A proposal for safe and efficient botulinum toxin injection points of the temporal muscle in sleep bruxism

Won-Kang Lee, D.D.S., M.S.D.

Department of Dental Science,
The Graduate School, Yonsei University

A proposal for safe and efficient botulinum toxin injection points of the temporal muscle in sleep bruxism

Directed by Professor Seong-Taek Kim, D.D.S., Ph.D.

The Doctoral Dissertation
Submitted to the Department of Dentistry,
and the Graduate School of Yonsei University
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

Won-Kang Lee

June 2014

This certifies that the doctoral dissertation

of Won Kang Lee is approved.

Thesis Supervisor : Seong Taek Kim

Thesis Committee Member : Jong Hoon Choi

Thesis Committee Member : Hee Jin Kim

Thesis Committee Member : Hyung Jun Kim

Thesis Committee Member : Jae Gi Lee

The Graduate School

Yonsei University

June 2014

감사의 글

박사과정 동안 많은 분들의 도움으로 무사히 과정을 이수할 수 있었습니다.
박사과정 내내, 그리고 이 논문을 준비하는 동안 많은 가르침을 주신 김 성택 교수님께 진심으로 감사 드립니다. 저에게 또 한 분의 마음 속 은사님이 생겼습니다. 교수님께 부끄럽지 않은 제자가 되겠습니다.

따뜻한 관심을 가져주신 최종훈 교수님, 김형준 교수님의 지도와 가르침이 큰 힘이 되었습니다. 많은 도움을 주신 해부학 교실의 김희진 교수님께 감사 드리며, 해부학 교실의 최유진선생님을 비롯한 조교 선생님들과 일러스트를 도와주신 김현주 선생님께 꼭 감사의 말을 전하고 싶습니다. 이재기 교수님, 너무 감사합니다. 말로는 다 할 수 없는 고마운 마음 잊지 않겠습니다. 바쁜 와중에도 배려와 관심을 가져주신 안형준, 권정승 교수님께도 감사 드립니다. 그리고 박주현선생님, 송지희 선생님을 비롯한 구강내과 수련의 선생님의 따뜻한 배려도 잊지 않겠습니다. 항상 식구처럼 대해주셔서 큰 도움이 되었습니다. 치과 의사 삶에 있어서 또 하나의 고향을 얻은 것처럼 마음이 참 든든했습니다.

오늘의 저를 있게 해주신 부모님 이방현, 현영주님과 오빠 이원걸, 그리고 세상에서 가장 마음이 넓은 남편 김 주동 부장에게 감사 드립니다. 엄마가 잘 챙겨주지 못해도 스스로 알아서 하고, 심지어는 엄마에게 힘내라고 위로해줬던 지환, 유환 두 아들에게 고맙다고 말하고 싶습니다. 항상 저에게 기운을 북돋아 주었던 친구 어광연, 조정미에게도 감사를 전합니다.

그리고 오늘의 저를 있게 해주신 마음 속 은사님이자 인생의 멘토이신 성재현 교수님께 감사의 마음을 전합니다.

미처 언급하지 못했지만 따뜻한 관심으로 도움을 주신 많은 선생님들께 마음속으로 깊이 감사 드립니다.

2014년 6월
저자 씀

TABLE OF CONTENTS

LIST OF FIGURES

Abstract

A proposal for safe and efficient botulinum toxin injection points of the temporal muscle in sleep bruxism

Won-Kang Lee, D.D.S., M.S.D.

Department of Dental Science,
The Graduate School, Yonsei University

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

Botulinum toxins (BoNT-A), purified exotoxins of *Clostridium botulinum*, have long been used for numerous neuromuscular disorders caused by muscular overactivation. Nowadays, the clinical indications for BoNT-A are constantly growing, ranging from the treatment of overactive skeletal muscle such as bruxism, to the management of painful disorders such as migraines.

The injection points on patients with bruxism are generally on the temporal region. For clinical applications on the temporal area, clinicians and investigators inject different anatomical regions. Optimizing the protocol for clinical use of BoNT-A is likely to improve the outcomes of therapy and is necessary in order to improve convenience for its use. In this study, we suggest a safe and efficient BoNT-A injection points, and generate a topographic map of considerable anatomic structures of the temporal region by dividing the temporalis muscle into 9 compartments.

19 sides of temporalis muscle from 10 Korean cadavers were used in this study. The superficial temporal artery (STA), middle temporal vein (MTV),

temporalis tendon and the temporalis muscle were studied. The relationship among the 3 components of the 9 total compartments, which were established using the reference line and the anterior, superior, and posterior boundaries of the temporalis muscle.

The shape of temporalis muscle above the zygomatic arch was rectangular with rounded upper right and left corners. The distance from the anterior temporalis margin to the posterior margin was the width of the temporalis rectangle and the distance from reference line to the superior temporalis margin was the height, so that the mean ratio of width to height was 5:4. With the results from this study, we set an outline of the temporalis muscle. We recommend A*m*, M*u* and P*m* as injection sites for BoNT -A on temporal region because there sites allow us to avoid large blood vessels and tendon, which improve the safety and efficacy of the injection. Further studies on the temporalis muscle's thickness and distribution of motor nerve ending might explore even more accurate injection points.

Key words : botulinum toxin, temporal region, injection point, compartment

A proposal for safe and efficient botulinum toxin injection point of temporal muscle in sleep bruxism

Won-Kang Lee, D.D.S., M.S.D

Department of Dental Science,
The Graduate School, Yonsei University

(Directed by Professor Kim Seong Teak, D.D.S., M.S.D., Ph. D.)

