Computer-Aided Design/Computer-Assisted Manufacture–Derived Needle Guide for Injection of Botulinum Toxin into the Lateral Pterygoid Muscle in Patients with Oromandibular Dystonia

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Aims: To evaluate the effectiveness and safety of botulinum toxin administration into the inferior head of the lateral pterygoid muscle of patients with jaw opening dystonia by using a computer-aided design/computer-assisted manufacture (CAD/CAM)–derived needle guide. **Methods**: A total of 17 patients with jaw opening dystonia were enrolled. After the patient's computed tomography (CT) scan was imported and fused with a scan of a plaster cast model of the maxilla, the optimal needle insertion site over the lateral pterygoid muscle was determined using the NobelClinician software. A total of 13 patients were injected both with and without the guide, and 4 patients underwent guided injection alone. The therapeutic effects of botulinum toxin injection and its associated complications were statistically compared between the guided and unguided procedures using paired *t* test. **Results:** Botulinum toxin therapy was performed 42 and 32 times with and without the guides, respectively. The needle was easily inserted without any complications in all procedures. There was a significant difference ($P < .001$) between the mean comprehensive improvements observed with (66.3%) and without (54.4%) the guides. **Conclusion:** The findings suggest that the use of needle guides during the injection of botulinum toxin into the inferior head of the lateral pterygoid muscle is very useful for aiding the accurate and safe administration of botulinum toxin therapy for jaw opening dystonia. *J Oral Facial Pain Headache 2018;32:e13–e21. doi: 10.11607/ofph.1955*

Keywords: *botulinum toxin therapy, computer-aided design/computer-assisted manufacturing, jaw opening dystonia, lateral pterygoid muscle, oromandibular dystonia*

Although numerous researchers have published anatomical,[1–5] functional, and electromyographic (EMG) studies[6–17] of the lateral pterygoid muscle, it remains one of the most poorly understood muscles in the human body. The lateral pterygoid muscle is considered to have two heads: the inferior and superior. Anatomical studies have reported considerably large interindividual differences in the anatomy of the lateral pterygoid muscle[1–5]; these discrepancies might account for the difficulty in obtaining direct EMG recordings from this muscle. Various methods have been reported for inserting EMG electrodes into the inferior and superior heads of the lateral pterygoid muscle.[6–23] Most of these methods involve freehand manual needle insertion, which occasionally results in complications such as hematoma or arterial bleeding[9,11,12] from an injury to the maxillary artery. Widmalm et al[11] pointed out that the risk of hematoma was especially high during EMG recordings from the superior head of the lateral pterygoid muscle, and Koole et al[12] reported that 4 out of 11 subjects fainted during the insertion of electrodes into both heads of the muscle. An insertion splint fabricated on an articulator has been used to facilitate accurate and reproducible EMG electrode placement into the superior and inferior heads of the lateral pterygoid muscle.[13–17] The orientation and insertion points of the splint were based on the data from the anatomical measurements of 22 cadavers.[24] It was possible to place the electrodes accurately and reproducibly using the splint; however, the position of the electrode was not always the most suitable for botulinum toxin therapy.

Table 1 Demographic Characteristics of Included Patients

Patient no.	Age (y)	Sex	Disease duration (mo)	Other dystonia	Medical history	Tardive dystonia	Task specificity
1	29	F	12	–	Schizophrenia	+	Chewing
2	53	F	15	–	–	–	Speaking
3	38	M	180	Generalized dystonia	–	–	–
4	40	M	60	–	–	–	Speaking
5	30	M	8	Torticollis	Schizophrenia	+	Chewing, speaking
6	52	M	5	–	–	–	Speaking, chewing
7	65	F	8	–	–	–	Speaking
8	66	M	120	–	Parkinson disease	–	Speaking
9	40	F	16	Torticollis	Depression	+	Speaking, chewing
10	36	M	84	–	Schizophrenia	+	Speaking
11	45	M	16	–	–	–	Speaking
12	64	M	24	–	–	–	Chewing
13	43	M	36	Torticollis, blepharospasm	Depression	+	–
14	34	F	24	Writer's cramp	Panic disorder	+	Chewing
15	51	F	2	Writer's cramp	Depression	+	–
16	64	M	36	Torticollis, blepharospasm	–	–	Chewing
17	75	M	5	Writer's cramp	–	–	Chewing
Mean ± SD	48.5 ± 12.8	–	38.3 ± 48.3	–	–	–	–

