

**Effect of Unilateral Injection of Botulinum  
Toxin on Lower Facial Contouring  
Evaluated by Three-dimensional Laser Scan**

**Yu Rim Cha**

The Graduate School

Yonsei University

Department of Dental Science

**Effect of Unilateral Injection of Botulinum  
Toxin on Lower Facial Contouring  
Evaluated by Three-dimensional Laser Scan**

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**Yu Rim Cha**

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**This certifies that the doctoral dissertation  
of Yu Rim Cha is approved.**

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**Thesis Supervisor : Seong Taek Kim**

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**Thesis Committee Member : Jong-Hoon Choi**

---

**Thesis Committee Member : Hyung-Joon Ahn**

---

**Thesis Committee Member : Hee-Jin Kim**

---

**Thesis Committee Member : Chang-Sung Kim**

**The Graduate School**

**Yonsei University**

**December 2011**

## 감사의 글

치과의사로서 임상진료를 하며 기본적인 진료의 질을 향상시키기 위한 고민에서 시작한 대학원 생활이 어느새 박사과정의 논문이라는 마무리를 향해 나아가고 있습니다. 제 인생에 있어서 하나의 과정을 대과 없이 마칠 수 있도록 도와주신 여러분께 지면으로나마 인사를 드리려 합니다.

먼저 박사 과정 동안 연구에 매진할 수 있도록 아낌없는 격려와 지도를 해주신 김성택 교수님께 진심으로 감사 드립니다. 그리고 저의 논문 심사를 맡아주시고, 소중한 충고와 조언을 해주셨던 최종훈 교수님, 안형준 교수님, 김희진 교수님, 김창성 교수님 그리고 권정승 교수님께 깊은 감사를 드립니다. 열정적인 교수님들의 강의는 임상에서 환자진료와 치과의사로서 제 마음가짐을 정리하는데 많은 도움이 되었습니다.

바쁜 수련의 생활 중에도 여러 도움을 주신 김지현 선생님, 김영건 선생님과 다른 수련의 선생님들께도 진심으로 감사의 말씀 드립니다.

언제나 여러가지로 도움을 주고 지지해주는 남편과 시댁식구들, 항상 밝고 예쁜 딸 지윤이, 마지막으로 못한 딸 때문에 언제나 고생하시는 부모님께 진심으로 감사 드립니다.

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차 유림

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## **ABSTRACT**

# **Effect of Unilateral Injection of Botulinum Toxin on Lower Facial Contouring Evaluated by Three- dimensional Laser Scan**

**Yu Rim Cha**

Dental Science

The Graduate School

Yonsei University

Many patients want to make their hypertrophic masseter muscle slim to reduce a prominent mandibular angle. Surgical reduction has become known widely in the past, but bilateral botulinum toxin injection in masseter muscle which offers a less invasive approach than surgical reduction becomes the center of public interest in an alternative treatment for hypertrophic masseter muscle. The aim of this study is to measure the volume and thickness change in unilateral hypertrophic masseter muscle with unilateral botulinum toxin type A injection using 3D laser scanning unlike former bilateral injection treatment for bilateral masseter muscle hypertrophy. The volume and thickness of lower facial contour of 10 unilateral hypertrophic masseter muscle patients were measured with 3D laser scan before 25 units of botulinum toxin type A injected unilaterally. In same way, the volume and thickness of



lower facial contour was measured 4, 8, 12 weeks after injection and superposed 3D laser scan of before injection, and then changed volume and thickness were determined. While not injected side showed little change, mean values of the volume and thickness of injection side at each time point diminished obviously between preinjection and 4, 8, and 12 weeks after postinjection and showed statistically significant difference. Unilateral Botulinum toxin type A injection diminished the volume and thickness of unilateral hypertrophic masseter muscle significantly. Consequently it is considered that unilateral botulinum toxin type A injection is very helpful to the esthetic treatment for muscle induced facial asymmetry patients.