Introduction

Botulinum toxins(BoNT-A), purified exotoxins of *Clostridium botulinum*, are associated with care for numerous neuromuscular disorders.[1,2]These toxins inhibit neuromuscular transmission and have been used for the treatment of diseases caused by muscular over-activation, such as bruxism.

Bruxism, a dinural or nocturnal parafunctional activity that includes tooth clenching or grinding, can result in several orofacial lesions, such as tooth wear, periodontal lesions, temporo-mandibular joint disorders and muscular pain.[3,4] Recent advances have shown that bruxism is caused by centrally mediated high levels of motor activity in the jaw muscles[5,6],and that abstaining from this activity may be helpful in reducing symptoms. BoNT-A, which blocks the release of acetylcholine, can inhibit muscle contraction, and may be used to alleviate bruxism[7-10]. In clinical applications in sleep bruxism, clinicians and investigators have used injection techniques with differing anatomical injection sites. The method of administering BoNT-A for bruxism therapy will determine, in part, the overall clinical outcome. Optimizing the protocol for clinical use of

BoNT-A is likely to improve the outcomes of therapy, and is also necessary to improve convenience of use. There is no established or standardized method for injecting BoNT-A for bruxism treatment. Inconsistencies across studies in the way BoNT-A is administrated may contribute to variations in clinical outcomes. Several therapeutic modalities have been employed, including the use of an oral splint, medication, and behavioral approaches, but none have been reported to be fully effective[11-13]. As more clinicians involved in the care of patients with sleep bruxism consider BoNT-A as a potential treatment, the need for a standardized protocol for drug administration increases. In this study, we suggest a proposal for safe and efficient BoNT-A injection points in the temporal muscle and generate a topographic map of considerable anatomic structures of temporal region by dividing the temporalis muscle into 9 compartments.

Materials and Methods

19 sides of temporalis from 10 Korean cadavers(7males and 3 female: mean age, 76.6years) were used in this study. Among 20 sides of the temporalis of 10 cadavers, one side was excluded because of history of surgery on the temporal area. 10 cadavers were embalming with a fluid containing 10% phenol/formaldehyde. The skin and underlying subcutaneous loose areolar tissues were removed, and a detailed dissection was performed, with extreme care taken not to damage the underlying main structures. The lateral canthus of the eye and tragus of the ear were set as landmarks to establish the reference line. The diameters of the superficial temporal artery at the level of the bifurcation and the front of the tragus were measured. The vertical distance from the reference line to the bifurcation point of the superficial temporal artery was also recorded. After that, the superficial temporal fascia and the superficial layer of the deep temporal fascia were removed to expose the middle temporal vein which passed across the temporal muscle insertion about 3cm above the zygomatic arch. Next, the deep temporal fascia was removed to expose the whole temporalis muscle. All the boundaries of the temporalis

muscle were disclosed. The most anterior, posterior and superior points of the temporalis were marked on the direct tracing sheet. The uppermost end of the temporalis tendon was noted. After each layered dissection of every specimen, photographs were taken after superimposing the clear guide sheet and performing direct tracing.

Anatomical landmarks and measurements were recorded as follows (Figure 1) ;

C: the lateral cathion of the eye

T: tragus of the ear (the most prominent point of tragus)

C-T : the reference line

A: the most anterior point of the temporalis

(A' : the contact point between the reference line and the perpendicular line from A)

P: the most posterior point of the temporalis

(P' : the contact point between the reference line and the perpendicular line from P)

S: the most superior point of the temporalis

E : the most posterior point of the ear lobe

(E' : the contact point between the referene line and the perpendicular line from E)

A'~P' : the width of the temporalis

A'~S' : the vertical height of the temporalis

A'~S'/ A'~P' : the ratio of the vertical height to width

A'~C : the distance from the canthus to the temporalis anterior margin

T~P' : the distance from the tragus to the temporalis posterior margin

On the disclosed boundary of the muscle, landmark A is the most anterior point of the temporalis muscle while S is the most superior point and P is the most posterior point. A', P' is the contact point between the reference line and the perpendicular line from A or P respectively. The temporalis muscle can be divided into 3 parts as anterior 1/3, middle 1/3 and posterior 1/3 according to its anatomical and functional characteristics. We divided the imaginary temporalis muscle rectangle into 9 compartments. From superficial to deep layers, the

topography of all anatomical structures considered were observed and measured.

Result

1) Temporalis muscle

When we assumed the line from A' to E' as the width of rectangle of temporalis and the distance from reference line to superior temporalis margin as the height, the average width of the temporalis muscle was 117.6mm, and the average height was 96mm. The mean ratio of width to height was 5:4. Though each specimen had various numerical values of width and height, the ratio between them was almost identical. The mean distance between A' and C was 3mm. Therefore, the anterior margin of the temporalis and the lateral canthus and be regarded as the same perpendicular level based on the reference line. The average distance between P' and T was 26.5mm. As the shape deformation of cadaveric ears was too severe, it was impossible to measure the distance from the tragus to E'. This distance played very important role for us in order to conceive the imaginary temporalis exterior to the skin. The distances from T to E' were measured in 20 male volunteers. The average distance from T to E' was 29mm. Though it was reported that no statistically significant loss of length occurred when the muscles were attached to the skeleton[14], muscle shrinkage may have occurred when the cadavers were fixed in embalming fluid. Therefore, it was acceptable that the most posterior margin of the temporalis to be asimilar vertical level to that of ear. Given the above information, we could figure to ourselves the imaginary temporalis superior to zygomatic arch, which was rectangular and had rounded upper right and left corners. (Fig.1)