Dystonia is a movement disorder characterized by sustained or intermittent muscle contractions that cause abnormal and often repetitive movements, postures, or both.[25] Oromandibular dystonia is a focal type of dystonia involving the masticatory and/or lingual muscles[26–28] and is subdivided into jaw closing, jaw opening, jaw deviation, jaw protrusion, and lingual dystonias, as well as a combination of these subtypes. The precise etiologies of these conditions remain unclear.[29,30] Dystonic contracture of the lateral pterygoid muscle can result in jaw opening, jaw deviation, or jaw protrusion dystonias and interferes with chewing, swallowing, and talking, resulting in social embarrassment and cosmetic disfigurement. In the most severe cases of jaw opening dystonia, temporomandibular joint (TMJ) dislocation followed by upper airway collapse can occur.[31]

The injection of botulinum toxin is the standard therapy for focal dystonias.[20–23,26,28,31–35] Botulinum toxin therapy is more effective when it is administered to the jaw closing muscles than when it is administered to treat the lateral pterygoid muscle,[28,32] which might reflect the anatomical complexity of the lateral pterygoid muscle and the difficulty of accurately inserting a needle into it.[19] Some patients with oromandibular dystonia exhibit dystonic contracture of the lateral pterygoid muscle.[19–23,26-29,31–35] Although the injection of botulinum toxin into the lateral pterygoid muscle requires skill and sufficient anatomical knowledge, such injections are rarely performed, and it is therefore practically impossible to become skilled at this procedure. Thus, it is necessary to establish a method that enables relatively inexperienced clinicians to correctly and safely inject botulinum toxin into the lateral pterygoid muscle.

Dental implants have emerged as a novel rehabilitative option for missing teeth. During dental implant placement, computed tomography (CT)–based templates are used to ensure precise implant placement and to reduce the risk of damage to adjacent structures.[36,37] The template is fixed in place in the oral cavity, making high-precision implant placement possible. This method might be useful for botulinum toxin therapy. The author of the present study modified the surgical template used for dental implant surgery and applied it to botulinum toxin injection. This report describes the use of a customized needle insertion guide during the injection of botulinum toxin into the lateral pterygoid muscle for jaw opening dystonia. The aim of the present study was to evaluate the effectiveness and safety of botulinum toxin administration into the inferior head of the lateral pterygoid muscle of patients with jaw opening dystonia by using a computer-aided design/computer-assisted manufacture (CAD/CAM)–derived needle guide.

Materials and Methods

Patients

A total of 69 patients with oromandibular dystonia (43 women and 26 men), all of whom exhibited dystonic contracture of the lateral pterygoid muscle, visited the author's department from August 2015 to July 2016. A total of 42 patients had jaw opening dystonia, 17 jaw deviation dystonia, and 10 jaw protrusion dystonia. Of these patients, 17 patients with jaw opening dystonia were randomly selected. After listening to a detailed and complete explanation of the planned treatment, they (6 women and 11 men; mean age with