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Key Words : botulinum toxin, unilateral masseter hypertrophy

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**Yu Rim Cha, D.D.S., M.S.D.**

Department of Dental Science,  
The Graduate School, Yonsei University

(Directed by Prof. Seong Taek Kim, D.D.S., M.S.D., Ph.D.)

**I. INTRODUCTION**

Masseter muscle hypertrophy, so called a square jaw line, denotes an abnormal condition that masseter muscle swells in one or both sides of the face. Since Legg had reported it in 1880 for the first time by literature, most of the treatments for masseter muscle hypertrophy have been conservative and surgical procedures but botulinum toxin is widely studied to improve masseter muscle hypertrophy recently.

otulinum toxin is highly potent and can cause botulism, but it is also a highly efficacious medication that can produce clinical benefits in patients with nerve and muscle disorders. The major source of botulinum toxin is the organism *Clostridium botulinum*; *C.barati* and *C. butyricum* also produce the toxin. The toxin is synthesized in seven serotypes, designated A, B, C, D, E, F, and G. Only serotype A has been approved by the Food and Drug Administration for treatment of various medical problems (Simpson 1996). Injection of botulinum toxin into a muscle causes muscle paralysis by binding to the cholinergic motor endplates. It is then taken up by the motor neurons and blocks acetylcholine release, thus causing a presynaptic neuromuscular blockade. Functionally denervated muscle comes to decrease in volume and thickness (Mandel & Tharakan 1999).

Botulinum toxin is widely used in medical fields such as masseter muscle hypertrophy, protective ptosis, rhinitis, lacrimation, tremor and specially management of wrinkles since 1992 (Jost 2006). In dental field, dentists use botulinum toxin to treat masseter muscle hypertrophy, nocturnal bruxism, temporomandibular disorders, migraine pain and others (Lee *et al.* 2010, Schwarts & Freude 2002, Kim & Kim 2006).

Masseter muscle hypertrophy is usually found bilaterally and sometimes unilaterally. Some case reports showed successful treatment for unilateral masseter muscle hypertrophy (Castro *et al.* 2005, von Lindern *et al.* 2001, To *et al.* 2001), but few of them had exact assessment tools. Ultrasonography, electromyography and computerized axial tomography(CT) have been used in evaluation of effectiveness of botulinum toxin type A (BoNT-A) for masseter muscle hypertrophy since 1994. In measuring shrinkage of masseter muscle, however, assessment tools considering outer contour of masseter muscle are more important. In this context, three-dimensional image capturing tools were developed in cosmetic fields and Shim *et al.* reported in 2011 the change of volume and thickness of masseter muscle before and after bilateral

injection of BoNT-A in 15 patients using 3 dimensional laser scan, which said volume and thickness of masseter muscle diminished 12 weeks after the injection.

The aim of this study is to find if there is statistically significant difference in volume and thickness of masseter muscle with unilateral BoNT-A injection and without injection with 3D laser scanning.

## II. MATERIALS AND METHODS

### 1. Patients and Methods

This study was performed in accordance with the Tokyo (2004) revision of the 1975 Declaration of Helsinki. The study population consisted of 10 patients of Department of oral medicine, college of dentistry, Yonsei University with asymmetric masseter muscle hypertrophy who needed lower facial contouring.

BoNT-A (BTXA<sup>®</sup>, Lanzhou Institute of Biological Products, Lanzhou, China) supplied as a freeze-dried powder was reconstituted at a dose of 100 units in 2 ml of sterile saline to give a concentration of 5 units/0.1 ml. The reconstituted drug was used immediately. A total of 25 units of BoNT-A was injected into masseter muscle unilaterally using a 1-ml syringe with a 29-gauge, 1/2-inch-long needle. Areas of masseteric prominence on clenching were marked, and injected into two points at the center of the lower one-third of the masseter muscle separated by 1 cm.