2) Superficial temporal artery (STA)

The STA arises from the external carotid artery. It runs along the posterior margin of the condylar process of the mandible, and crosses the posterior root of the zygomatic process of the temporal bone[15]. Above the zygomatic arch, it divides into 2 large terminal branches: the anterior frontal branch and the posterior parietal branch[16]. Though the numerous reports have described the superficial temporal artery, few articles about the topography of this artery,

especially with temporal anatomical landmarks, could be found in the temporal region exterior to the skin. The data were divided into three parts: (1) the position of bifurcation from the reference line; (2) the compartment to which the position of the bifurcation belongs; and (3) the diameter of the vessels. The location of the STA at the level of the reference line averaged 20.9mm anterior to the tragus of the ear. The mean outer diameter of the superficial temporal artery was 3.0mm which was greater than those of its branches. There were not only STA but also STV, which appears relatively thickly at the borderline between M*l* and P*l*. Injections into this area should be given carefully. Almost all cases had bifurcations above the reference line. one case had bifurcation on the reference line. The location of bifurcation was 40mm superior to the reference line and within M*m*. (Fig.2)

3) Middle temporal vein (MTV)

The MTV started close to the lateral orbit angle, formed by small affluents from the epicranial surface[17]. Its course had two segments: one horizontal and the other vertical. The horizontal segment passed across the temporal muscle 2.5cm above the reference line. Its average diameter was 4.26mm. It turned downwards and descended almost vertically to join the superficial temporal vein at the level of the tragus. The compartment that the horizontal section ran in all specimens was M*l*. (Fig.2)

4) Temporalis tendon

The temporalis tendon appeared as the lower concentrated part of the tendinous insertion lamina[18]. The tendinous insertion lamina was very thick and radiated aponeurosis. It was first hidden deep in the muscle, but then appeared outwards and narrowed into a broad tendon, and extended very high through the muscle. In all the specimens, this lamina separated the temporalis muscle in a sagittal plane into two unequal parts. The superficial part was tiny and thin and inserted on the medial aspect of the deep temporal fascia and the lateral aspect of the lamina. Sometimes, it was confused with the deep temporal fascia. The deep part, which had been described the temporalis itself was thicker than the superficial part and was inserted inward on the temporal fossa and outward on the medial aspect of

the lamina. The insertion lamina did not reach the temporalis and thus did not separate the muscle completely throughout its entire depth. A dissection of the superficial part of the temporalis over the tendinous lamina showed the latter ends between the upper ends and the three lower quarters of the muscle. It showed the different characteristics among the three parts of the temporalis, anterior 1/3, middle 1/3, and posterior 1/3. The anterior part of anterior 1/3 showed few tendinous insertion lamina superior to the zygomatic arch and the reference line. The latter part of anterior 1/3 had low-positioned insertion lamina within A*l*. In the middle 1/3 of the temporalis, the tendinous insertion lamina extended very high through the muscle, reaching M*m*. In almost all cases, the most superior margin of tendinous insertion was higher than the position of STA bifurcation. It occupied the entire M*l*, extended to M*m*, but none extended beyond M*u*. As the ear occupied the P*l* space and masked the tendinous insertion, was not observed in the posterior 1/3.(Fig.2)

The results were arranged according to each compartment as follows:(Figure 2)

Compartment A*l*

: Its anterior part was almost occupied by the temporal process of the zygomatic bone.

Cautions should be taken so that the vicinal Orbicularis oris muscle is not affected.

Compartment M*l*

: The relatively thick middle temporal vein passed with an average diameter of 4.26mm. All areas were covered with the thick tendinous insertion lamina. The anterior area of the tragus, the border line between M*l* and P*l*, should be averted, because the superficial temporal artery and vertical segment of the superficial temporal vein ran along the vertical axis. The STA bifurcation point was also in M*l*.

Compartment P*l*

: It was mostly taken up by the ear. It is not suitable for the injection.

Compartment A*m*

: There was no considerable anatomic landmark or tendinous insertion that

needed to be avoided. Temporalis muscle was well developed. It is recommendable injection site.

Compartment M*m*

: The tendinous insertion lamina extended very high through the muscle occupying Mm. Compartment P*m* & M*u*

: Though there were some tributaries of blood vessels, there were few anatomical structures to be sidestepped. The temporalis of this area is thick and well-developed with no tendinous extension in it. P*m* and M*u* were two of the most suitable injection points. Pm was an especially effective injection point and lay just above the superior margin of the ear.

Compartment Au & Pu

: There were no considerable anatomical structures in Au and Pu. This sites are not recommendable for injecting toxin. Moving to the superior and posterior regions, the thickness of temporalis muscle lessened. Muscle in these areas was too thin the drug to work effectively. Therefore, these areas were excluded from the recommended injection sites.