Table 2 Rating Scale Used to Evaluate Oromandibular Dystonia

Points	Mastication scale	Speech scale	Pain scale	Discomfort scale
4	Only able to consume liquids	Inaudible (over 50% of speech)	Severe pain (visual analog scale score > 75%)	Severe discomfort
3	Finds it difficult and takes a long time to eat soft food	Inaudible (under 50% of speech)	Moderate, intermittent to continuous pain (visual analog scale score 50% to 75%)	Moderate to severe discomfort
2	Only able to eat soft food	Audible, but hard to comprehend	Mild continuous to moderate intermittent pain (visual analog scale score, 25% to 50%)	Mild to moderate discomfort
1	Able to eat anything, but it takes a long time	Finds it hard to speak clearly	Mild, intermittent pain (visual analog scale score, < 25%)	Mild discomfort
0	Normal	Normal	No pain	No discomfort

The clinical scoring system[29,39] was used to evaluate changes in the patients' symptoms. The total of the four subscores (0 to 4 points each) was used as the total comprehensive score (0 to 16 points).

standard deviation [SD] = 48.5 ± 12.8 years) agreed to participate in the current study. The demographic characteristics of the patients are summarized in Table 1. Thirteen patients had botulinum toxin therapy before this study started. Oromandibular dystonia was diagnosed on the basis of the patients' EMG findings and the characteristic clinical features such as stereotypy, task specificity, cocontraction, and morning benefit.[27,29,38,39] Of the 17 patients, 7 (41.2%) were on psychiatric medication and had tardive dystonia. In one patient (5.9%) the dystonia was secondary to Parkinson disease, and in nine (52.9%) it was idiopathic. Eight patients (47.1%) had another type of dystonia in a different part of their body (Table 1). Fourteen patients (82.4%) exhibited task specificity; ie, their dystonia only occurred during speaking or chewing. The patients' chief complaints were dysarthria, masticatory disturbance, and muscle pain, which were resistant to pharmacotherapy, dental treatment, and surgery.

All patients provided their written informed consent after listening to a detailed and complete explanation about the planned treatment that included the guided and unguided procedures. This study was performed in accordance with the Declaration of Helsinki after obtaining the approval of the institutional review board and ethics committee of the Kyoto Medical Center.

Evaluation of Symptoms

Masticatory disturbance, dysarthria, discomfort, and pain were assessed separately, as reported previously,[29,39] to evaluate the severity of the patients' symptoms. The average pain intensity in the past 2 weeks was examined using a 100-mm visual analog scale (VAS), the endpoints of which represented "no pain" and "the worst conceivable pain," respectively (Table 2). Other problems, including discomfort and esthetic issues, were evaluated using a scoring system for discomfort. Each of the four items was scored on a 5-point scale from 0 (normal) to 4 (severe symptoms), and the total of the four scores was used as a comprehensive measure of each patient's condition.[29,39] The severity of the symptoms was evaluated at the first visit and after the guided and unguided procedures. The pretreatment scores were evaluated again before the guided injections. Subjective ratings of improvement were also evaluated (see below).

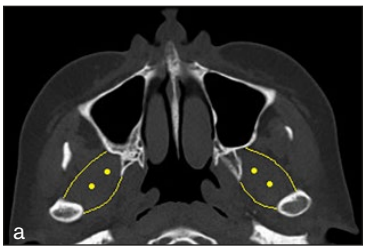
Needle Insertion Guide

CAD/CAM–derived needle guides were fabricated as follows:

CT scans were obtained without interarch teeth contacts with the patients occluding their incisors on an elastic block to avoid overlapping of the dental images of the opposing arches, which ensured that the occlusal surface of the arch was clearly visible and prevented involuntary movements during the scanning procedure. The CT data (slice width 0.5 mm) were stored in Digital Imaging and Communications in Medicine (DICOM) format.