The volume and thickness of masseter muscle was measured 4 times; before the injection, 4, 8, and 12 weeks after the injection using a Vivid 9i<sup>®</sup> laser scanner (Minolta, Tokyo, Japan) which emits a harmless Class I laser beam rated safe for eyes by the US Food and Drug Administration. All images were saved on a personal computer and merged into single 3D facial images using image analysis software (Rapidform<sup>®</sup> 2004, Inus Technology, Seoul, Korea). The border of the lower face was delineated by the following reference points: ala, cheilion, labral inferior, soft-tissue pogonion, soft-tissue menton, soft-tissue gonion, and tragion. The volume and bulkiest height of the lower face were measured bilaterally: BoNT-A injected side and not injected side.

### III. RESULTS

The volume and thickness of masseter muscle decreased with time (Table 1, 2, 3, 4 and Fig 1, 2). The mean values of the volume at each time point are shown in Table 5 and 6. The values of experimental group (BoNT-A injection side) showed more obvious decrease than those of control group (without BoNT-A injection side). In paired *t*-test and independent *t*-test experimental group showed statistically significant difference ( $p<0.005$ ), while control group showed no statistically significant difference.

The mean values of the bulkiest height at each time point are shown in Table 7 and 8. The values of experimental group show more obvious decrease than those of control group. In paired *t*-test experimental group showed statistically significant difference ( $p<0.005$ ), while control group showed no statistically significant difference.

In independent *t*-test experimental group showed statistically significant difference. ( $p<0.005$ )

The experimental group showed greater mean values of the reduction of muscle volume and thickness than control group.

Time	pre	4weeks	8weeks	12weeks
Exp	40026	38872	38461	37976
Control	35814	35541	35608	35626

Table 1. Mean value of the volume measured before the injection, 4, 8, and 12 weeks after the injection.

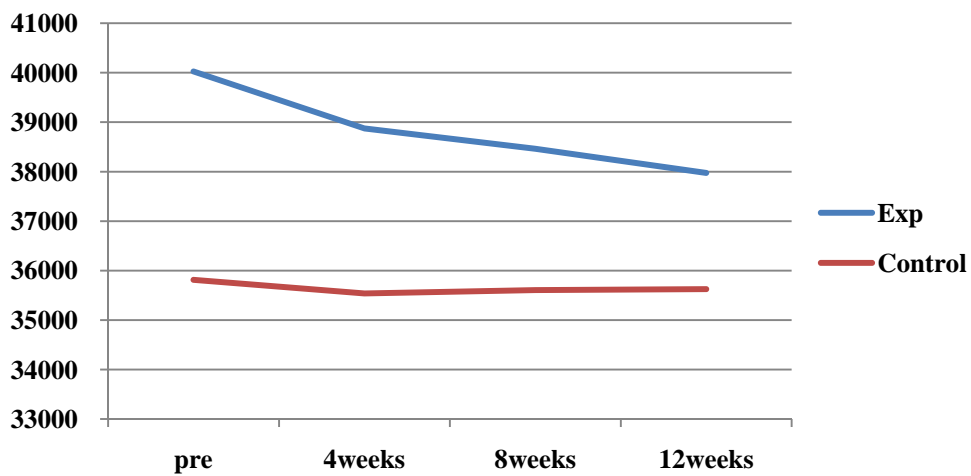


Fig 1. Mean value of the volume measured before the injection, 4, 8, and 12 weeks after the injection.

Time	pre	4weeks	8weeks	12weeks
Exp	0.00	-1.46	-2.06	-2.41
Control	0.00	-0.27	-0.33	-0.31

Table 2. Mean value of the thickness change measured before the injection, 4, 8, and 12 weeks after the injection.