To summarize the results above, Am, Pm and Mu are the best sites for BoNT-A injection to treat sleep bruxism.(Fig.3)

Discussion

The BoNT-A injection for bruxism, first described by Van Zandijcke and Marchau, [19] has been reported to be an effective treatment. [20-24] According to a recent study by Young Joo Shim et al., BoNT-A injection could not reduce the frequency, number of bursts or duration of rhythmic masticatory muscle activity (RMMA) episodes, but it could decrease the peak amplitude of EMG bursts and reduce the frequency of RMMA episodes in sleep bruxism.[25] It is equally as effective as nocturnal oral splints for bruxism.[31] Some studies have injected BoNT-A in both the masseter and temporalis muscles for severe bruxism patients[19,20,26,27], whereas other studies reported that masseter muscle injection alone could effectively reduce nocturnal bruxism.[21-24,] Many studies showed that the bruxism activity was significantly reduced after BoNT-A injection in the

masseter muscle, but the activity still persisted in the temporalis muscle. It is expected that injection into the two masticatory muscles would be more effective than injection into one muscle. [29] Though many investigators have studied the efficacy of botulinum toxin in bruxism, there are few description of the exact injection technique, which has not been established yet. There was no established methodology for the injection of BoNT-A for sleep bruxism. If there were some reasonable guidelines for injection, we could have practiced the BoNT-A injection for sleep bruxism with easy and feeling relieved. While there are definite guideline for masseteric muscle injection sites,[30] there are no such guideline for temporalis muscle injections. Moreover, the unfavorable result of an "hourglass deformity" of the facial region can result from depression of the temporal area prompted by injection by an improper site in the temporalis and an imappropriated dose of BoNT-A.[28] Therefore, more research must be done in order to create guidelines for the temporalis muscle injections.

There are many considerable anatomical structures like arteries and veins in the temporal region of the face. The injection technique involves placing the toxin into the temporalis muscle while making an effort not to damage any surrounding blood vessels. It may be helpful to reduce adverse effects after injection. To improve the efficiency of the drug, injections have to be given in the muscular areas rich with motor nerve terminal endings. The injections that avoided the tendinous area with few motor nerve ending suggested improvement in the efficacy of the toxin. Moreover, it could reduce the possibility of post-injection tendinitis, which often elicited after contract with a needle.

Because the temporalis muscle cannot be seen through the skin, we created imaginary muscle boundaries under the skin. It is more difficult to palpate the muscle boundaries of temporalis than to do the same of masseteric muscle. The temporalis is larger and its boundary more blurred than that of masseteric muscle, so clinicians hesitate to inject toxin with confidence in temporal region. Additionally, there are many anatomical structures to be considered in the temporal region. It is necessary to understand the topography of the temporal region before performing BoNT-A injection. Studies that have explored the

distribution of the superficial temporal artery in Asian (Tien-Hua Chen et. al[34]) reported the distance from the STA to the surrounding bony skeletal landmark. In that report, the STA was 1.14cm anterior to the anterior margin of the bony external auditory canal and its bifurcation point was about 5cm above the zygomatic arch. The superficial temporal artery was present approximately to the front of the tragus with the distance of 2.09cm along the vertical axis and divided by two branches 4.0cm above the reference line in this study. Bony landmarks like the anterior border of the external auditory canal and the zygomatic arch cannot be seen through the skin. It is thus easier to identify more noticeable soft tissue landmarks than bony landmarks with the naked eye, so we based the reference line on the lateral canthus of the eye – and the tragus of the ear (most prominent point) in this study. The considerable differences between two studies didn't found. Considering the difference between the landmarks, the results were similar enough that we could use the numerical values of the measurements to guess the topography of anatomic structures. Chebotarev et al.(2007)[31] found similar results. We had to be careful not to damage the blood vessels in the space in front of tragus during injection.

We estimated the location of the temporalis muscle boundary upon analyzing data recorded from this study. As A (anterior boundary of the temporalis muscle) was nearly the same vertical level as the canthus (average distance: 3.0mm), we drew a line perpendicular to the point canthus as the anterior boundary of the temporalis. The posterior margin of the temporalis muscle was in the same condition as that of anterior. Because the linear distance between E' and P' was not significant (2.5mm), considering E' as P' can account for the shrinkage of cadaveric muscle fiber. After drawing the muscle boundaries in mind, those boundaries were then divided into 9 compartments. We divided the muscle into smaller compartments to simplify the relationship between soft tissue landmarks and anatomic structures, and to more easily propose a proper injection site. The relative positional ratios between the anatomic structures were constant throughout the specimens. First, establish the reference line as canthus- tragus, and the distance from C to E' as the bottom side of the temporalis rectangle. Then,

the vertical side of rectangle can be configured at the rate of 80% of the bottom side. Based on the results of this study, A*m*, M*u* and P*m* are suitable injection sites. In all specimens, the superior quarter of the temporalis was free from any tendinous tissue. BoNT-A affected the motor nervous system predominantly by inhibiting the release of neurotransmitters from the nerve terminal. This occurred by injecting toxin directly into the temporalis muscle regions rich with motor nerve terminal endings. The tendinous area was poorly innervated, with sensory nerves instead of motor ones, the majority of which were located within the paratendon and not the tendon itself[33]. Therefore, it was better to inject toxin above the tendinous uppermost end instead of within the tendon area. All injections would be best done within the hairline to avoid the development of anterior temporal fossa atrophy. The injection points A*m*, M*u* and P*m* were all within the hair line, which reduces the risk of a deficient temple developing. Although we proposed the safe and efficient injection area in the form of a compartment, it was impossible to suggest the exact injection point not an area. Further studies might look for an more exact location for the injection, and carry out the following: (1)Measure the thickness of temporalis muscle around the suggested compartment to ensure the most optimal position(using ultrasonic, for the thickness of temporalis can be measured in vivo); (2)Verify the position by studying deep temporal nerve distribution via the sihler's stain method to observe the efficiency of botulinum toxin; (3)Study the diffusion area if the suggested dose were injected in human temporal region in vivo and; (4)Study the deep temporal artery further, for although the position of the main arteries supplying the temporalis muscle is deep enough to overlook the possibility of injection injury, it would be of help to know the site's relative position within 9 compartments to proceed with confident.