An impression of the maxilla was taken with an alginate impression material and used to fabricate a master cast for each patient. After the direct importation and fusion of the patients' CT scans and images of their maxillary plaster models by using NobelProcera 2G (Nobel Biocare),[36] the most appropriate position (midportion of the muscle belly) to insert the needle tip into the inferior head of the lateral pterygoid muscle was accurately determined using NobelClinician version 2.4 (Nobel Biocare).[36]

The orientation and volume of the inferior and superior heads of the lateral pterygoid muscles and the relationship among the adjacent bones, such as the condyle, pterygoid plate, coronoid process, and maxillary tuberosity, were analyzed by using axial, frontal, sagittal, and three-dimensional images (Fig 1). Subsequently, two points approximately 10 to 15 mm apart within the midportion of the muscle for botulinum toxin injections were determined. The two points were set to allow adjustment of the needle tip for botulinum toxin injection into the center of the target muscle. The insertion point was defined as the mucobuccal fold of the distal root of the maxillary second molar. The orientation of two metal sleeves (medial and distal) for the anchor pins (10 mm long, 1.5 mm in diameter) that



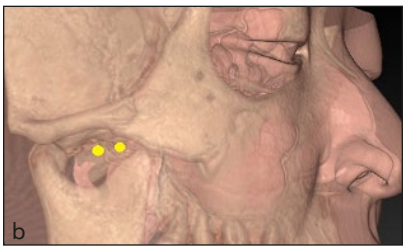
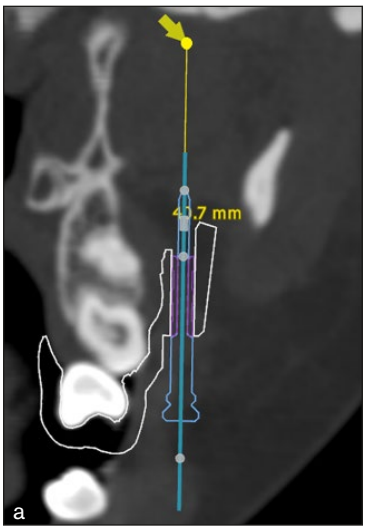
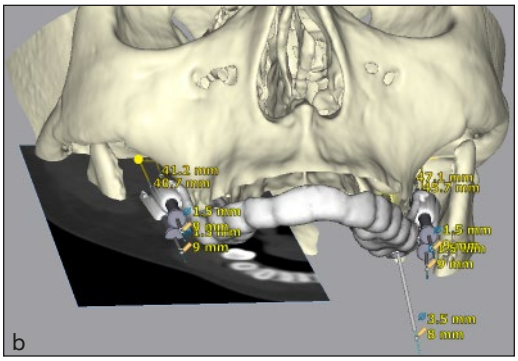


Fig 1 (a, b) Based on the data obtained from computed tomography and a plaster model, the orientation and volume of the lateral pterygoid muscles and the adjacent bony structures are checked using axial, frontal, sagittal, and three-dimensional images. Two points within the center of the inferior head of the lateral pterygoid muscle are determined for botulinum toxin injections.





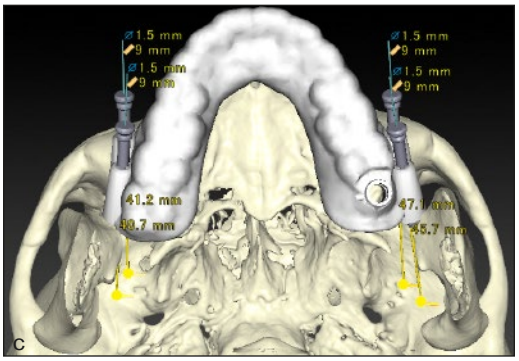


Fig 2 Design for the needle guide using CAD/CAM–based data. The orientation of the two metal sleeves (medial and distal) for the anchor pins from the insertion point to each of the two points inside the muscle is adjusted to avoid contact with the adjacent bony structures during needle insertion. The millimeter values represent distances from the metal sleeves to the target points *(yellow circles)* or length and diameter of anchor pins.

extended from the insertion point to each of the two points inside the muscle was adjusted to avoid contact with the adjacent bony structures during needle insertion (Fig 2). The distance from the metal sleeve penetration point to each point inside the muscle was recorded for each sleeve on both sides. A stereolithographic CAD/CAM–derived needle insertion guide was fabricated with a rapid prototyping machine (NobelGuide, Nobel Biocare) (Fig 3). Two metal guide sleeves were embedded into each side of the template. The guides were sterilized before use.