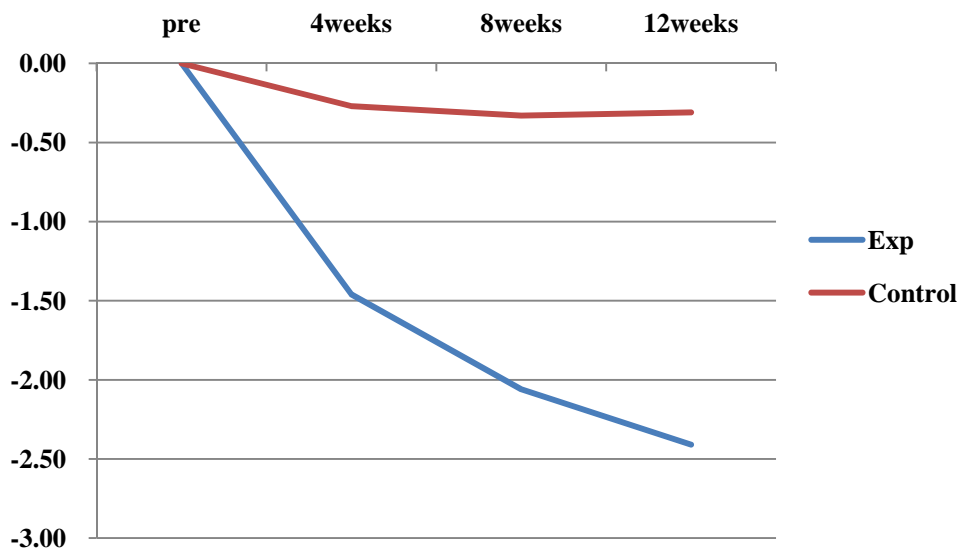


Fig 2. Mean value of the thickness change measured before the injection, 4, 8, and 12 weeks after the injection.



Volume diff	Pre-injection		4 weeks		8 weeks		12 weeks	
	Exp (mm)	Control (mm)	Exp (mm)	Control (mm)	Exp (mm)	Control (mm)	Exp (mm)	Control (mm)
<b>1</b>	0	0	980	360	363	171	2436	-308
<b>2</b>	0	0	1301	-155	2285	548	2734	109
<b>3</b>	0	0	1232	364	1812	1036	1839	439
<b>4</b>	0	0	1162	1339	1255	64	2298	601
<b>5</b>	0	0	931	1027	2165	856	1187	1397
<b>6</b>	0	0	600	20	1510	477	2275	35
<b>7</b>	0	0	3717	259	3665	553	4425	500
<b>8</b>	0	0	463	190	646	215	1050	260
<b>9</b>	0	0	424	-649	596	-1685	274	-670
<b>10</b>	0	0	728	-16	1349	-170	1984	-477

Table 3. Change of the volume measured before the injection, 4, 8 and 12 weeks after the injection using a Vivid 9i® laser scanner

Thickness Change	Pre-injection		4 weeks		8 weeks		12 weeks	
	Exp (mm)	Control (mm)	Exp (mm)	Control (mm)	Exp (mm)	Control (mm)	Exp (mm)	Control (mm)
<b>1</b>	0.0	0.0	-0.9	-0.5	-0.3	-0.3	-2.2	0.0
<b>2</b>	0.0	0.0	-1.3	0.0	-2.8	-0.7	-2.9	0.0
<b>3</b>	0.0	0.0	-1.5	0.0	-1.6	-0.4	-2.1	0.0
<b>4</b>	0.0	0.0	-1.5	-1.0	-2.2	-0.3	-2.8	-0.6
<b>5</b>	0.0	0.0	-1.3	-0.8	-2.7	-0.7	-1.2	-0.5
<b>6</b>	0.0	0.0	-0.4	0.0	-1.3	-0.3	-2.0	0.0
<b>7</b>	0.0	0.0	-3.9	-0.8	-4.3	-0.7	-4.5	-0.8
<b>8</b>	0.0	0.0	-0.8	-0.3	-1.5	-0.5	-2.0	-0.6
<b>9</b>	0.0	0.0	-1.0	0.7	-1.2	1.3	-0.9	0.3
<b>10</b>	0.0	0.0	-2.0	0.0	-2.7	-0.7	-3.5	-0.9

Table 4. Change of the Thickness of the muscle measured before the injection, 4, 8 and 12 weeks after the injection using a Vivid 9i® laser scanner