Conclusion

In this study, new sites were suggested for safe and efficient BoNT-A injection onto the temporal muscle to treat sleep bruxism. According to the results of this study, clinicians can follow the following protocol when injecting BoNT-A for

muscle overactivation treatments such as bruxism in temporal region, to see superior results:

1. Establish the lateral canthus of the eye and the tragus of the ear as landmarks for the reference line.
2. Draw a line perpendicular to the point canthus(equal to the most anterior margin of the temporalis muscle)
3. Draw a line perpendicular to the most posterior point of the external ear lobe (similar to the most posterior margin of the temporalis muscle)
4. Draw an imaginary rectangle according to the ratio of width versus height of 5:4
5. Divide the rectangle into 9 smaller compartments.
6. Among the compartmenst, A*m*, M*u* and P*m* were recommendable for injection sites. (fig.3)

With this protocol, we can anticipate more effective outcomes in bruxism treatments and thus reductions in adverse side effects.

References

1. Blitzer A, Sulica L. Botulinum toxin: basic science and clinicaluses in otolaryngology. Laryngoscope 2001;111:218-26.
2. Yin S, Stucker FJ, Nathan CO. Clinical application of botulinum toxin in otolaryngology, head and neck practice (brief review). J La State Med Soc 2001;153:92-7.
3. Bader G, Lavigne G. Sleep bruxism; an overview of an oromandibular sleep movement disorder. Sleep Med Rev 2000;4:27-43.
4. Pavone BW. Bruxism and its effect on the natural teeth. J Prosthet Dent 1985;53:692-6.
5. Kato T, Thie NM, Huynh N, Miyawaki S, Lavique GJ. Topical review: sleep bruxism and the role of peripheral sensory influences. J Orofac Pain 2003;17:191-213.
6. Lavigne GJ, Huynh N, Kato T, Okura K, Adaachi K, Yao D, Sessle B. Genesis of sleep bruxism: motor and autonomic-cardiac interactions. Arch Oral Biol 2007;52:381-4.
7. Van Zandijcke M, Marchau MM. Treatment of bruxism with botulinum toxin injections. J Neurol Neurosurg Psychiatry 1990;53:530.
8. Ivanhoe CB, Lai JM, Francisco GE. Bruxism after brain injury: successful treatment with botulinum toxin-A. Arch Phys Med Rehabil 1997;78:1272-3.
9. Tan EK, Jankovic J. Treating severe bruxism with botulinum toxin. J Am Dent Assoc 2000;131:211-216.
10. Pidcock FS, Wise JM, Christensen JR. Treatment of severe post-traumatic bruxism with botulinum toxin-A: case report. J Oral Maxillofac Surg 2002;60:115-7.
11. Okeson JP. The effects of hard and soft occlusal splints on nocturnal bruxism. J Am Dent Assoc 1987;114:788-91.
12. Saletu A, Parapatics S, Saletu B, Anderer P, Prause W. Putz H, Adelbauer J, Saletu-Zyhlarz GM. On the pharmacotherapy of sleep bruxism: placebo-controlled polysomnographic and psychometric studies with clonazepam. Neuropsychobiology 2005;51:214-25.

13. Lobbezoo F, Van der Zaag J, Van Selms MK, Hamburger HL, Naeije M. Principles for the management of bruxism. J Oral Rehabil 2008;35:509–23.
14. Cutts A. Shrinkage of muscle fibres during the fixation of cadaveric tissue. J Anat 1988;160:75-8.
15. Abul-Hassan HS, von DrasekAscher G, Acland RD. Surgical anatomy and blood supply of the fascial layers of the temporal region. Plast Reconstr Surg 1986;77(1):17-28.
16. Sinna R, Hajji H, Qassemyar Q, Perignon D, Benhaim T, Havet E. Anatomical background of the perforator flap based on the deep branch of the superficial circumflexiliac artery (SCIP Flap): A cadaveric study. Eplasty. 2010;10:11.
17. Cvetko E. A case of an unusual arrangement of numerous tributaries to the middle temporal vein and its fenestration. Surg Radiol Anat 2013;35:355-7.
18. Bénateau H, Alix T, Labbé D, Elissalde JM, Salamé E. Anatomic study of the tendinous insertion lamaina of the temporalis muscle. Sur Radiol Anat 2004;26:281-4.
19. Van Zandijcke M, Marchau MM. Treatment of bruxism with botulinum toxin injections. J Neurol Neurosurg Psychiatry 1990;53:530.
20. Ivanhoe CB, Lai JM, Francisco GE. Bruxism after brain injury: successful treatment with botulinum toxin-A. Arch Phys Med Rehabil 1997;78:1272–3.
21. Watts MW, Tan EK, Jankovic J. Bruxism and cranial cervical dystonia: is there a relationship? Cranio 1999;17:196–201.
22. Tan EK, Jankovic J. Treating severe bruxism with botulinum toxin. J Am Dent Assoc 2000;131:211–6.
23. Pidcock FS, Wise JM, Christensen JR. Treatment of severe post-traumatic bruxism with botulinum toxin-A: Case report. J Oral Maxillofac Surg 2002;60:115–7.
24. See SJ, Tan E. Severe amphetamine-induced bruxism:Treatment with botulinum toxin. Acta Neurol Scand 2003;107:161–3.
25. Shim YJ, Lee MK, Kato T, Park HU, Heo K, Kim ST. Effects of Botulinum Toxin on jaw motor events during sleep in sleep bruxism patients: A polysomnography evaluation. J Clin Sleep Med 2014;10:291-298.