Botulinum Toxin Therapy

Botulinum toxin type A (Botox, Allergan) was reconstituted with normal saline to reach a final concentration of 2.5 to 5 units/0.1 mL. The guide was fixed to the patient's maxilla (Fig 4a), and a disposable hypodermic needle electrode (TECA MyoJect Luer Lock, 37 mm × 25 G, 50 mm × 25 G, Natus Neurology) was inserted through a metal sleeve (Fig 4b). The correct placement of the electrode was verified by evaluating the EMG activity during mouth opening or contralateral mandibular movement by using an EMG instrument (Neuropack n1, MEM-8301, Nihon Kohden) after amplification and filtering (low-cut filter, 10 Hz; high-cut filter, 3 kHz) and digitizing at a sample frequency of 10 kHz and 16-bit resolution. Subsequently, after aspiration, 10 to 25 units of botulinum toxin were injected into the inferior heads of the lateral pterygoid muscles.[35] The toxin was injected through the other sleeves in the same fashion. The needle guides were cleaned using an ultrasonic cleaner before being stored in a dry environment to permit their resterilization and use for subsequent injections.

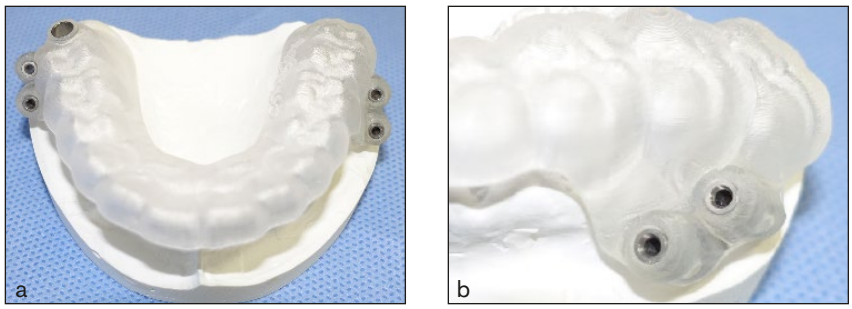


Fig 3 CAD/CAM–derived needle guide on the model. **(a)** A needle guide is fabricated using a stereolithographic method based on a master cast. **(b)** Two metal guide sleeves are embedded into each side of the guide.

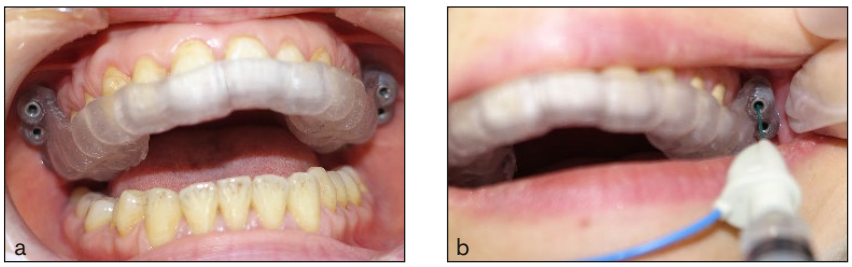


Fig 4 Botulinum toxin therapy using CAD/CAM–derived needle guide. The point of insertion is the mucobuccal fold of the distal root of the maxillary second molar. **(a)** The guide is inserted into the oral cavity and stabilized with the help of the teeth. **(b)** The injection needle is inserted through the metal sleeve, and its correct placement confirmed using EMG monitoring.

Needle insertion without the guide was performed as follows. The insertion point was defined as the mucobuccal fold of the distal root of the maxillary second molar. The disposable hypodermic needle electrode was angled posteriorly and superiorly by 30 degrees in relation to the occlusal plane and medially by 20 degrees. The needle was inserted 20 to 30 mm from the surface.[35] Verification of correct needle placement and injection of botulinum toxin was performed in the same fashion as the guided method.