<b>Volume_diff</b>		<b>EXP</b>						<b>Control</b>					
<b>Time</b>	<b>Mean</b>	<b>SD</b>	<b>Std. Error</b>	<b><i>t</i></b>	<b>df</b>	<b>Sig</b>	<b>Mean</b>	<b>SD</b>	<b>Std. Error</b>	<b><i>t</i></b>	<b>df</b>	<b>Sig</b>	
<b>pre</b>	0.0	0.0	0.0				0.0	0.0	0.0				
<b>4weeks</b>	-1153.8	953.1	301.4	3.83	9	<b>0.004</b>	-273.9	568.5	179.8	1.52	9	0.162	
<b>8weeks</b>	-1564.6	984.5	311.3	5.03	9	<b>0.001</b>	-206.5	757.3	239.5	0.86	9	0.411	
<b>12weeks</b>	-2050.2	1121.4	354.6	5.78	9	<b>0.000</b>	-188.6	601.1	190.1	0.99	9	0.347	

Table 5. Mean change in muscle volume of experimental group and control group.  
(Paired test: comparison of mean value of pre-injection and each week)

Levene's test Equal variances assumed			Levene's test Equal variances not assumed		
<i>t</i>	df	Sig	<i>t</i>	df	Sig
-2.51	18	<b>0.022</b>	-2.51	15	<b>0.024</b>
-3.46	18	<b>0.003</b>	-3.46	17	<b>0.003</b>
-4.63	18	<b>0.000</b>	-4.63	14	<b>0.000</b>

Table 6. Mean change in muscle volume of experimental group and control group. (Independent test: comparison of mean value of BoNT-A injected side and not injected side at each week)

Thickness	EXP						Control					
	Mean	SD	Std. Error	<i>t</i>	df	Sig	Mean	SD	Std. Error	<i>t</i>	df	Sig
<b>Pre</b>	0.00	0.00	0.00				0.00	0.00	0.00			
<b>4weeks</b>	-1.46	0.97	0.31	4.78	9	<b>0.001</b>	-0.27	0.51	0.16	1.66	9	0.131
<b>8weeks</b>	-2.06	1.12	0.36	5.80	9	<b>0.000</b>	-0.33	0.60	0.19	1.74	9	0.116
<b>12weeks</b>	-2.41	1.06	0.34	7.17	9	<b>0.000</b>	-0.31	0.41	0.13	2.36	9	<b>0.042</b>

Table 7. Mean change in muscle thickness of experimental group and control group.  
(Paired test: comparison of mean value of pre-injection and each week)

Levene's test Equal variances assumed			Levene's test Equal variances not assumed		
<i>t</i>	df	Sig	<i>t</i>	df	Sig
-3.44	18	<b>0.003</b>	-3.44	14	<b>0.004</b>
-4.30	18	<b>0.000</b>	-4.30	14	<b>0.001</b>
-5.82	18	<b>0.000</b>	-5.82	12	<b>0.000</b>

Table 8. Mean change in muscle thickness of experimental group and control group. (Independent test: comparison of mean value of BoNT-A injected group and not injected group at each week)

## IV. DISCUSSION

Asian people generally do not like a square, wide-looking face, which has made contouring of the lower face one of most popular esthetic procedures in Asia. The use of BoNT-A has expanded as a treatment for masseteric hypertrophy in the presence of a square face because it is less invasive and is safer than surgical procedure (Kim *et al.* 2009).

Masseter muscle hypertrophy is an uncommon condition that can be presented as swelling of the masseter muscle. The origin of this condition is unclear because masticatory muscle hyperactivity or parafunction and dysfunction in the stomatognathic system cannot be verified in all instances of hypertrophy (Choe *et al.* 2005). Cases of muscular hypertrophy in connection with neuroleptically induced facial dystonia suggest that the hypertrophy may be attributed to a disturbance of the neurotransmitter balance between dopamine and acetylcholine (Choe *et al.* 2005).

Nevertheless, it is obvious that bite force contributes much to masseteric hypertrophy and the maximum bite force was significantly reduced after injection of BoNT-A for treatment of masseteric hypertrophy (Ahn & Kim 2007); Splint therapy which diminishes bite force has a short-term effect of reducing side-related asymmetries at masseter muscle sites (Bertram *et al.* 2001). On the grounds that BoNT-A denervates muscle diminishes bite force and finally decreases volume and thickness of muscle, BoNT-A is widely used in treating masseter muscle hypertrophy.