26. Nash MC, Ferrell RB, Lombardo MA, Williams RB. Treatment of bruxism in Huntington's disease with botulinumtoxin. J Neuropsychiatry Clin Neurosci 2004;16:381-2.
27. Guarda-Nardini L, Manfredini D, Salamone M, Salmaso L, Tonello S, Ferronato G. Efficacy of botulinum toxin in treating myofascial pain in bruxers: A controlled placebo pilot study. Cranio 2008;26:126-35.
28. Guyuron B, Rose K, Kriegler JS, Tucker T. Hour glass deformity after botulinum toxin type A injection. Headache 2004;44:262-4.
29. Lee SJ, McCall WD Jr, Kim YK, Chung SC, Chung JW. Effect of botulinum toxin injection on nocturnal bruxism: A randomized controlled trial. Am J Phys Med Rehabil 2010;89:16-23.
30. Kim DH, Hong HS, Won SY, Kim HJ, Hu KS, Choi JH, Kim HJ. Intramuscular nerve distribution of the masseter muscle as a basis for botulinum toxininjection. J Craniofac Surg 2010 Mar;21(2):588-91.
31. Chebotarev S, Petrishin VL. Topographic-anatomical aspects of nerve-saving operations in the temporal area and in the lateral part of a face. Morfologiia 2007;131(3):26-9.
32. Long H, Liao Z, Wang Y, Liao L, Lai W. Efficacy of botulinnum toxins on bruxism : an evidence- based review. Int. Dent.J 2012;62: 1-5.
33. Benjamin M, Kaiser E, Milz S. Structure-function relationships in tendons: a review. J. Anat 2008;212:211-28.
34. Chen TH, Chen C, Shyu JF, Wu CW, Lui WY, Liu JC. Distribution of the Superficial Temporal Artery in the Chinese Adult. Plast Reconstr Surg 1999 Oct;104(5):1276-9.

Legends

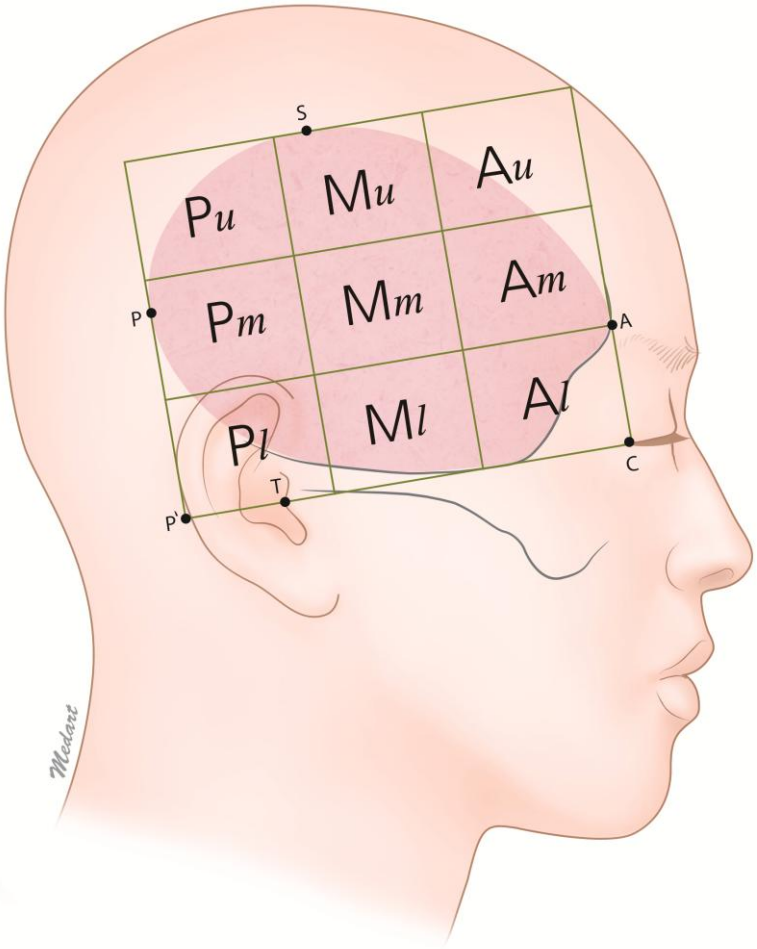

Figure. 1. Reference line and anatomical landmarks in temporal region. T: the tragus of the ear (the most prominent point of tragus), C-T : the reference line, A: the most anterior point of the temporalis, (A' : the contact point between the reference line and the perpendicular line from A), P: the most posterior point of the temporalis, (P' : the contact point between the reference line and the perpendicular line from P), S: the most superior point of the temporalis, E : the most posterior point of the ear lobe, (E' : the contact point between the referene line and the perpendicular line from E), A'~P' : the width of the temporalis, A'~S' : the vertical height of the temporalis, A'~S'/ A'~P' : the ration of the vertical height to width, A'~C : the distance from canthus to temporalis anterior margin,T~P' : the distance from the tragus to the temporalis posterior margin. The nine compartments were named as labeled above. A is for Anterior, M is for Middle, P is for Posterior, *l* is for lower, *m* is for middle, *u* is for upper