Based on the patient's response, the effect of botulinum toxin lasted a minimum of 3 to 4 months. The injections were repeated over time if the effects disappeared. In 13 patients, the botulinum toxin therapy was first performed without the guide and then with it, and 4 patients underwent guided placement alone.

Data Analyses

The effects and complications of botulinum toxin therapy were compared between the guided and unguided procedures. The degree of comprehensive improvement (%), where 0% represents no improvement and 100% indicates complete recovery, was calculated using the following formula:

(pretreatment total score – posttreatment total score) / pretreatment total score (%)

Subjective improvement was assessed using a linear self-rating scale ranging from 0% (no improvement) to 100% (complete cure). The patients were asked to rate their improvement from 0% to 100%, as reported previously.[27,29,38,39]

Comprehensive and subjective improvements were evaluated 1 month after the last Botox injection. The measures were made after the injections without the guide for the patients and then again after the injections with the guide for all patients (Table 1). The results obtained before and after the botulinum toxin therapy were compared between the guided and unguided procedures. The paired *t* test was used for comparisons between the data obtained before and after treatment. All analyses were performed using SPSS version 14.0 (SPSS Japan). A value of $P < .05$ was considered statistically significant.

Results

The mean ± SD distances from the metal sleeve to the center of the target muscle were 40.1 ± 6.5 mm (women: 35.6 ± 4.8; men: 43.4 ± 4.0) for the medial sleeve and 41.3 ± 5.6 mm (women: 37.3 ± 3.5; men: 43.0 ± 5.6) for the distal sleeve on the right side, whereas they were 44.3 ± 5.6 mm (women: 41.1 ± 4.0; men: 45.7 ± 5.9) for the medial sleeve and 42.3 ± 4.2 mm (women: 40.0 ± 4.0; men, 42.1 ± 6.4) for the distal sleeve on the left. These distances included the length of the sleeves and the thickness of the stereolithographic resin; therefore, the actual distance from the mucobuccal fold to the center of the muscle was 15 mm less than the values mentioned above.

Thirteen patients were injected both with and without the guide, while 4 patients underwent guided injection alone (Table 3). Botulinum toxin therapy was performed 32 times without the guide and 42 times with the guide. In each case, the needle was easily inserted at the first attempt. No significant complications occurred.

Table 3 Results Obtained With and Without the Guides

	Without guide			With guide		
Patient no.	Botox injection (no. of times)	Comprehensive improvement (%)	Subjective improvement (%)	Botox injection (no. of times)	Comprehensive improvement (%)	Subjective improvement (%)
1	4	50.0	60.0	1	50.0	70.0
2	2	50.0	60.0	3	50.0	60.0
3	1	30.0	30.0	4	40.0	33.0
4	3	42.9	50.0	1	42.9	50.0
5	5	66.7	70.0	3	77.8	80.0
6	6	50.0	60.0	3	62.5	60.0
7	1	57.1	60.0	2	71.4	60.0
8	2	55.6	50.0	4	66.7	75.0
9	2	70.0	60.0	5	80.0	70.0
10	2	66.7	75.0	3	71.4	75.0
11	1	50.0	50.0	2	50.0	50.0
12	2	66.7	75.0	3	66.7	75.0
13	2	60.0	50.0	3	80.0	70.0
14	–	–	–	2	85.7	80.0
15	–	–	–	1	71.4	75.0
16	–	–	–	2	60.0	60.0
17	–	–	–	2	100.0	95.0
Mean ± SD	2.5 ± 1.6	54.3 ± 10.8[a]	56.5 ± 11.1[b]	2.5 ± 1.2	66.3 ± 16.2[a]	66.9 ± 14.4[b]

[a]The mean comprehensive improvements brought about by the botulinum toxin injection with the guide and without the guide differed significantly ($P < .001$)
[b]The mean subjective improvements brought about by the botulinum toxin injections with the guide and without the guide differed significantly ($P < .01$).