To produce satisfactory result, BoNT-A usually injected in masseter muscle bilaterally. Shim *et al.* (2011) reported the mean values of the volume and bulkiest height reduced by

2833.86mm<sup>3</sup> and 2.99mm, respectively, between preinjection and 12 weeks postinjection. In this study, unilaterally BoNT-A injection side showed decrease 2050.2mm<sup>3</sup> in the volume and 2.41mm in bulkiest height after 12 weeks. Less than bilateral injection, unilateral injection showed statistically significant differences in decreasing volume and thickness of masseter muscle. And not injected masseter muscle showed diminished volume and thickness too even though there was no statistically significant difference. Therefore, unilateral BoNT-A injection is effective at treating unilateral masseter muscle hypertrophy, which causes diminished bite force and, consequently, slight shrinkage of masseter muscle.

Commonly, BoNT-A injection for asymmetric masseter muscle hypertrophy is shot bilaterally with concern if unilateral shot gives rise to a hypertrophic masseter muscle in not injected side. But result of this study represents not injected sides of facial asymmetric patients did not show increased volume and thickness of masseter muscle.

The limitation of this study is what patients with facial asymmetry were not distinguished bony origin from muscle origin. So, future studies would be needed and should classify the origin of facial asymmetry. Also, an electromyography test would be needed in both sides of masseter muscle before and after unilateral BoNT-A injection to find if there is any change in bite force of both sides.



## **V. CONCLUSION**

The volume and thickness of masseter muscle showed statistically significant decrease with time, which improved patients' facial asymmetry. So, for a patient who wants less expensive treatment or more convenient eating, unilateral BoNT-A injection would be the best alternative treatment.

The unilaterally BoNT-A injected side showed greater mean values of the reduction of muscle volume and thickness than not injected side, which implies facial asymmetry could be corrected but for bony origin.

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## ABSTRACT (in Korean)

# 편측성 교근비대 환자에서 편측 보툴리눔 독소 주사 후 안모의 변화

<지도 김 성 택 교수>

연세대학교 대학원 치의학과

차 유 립

교근비대 환자들은 그들의 각진 턱을 심미적으로 개선시키기 위해서 교근의 두께를 줄이기를 희망한다. 과거에는 주로 수술적인 방법에 의존했지만 최근에는 교근에 보툴리눔 독소주사가 수술에 비해 덜 침습적이기에 그 대안으로 관심이 대두되고 있다. 이 연구의 목적은 기존의 양측성 교근비대에서 양측에 동량을 주사하는 방법과 다르게 편측성 교근비대 환자에서 보툴리눔 독소를 편측으로만 주입 후 삼차원 레이저스캐너를 이용하여 안모의 부피와 두께의 변화를 측정하고자 하였다. 삼차원 레이저스캐너를 이용하여 술전에 편측성 교근비대 환자 10 명의 하안모 부피와 두께를 측정한 후, 편측으로 보툴리눔 A 형 독소 주사 25U 이 주사되었다. 주사 4 주, 8 주, 12 주 후 같은 방법으로 하안모의 부피와 두께를 측정한 뒤 술전의 삼차원 사진과 중첩하여 변화된 부피와 두께를 비교하였다.

주사한 쪽의 부피와 두께는 술전에 비해 보툴리눔 독소 주사 4 주, 8 주, 12 주 후 현저히 줄어들었으며 통계학적으로 유의미한 결과를 보였다. 반면 주사안한 쪽의

부피와 두께는 특기할 변화가 없었다. 따라서 편측성 교근비대 환자에서 편측 보툴리눔 독소 주사 후 주사한 쪽의 부피와 두께가 현저히 감소하여 근육성 비대칭 환자에서 편측 보툴리눔 독소 주사가 심미적 개선에 도움을 줄 수 있을 것으로 사료된다.

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**주요단어:** 보툴리눔 독소, 편측성 교근비대