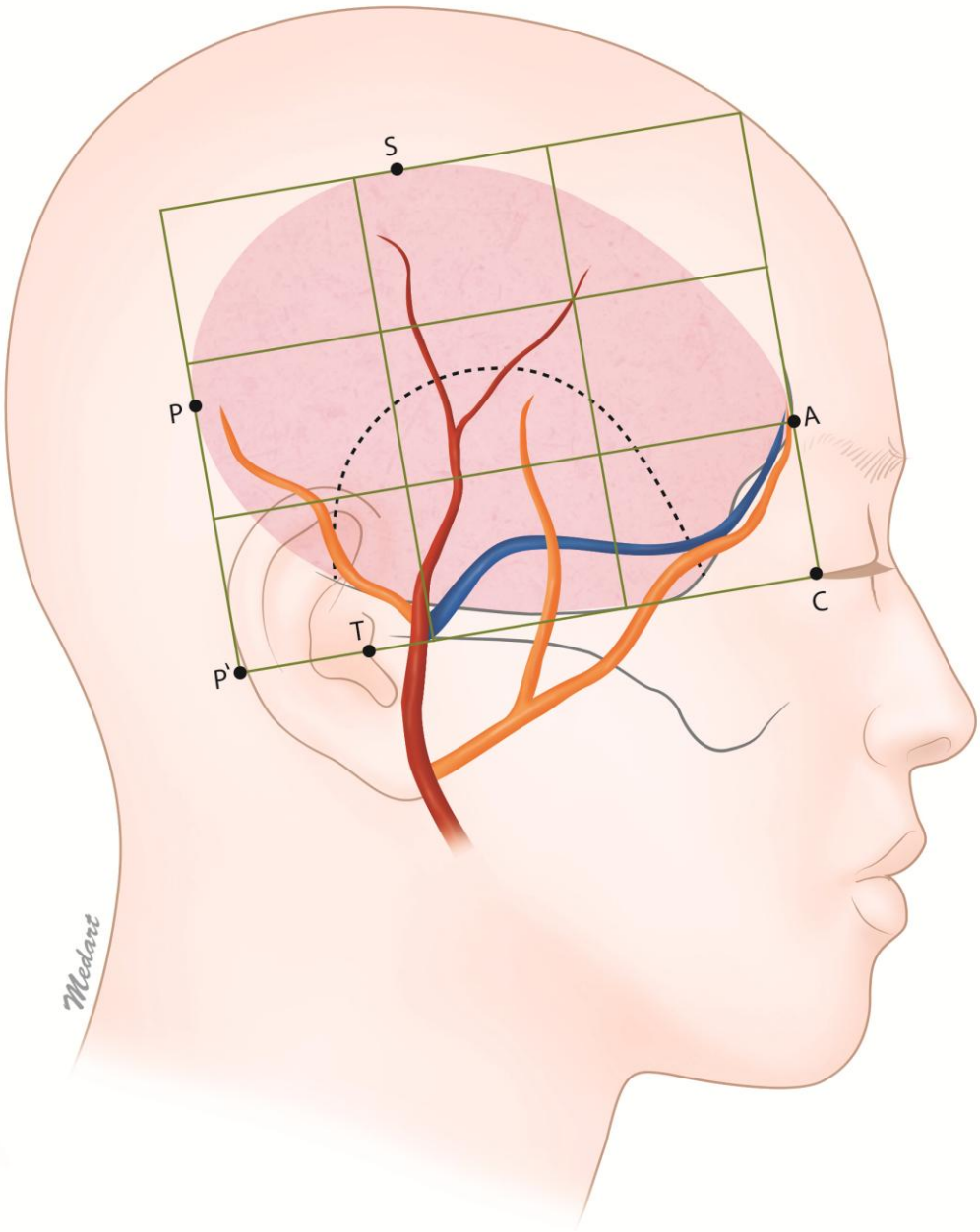

Figure 2. 9 Compartments and considerable anatomical structures

Red: superficial temporal artery, orange : deep temporal artery, blue : middle temporal vein, dot: uppermost end of the temporalis tendon