The scores for each of the four comprehensive scales and the mean total comprehensive score decreased significantly ($P < .0001$) after the botulinum toxin therapy (Table 3). The mean comprehensive improvement (the percentage reduction in the total comprehensive score) achieved without the guide was 54.3%. The comprehensive improvements seen with (66.3%) and without (54.3%) the guides differed significantly ($P < .001$). The mean subjective improvement achieved without the guide was 56.5% (Table 3). There was a significant ($P < .01$) difference between the mean subjective improvements observed with (66.9%) and without (56.5%) the guides. A close relationship was detected between the improvements in the subjective and the total comprehensive scale scores (correlation coefficient: 0.85).

Discussion

The present study is the first to report on the clinical use of customized CAD/CAM–derived needle insertion guides during botulinum toxin therapy for the inferior head of the lateral pterygoid muscle. The guides were very helpful for facilitating precise and safe botulinum toxin therapy for the lateral pterygoid muscle.

There were some limitations of this study. First, although significantly greater comprehensive and subjective improvements were seen when the guide was used, in 13 patients who underwent both guided and unguided procedures, the botulinum toxin therapy was first performed without the guide and subsequently with it; thus, the treatment order or time-related effects might have affected the therapeutic results. Second, a placebo effect associated with the use of a novel method cannot be excluded. Double blinding was clinically impossible for this study, as both the author and the patients would have easily noticed a "sham guide," and placebo injection was not performed for ethical reasons. Although the setting is very difficult, randomized controlled trials with a larger number of patients might be required to elucidate the therapeutic efficacy of the current method. Third, the objective evaluation of changes in the dystonic symptoms after treatment is highly difficult in oromandibular dystonia, similar to other focal dystonias. Development and validation of an objective rating scale for oromandibular dystonia may be beneficial for further studies.

The lateral pterygoid muscle can be accessed via intraoral and extraoral routes.[35] However, the intraoral approach is preferable on the following grounds.[13] First, this approach makes the patients less anxious because it is similar to the approach employed during routine intraoral injections in dental treatment. Second, it reduces the risk of damage to the maxillary artery. Third, the teeth close to the insertion point provide a more reliable fixation point for the device regulating the direction of the needle electrode. The more times the needle is inserted, the greater the risk of complications and pain.[19] The success rate of botulinum toxin therapy and the frequency of injuries to the adjacent tissues are closely related to the accuracy of the needle insertion.[19] In other words, the more accurately the needle is inserted, the more likely the improvement in the patient's condition and the lower

the risk of complications. Since 1988, the author has inserted needles into the lateral pterygoid muscles several thousand times for EMG studies,[14–17] muscle afferent block,[27,31,40] and botulinum toxin therapy.[31,35] The use of a CAD/CAM–derived guide allows clinicians to perform injection procedures without any complications[9,11,12] at skill levels that would normally take years to achieve. By using the guide, the needle was easily inserted without any complications in all the procedures in this study, and the results suggest that this method is highly safe. In each case, the correct placement of the electrode was verified using EMG at the first attempt, which revealed the accuracy of the method. The needle insertion guide described in the present study has enabled the development of what the author considers to be the most accurate method for injecting botulinum toxin into the inferior head of the lateral pterygoid muscle reported so far.

As the author had almost 30 years of experience with injecting needles into the lateral pterygoid muscles, such a guide for injection was unnecessary. In fact, no complication—such as bleeding—occurred even without the guide in this study. If a beginner without experience injecting into the lateral pterygoid muscle were to inject Botox into the muscle for the first time without the guide, the therapeutic effect might be much less than that attained in the present study and would possibly result in arterial bleeding or hematoma. One of the patients had severe bleeding while receiving a previous Botox injection from a neurologist. Perhaps the difference in improvement between guided and unguided injections performed by inexperienced clinicians would be much larger than that in this study; however, it would be very risky, and studying complication rates during unguided injection by inexperienced clinicians cannot be ethically approved.

