.8 ± 8.5	44.7 ± 13.7

*Values are mean ± SD (degrees).

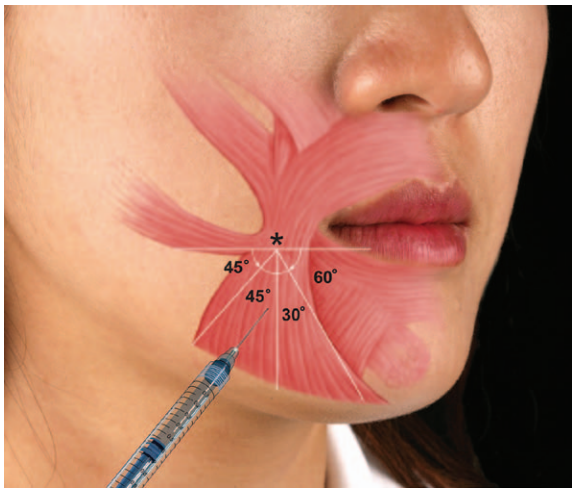


Fig. 2. The location relationship between the reference lines and perioral muscles. The medial and lateral borders of the depressor anguli oris muscle are sometimes difficult to determine because they can be close to the lateral border of the depressor labii inferioris and the platysma and risorius muscles, respectively. The present findings suggest that the fan-shaped area located at less than 45 degrees lateral and less than 30 degrees medial to the modiolus is only part of the depressor anguli oris muscle.

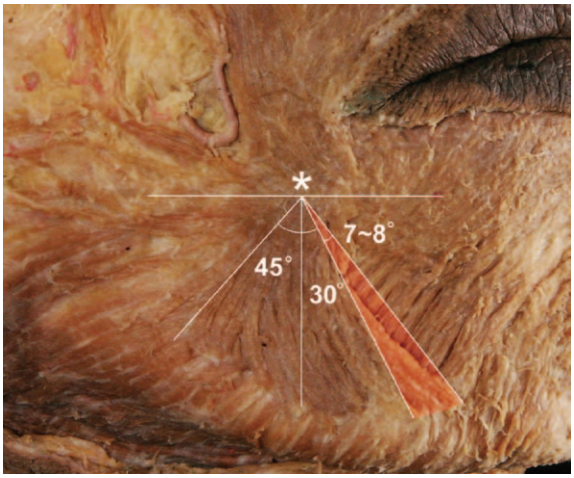


Fig. 3. The modiolus can be palpated using the fingers and may be used as a clinical landmark of the inferior face. It is very difficult to establish a singular, definitive location of the modiolus as a specific point in cadavers. However, it is possible to estimate the location of the modiolus in humans. Therefore, the modiolus may be a very important surface anatomical landmark for botulinum toxin type A injection into the depressor anguli oris muscle in the clinical setting. If the modiolus can be identified in patients, the botulinum toxin type A injection site in the depressor anguli oris muscle should be located less than 45 degrees lateral and less than 30 degrees medial to the modiolus with reference to L_V. If L_{P3} leans more medially at an angle of 7 to 8 degrees, the medial border of the depressor anguli oris muscle overlaps with the depressor labii inferioris in the *shaded area*. Therefore, the physician must avoid that *shaded area* when performing botulinum toxin type A injection into the depressor anguli oris muscle.

and index finger to compress the mucosa and skin simultaneously. Therefore, the modiolus is a very important clinical and surface anatomical reference of beauty and aesthetics of the lower face.

The depressor anguli oris muscle has a fan shape and is located at less than 45 degrees lateral and less than 30 degrees medial to the modiolus with reference to L_V. The platysma and risorius muscles are located on the lateral side of the depressor anguli oris muscle, and the depressor labii inferioris is located on its medial side.

It is difficult to predict the position of the medial border of the depressor anguli oris muscle because it lies between the depressor anguli oris muscle and the depressor labii inferioris in a medial curved line and differs between individuals. Therefore, L_{P3} can be used as a guide line when injecting botulinum toxin type A into the medial side of the depressor anguli oris muscle. The depressor anguli oris muscle and depressor labii inferioris muscle coexist in the area bounded by L_{P1} and L_{P3}. Thus, if botulinum toxin type A was injected into this area, it could influence both muscles and cause asymmetry of the lower face. The physician must therefore avoid this area when performing botulinum toxin type A injection to the depressor anguli oris muscle (Fig. 2). The present findings suggest that the following steps should be followed for botulinum toxin type A injection into the depressor anguli oris muscle:

1. Identify and check the location of the modiolus by palpating the cheek.
2. Draw a sagittal line passing through the modiolus (i.e., L_V).
3. Draw an oblique line with an angle of 30 degrees on the medial side of the modiolus (i.e., L_{P3}).
4. Draw an oblique line with an angle of 45 degrees on the lateral side of the modiolus (i.e., L_{P2}).

The fan-shaped area bounded by L_{P2}, L_{P3}, and the inferior margin of the mandible then represents the safest and most effective site for

botulinum toxin type A injection into the depressor anguli oris muscle (Fig. 3). The results of this study may be helpful for maximizing the efficacy and minimizing the side effects of botulinum toxin type A injection into the depressor anguli oris muscle.

CONCLUSIONS

The fan-shaped area with reference to the modiolus will be helpful for enabling physicians to perform safe and effective injection sites to the depressor anguli oris muscle. The findings of this study also provide clinical and surface anatomical information for injecting botulinum toxin type A into the depressor anguli oris muscle.

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REFERENCES

1. Perkins SW. The corner of the mouth lift and management of the oral commissure grooves. *Facial Plast Surg Clin North Am.* 2007;15:471–476, vii.
2. Goldman A, Wollina U. Elevation of the corner of the mouth using botulinum toxin type a. *J Cutan Aesthet Surg.* 2010;3:145–150.
3. Raspaldo H, Niforos FR, Gassia V, et al. Lower-face and neck antiaging treatment and prevention using onabotulinumtoxin A: The 2010 multidisciplinary French consensus—Part 2. *J Cosmet Dermatol.* 2011;10:131–149.
4. Kaplan SE, Sherris DA, Gassner HG, Friedman O. The use of botulinum toxin A in perioral rejuvenation. *Facial Plast Surg Clin North Am.* 2007;15:415–421, v.
5. Le Louarn C, Buis J, Buthiau D. Treatment of depressor anguli oris weakening with the face recurve concept. *Aesthet Surg J.* 2006;26:603–611.
6. Yu SK, Lee MH, Kim HS, Park JT, Kim HJ, Kim HJ. Histomorphologic approach for the modiolus with reference to reconstructive and aesthetic surgery. *J Craniofac Surg.* 2013;24:1414–1417.
7. Shimada K, Gasser RF. Variations in the facial muscles at the angle of the mouth. *Clin Anat.* 2005;2:129–134.
8. Greyling LM, Meiring JH. Morphological study on the convergence of the facial muscles at the angle of the mouth. *Acta Anat (Basel)* 1992;143:127–129.
9. Hu KS, Yang SJ, Kwak HH, et al. Location of the modiolous and the morphologic variations of the risorius and zygomaticus major muscle related to the facial expression in Koreans. *Korean J Phys Anthropol.* 2005;18:1–11.
10. Hur MS, Hu KS, Cho JY, et al. Topography and location of the depressor anguli oris muscle with a reference to the mental foramen. *Surg Radiol Anat.* 2008;30:403–407.