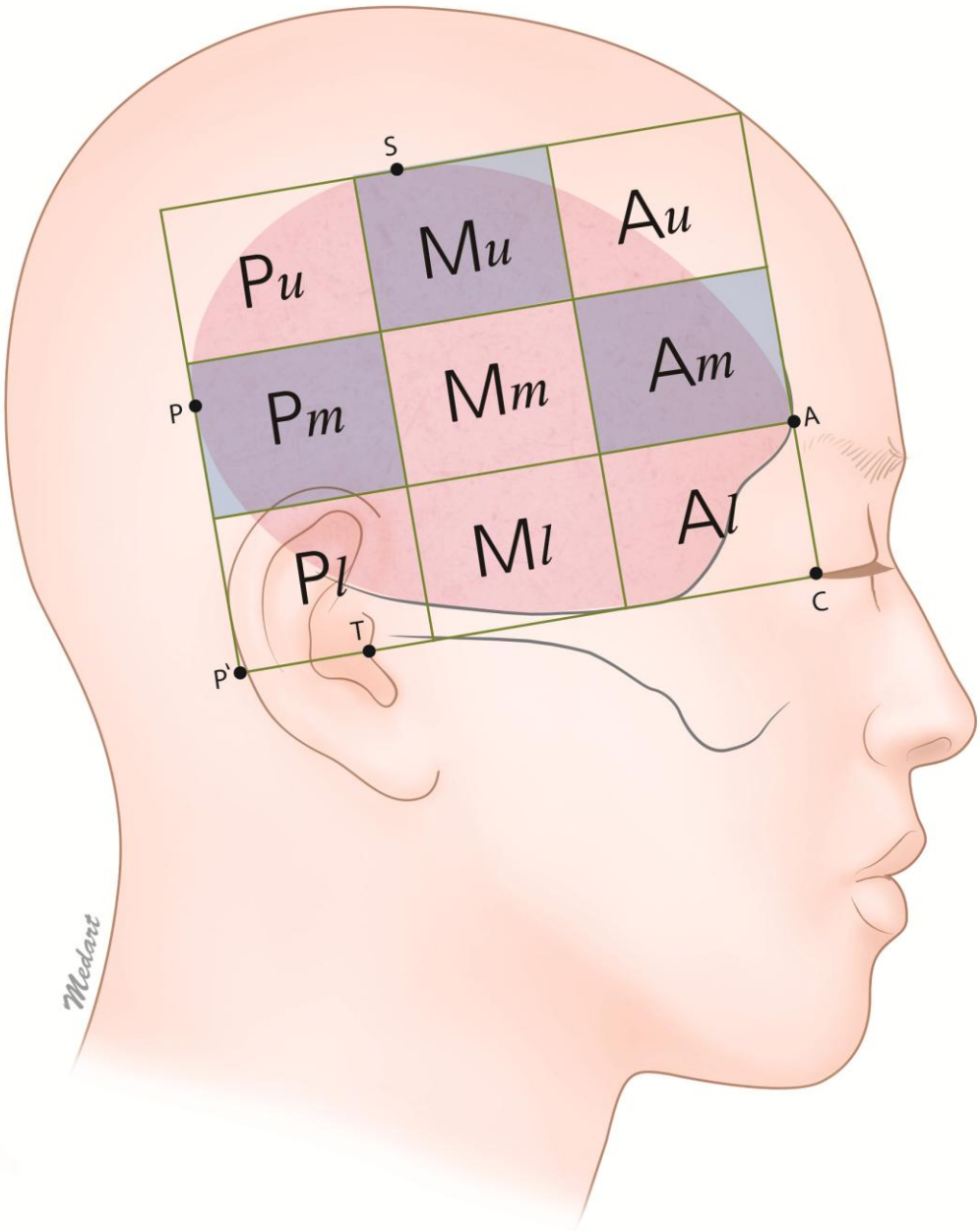

Figure3. Recommended injection sites and nine compartments. A*m*, M*u* and P*m* were most highly recommended as injection sites

Abstract(in Korean)

수면 이갈이에서 측두근의 안정적이고 효율적인 보툴리눔 독소 주사 점에 대한 제안

이 원 강

연세대학교 대학원 치의학과

< 지도교수 김 성 택 >

보툴리눔 독소는 *클로스트리디움 보툴리눔*(*Clostridium. botulinum*)이란 혐기성 박테리아에서 분비 되는 독소로 근육의 과활성과 관련된 근신경계 질환 치료제로 많이 사용되어왔다. 최근에는 이갈이 치료에도 사용 빈도가 증가되고 있다. 이갈이 치료에서는 측두근에 독소를 주사하는데, 치료를 위한 측두근 주사법은 아직까지 임상가나 연구가들 사이에 기준화 된 정석적 방법이 없다. 정확한 용량을 올바른 위치에 주사해야 약효를 극대화 할 수 있고 안전하게 사용할 수 있다. 이 연구의 목적은 야간 이갈이 치료를 위해 보툴리눔 독소를 측두근에 주사할 때 주변 해부학적 구조물과 측두근의 형태를 고려해 가장 효율적이고 안정적인 주사점을 제안하는 것이다. 더불어 주사할 때 측면에서 측두근을 직접 볼 수 없으므로, 찾기 쉬운 측두부 기준점을 근거로 측두근을 구획화하고, 구획 내 주요 해부학적 구조물의 상대적 위치관계에 대한 정보를 주고자 하였다.

모두 19쪽의 측두부를 층별로 해부하여 얕은측두동맥, 중간측두정맥, 측두근의 경계, 측두인대 의 위치관계를 기준점과 기준선을 근거로 살펴보았다. 또한 설정된 기준선과 측두근의 최전방, 최상방, 최후방 경계를 이용하여 측두부를 9개의 구획으로 나누어 각 구획 별로 주의해야 하는 해부학적 구조물의 상대적 위치관계를

조사하였다.

측두근의 관골 상방 부위는 좌, 우 윗 모서리가 둥근 직사각형에 가까운 형태였으며, 측두근의 전방경계에서 후방경계까지 거리를 가로, 기준선에서 측두근 상방경계까지의 거리를 세로로 설정하였을 때, 각 시료마다 수치는 서로 달랐지만 가로 : 세로의 비율은 5 : 4로 일정하였다. 측두근의 전방경계와 외안각은 거의 같은 수직선 상에 존재하였고, 측두근의 후방경계와 귀의 최후방경계도 수직선상의 거리 차이가 거의 없어 같은 수직선상에 존재한다 가정해도 무방하였다. 따라서 눈의 측면 안각과 귀의 가장 후방 부위까지의 거리를 가로로 설정하여 가로 : 세로 비율이 5:4가 되도록 사각형을 그리면 대략적인 측두근의 위치를 설정할 수 있었다.

측두근의 구획화 된 부위와 주요 해부학적 구조물의 상대적 위치관계를 모두 고려한 결과 4,6,8구획이 가장 주사하기에 적절한 부위였으며, 2구획은 주사 시에 반드시 피해야 하는 부위였다.

야간 이갈이 치료를 위해 측두근에 효과적이고 안전하게 보툴리눔 독소를 주사하기 위해서는 되도록이면 직경이 큰 혈관들과, 독소의 효율이 떨어지는 인대부위는 피하고, 근육이 많고 운동신경말단의 분포가 풍부한 곳에 주사하는 것이 좋다. 본 연구의 결과를 토대로 운동신경말단의 분포와 측두근 두께에 대한 연구가 더해진다면 더 정확한 주사 점의 제시가 가능할 것으로 생각된다.

핵심 되는 말 : 보툴리눔 A형 독소, 이갈이, 측두근, 주사 점, 구획