It is very difficult to inject botulinum toxin accurately and safely in patients in whom the space between the coronoid process and maxilla is extremely narrow or who exhibit hyperkinetic involuntary movements of the head, jaw, and/or mouth. The method described in the present study should be considered for patients who need to undergo repeated injections before EMG confirmation and who suffer pain or bleeding after the injections, which can result in unsatisfactory therapeutic effects. However, it is not always necessary for patients who can be easily assessed using the conventional technique,[35] as the use of such guides is associated with additional costs related to CT and the fabrication of the guide itself.

The method described in this study will aid the injection of botulinum toxin and studies of the functional role of the lateral pterygoid muscle. Such insertion guides could also be modified for use with other muscles, such as the superior head of the lateral pterygoid, medial pterygoid, and tensor veli palatini muscles. Furthermore, if such guides could be stabilized on the mandibular dental arch, it might be possible to use them for injections into the genioglossus, digastric, geniohyoid, mylohyoid, and/or stylohyoid muscles.

In a previous study,[37] the average differences between the pre- and postoperative CT measurements of the implant apex were 0.7 mm (buccolingual), 0.63 mm (mesiodistal), and 0.52 mm (depth). Template-guided implantation enables preoperative computer-assisted planning to be put into surgical practice. Needle insertion during botulinum toxin therapy does not always require such precision; instead, it is preferable to move the needle insertion site to a part of the target muscle that exhibits more hyperactivity to facilitate EMG guidance and the confirmation of dystonic contracture. Although relatively large differences in the insertion depth were detected among individuals, genders, and sides in the present study, the mean differences agreed with previous results.[13,24] Some patients with temporomandibular disorders and coexisting migraine have been reported to exhibit hypertrophy of the lateral pterygoid muscle.[41] Oromandibular dystonia can also provoke overgrowth of the lateral pterygoid muscle. Conventional techniques based on anatomical data or indices do not result in the needle being inserted at the optimal points in all patients. Thus, the use of customized guides might be necessary in such cases.

Jaw opening and jaw deviation dystonias are rarer than other types of focal dystonias, and the precise etiologies of these conditions remain unclear.[30,40] The number of patients that present with these conditions at individual institutions is very low, even at movement disorder clinics or the neurologic departments of university hospitals. However, these conditions are misdiagnosed or go undiscovered in many patients; thus, the real prevalence rates of these conditions must be much higher than previous estimates—indeed, based on the author's experience, there are many such patients, some of whom have to travel great distances for treatment at centers such as the author's center.[42] Thus, it is impractical for patients to repeatedly visit the center for multiple botulinum toxin injections. If the local clinician could perform such injections using a needle insertion guide, it would be possible to reduce the economic burden and time constraints associated with repeated long-distance health-related trips. Such guides can be used repeatedly in the same patient after resterilization. For example, if a clinican could send data on the patient's CT findings and a plaster model of their maxilla, the author could prepare an insertion guide at the patient's first visit. Soon, technical developments will enable the direct import of digital surface data generated by intraoral scans, and the follow-up examinations and subsequent injections could be conducted by the patients' attending clinician.

Conclusions

Needle insertion guides produced using CAD/CAM were shown to be very useful for ensuring the accurate and safe injection of botulinum toxin into the inferior head of the lateral pterygoid muscle in patients with jaw opening dystonia.

Acknowledgments

This study was supported by grants from the Japanese Ministry of Health, Labor, and Welfare (15K09370, 24592946, and 22111201). This study was conducted in accordance with the Declaration of Helsinki following the approval of the institutional review board and ethics committee of the Kyoto Medical Center. The authors report no conflicts of interest.

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