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Original article

Comparison of endoscopic-guided vs. electromyography-guided Botulinum toxin injection treatments in adductor spasmodic dysphonia

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Abstract

Background: Electromyography (EMG)-guided botulinum injection is recommended in clinical practice guideline for spasmodic dysphonia. However, other alternative techniques have been practiced in absence of EMG machine. Comparison of the techniques is limited in the literatures.

Objectives: This study aimed to compare the effectiveness of treatment between the EMG-guided technique and the endoscopic-guided technique in adductor spasmodic dysphonia.

Methods: Five patients who were diagnosed with adductor spasmodic dysphonia (AdSD) were enrolled and then randomized into two groups. Patient data (before and after treatment) were collected. The outcome measurement included voice analysis, voice handicap index (VHI), duration aspiration, duration of breathiness, mean effective duration, and satisfaction score (visual analog scale). The difference between the pretreatment data and the posttreatment data at 1 and 3 months was compared.

Results: The mean effective duration between of the EMG group and the endoscopic group was not significantly different. There were no significant differences in voice analysis differences in the EMG group and the endoscopic group after botulinum toxin injection 1 month and 3 months after treatment. There were no significant differences in adverse effects between the two groups in both durations of breathiness and duration of aspiration. No significant difference in satistactions score among two groups was observed.

Conclusion: Botulinum toxin injection under endoscopic guidance is a feasible technique for the treatment of adductor spasmodic dysphonia in the context of lack of EMG equipment. Additionally, endoscopic guidance is a simple and inexpensive device, composed of materials at hand in every otolaryngology unit. However, we suggest that the optimal injection technique would be determined by surgeon training, equipment availability, and preferences.

Keywords: Adductor spasmodic dysphonia, botulinum toxin, electromyography, vocal injection.

Spasmodic dysphonia (SD) is a localized neuromuscular disorder, also known as laryngeal dystonia, which is frequently misdiagnosed in speech-language pathology.[1] The most common form of spasmodic dysphonia is adductor spasmodic dysphonia (AdSD), which causes a strained, strangled, or "over-pressurized" voice and prolonged vowel sounds, making it difficult to initiate or complete words due to spasms or stuttering-like symptoms.[2] The SD prevalence was estimated to be 3.5 - 7.0/100,000 population, and AdSD was predominant (90.0% - 95.0%)[3]

The gold standard treatment for spasmodic dysphonia is botulinum toxin injection into the affected laryngeal muscle.[4] +Presently, percutaneous botulinum toxin injection using electromyography (EMG) guidance has proven effective in treating spasmodic dysphonia.[5-7] However, an electromyography device is generally unavailable in most otolaryngology clinics. Therefore, alternative techniques have been developed to deliver botulinum toxin to the vocal folds, such as the transnasal approach, transoral approach, and percutaneous injection with endoscopic guidance using flexible nasolaryngoscopy. [8, 9] The utilization of these alternative techniques has the potential to enhance the accessibility of spasmodic dysphonia treatment within general otolaryngologic facilities.

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This study aimed to compare the effectiveness of botulinum toxin injection between EMG-guided technique and endoscopic-guided technique in adductor spasmodic dysphonia.

Materials and methods

This study was conducted as a prospective, randomized-controlled trial at the outpatient clinic of the Department of Otolaryngology-Head and Neck surgery, King Chulalongkorn Memorial Hospital. The study was approved by the Institutional Review Board of the Faculty of Medicine at Chulalongkorn University, and a certificate of ethical approval was granted (IRB no. 273/61). The study population includes all patients diagnosed with adductor spasmodic dysphonia and aged between 18 and 70 years who received botulinum toxin injection at the otolaryngology clinic of King Chulalongkorn Memorial Hospital.

Subjects' baseline data, including baseline characteristics (age, gender, date of adductor spasmodic dysphonia diagnosis, and history of botulinum toxin treatment), were recorded. Patients were asked to complete a self-assessment questionnaire using the voice handicap index-30 (VHI30), which has been validated in Thai.[10] Additionally, pre-treatment data collection included acoustic analysis using Dr. Speech software (Tiger DRS, Inc.) to measure maximum phonation time (MPT), jitter, shimmer, and fundamental frequency (F0).

The subjects were randomized into two groups: the EMG-guided group and the endoscopic-guided group. The randomization of the patients was concealed from the researcher who collected the data (VHI, voice analysis, and questionnaire). The botulinum toxin injections were performed on the thyroarytenoid muscle of the allocated patients by a single experienced laryngologist.

Post-treatment data were first collected one month after injection. At this point, (VHI30) and self-assessment questionnaires were administered, including duration of aspiration, duration of breathiness, and satisfaction score. Patients'satisfaction was measured by the visual analog scale (VAS). Patients rate their satisfaction on a scale of 0 to 10. At three months after treatment, data collection was performed again, which included Thai VHI30, acoustic analysis, and self-assessment questionnaires on the effective duration of botulinum toxin injection.

Botulinum toxin injection treatment protocol

For the EMG-guided group, patients were placed in a supine position with neck extension, and 1.0% lidocaine with adrenaline was injected into the skin. A 27-gauge, 37-mm Teflon-coated injection needle connected to a 1-cc syringe preloaded with botulinum toxin (BOTOX, Allergan Inc, Irvine, CA, USA) was inserted through the cricothyroid membrane into the thyroarytenoid muscle under EMG guidance. The needle was adjusted until crisp motor unit action potentials were elicited, and then botulinum toxin was injected 2.5 units in each vocal cord.

As for the endoscopic-guided group, patients were placed in a sitting position with slight neck extension. Before the procedure, a 10.0% lidocaine spray was applied to the nasal cavity, pharynx, and larynx, and 1.0% lidocaine with adrenaline (1:100,000) was injected into the skin. The botulinum toxin was injected directly into the thyroarytenoid muscle through the cricothyroid membrane using a disposable 25-gauge, 1.5-inch needle under transnasal flexible nasolaryngoscopy (Olympus ENF type VH Rhinolaryngo videoscope, Olympus medical system, Tokyo, Japan). The appropriate needle location was confirmed under direct visualization by endoscopy prior to injection. Botulinum toxin was injected 2.5 units in each vocal cord.

Statistical analysis

Statistical analysis was performed using the SPSS software package, version 17.0 (SPSS Inc., Chicago, IL). Descriptive analysis of all data was performed and reported as means and standard deviations (SD). Paired *t* - tests were used to analyze comparative results of voice parameters, maximum phonation time, and VHI between pre- and post-botulinum toxin injection within the same group, while unpaired *t* - tests were used for comparisons between groups. Satisfaction scores for the botulinum toxin injection technique were analyzed using the Mann-Whitney U test. A $P < 0.05$ was considered statistically significant.

Results

The study was conducted between January 2019 and January 2020, with a sample size of 36 patients. However, only six patients were included in the study: three in the EMG group and three in the endoscopic group. One patient in the EMG group was lost to follow-up. All of the remaining patients were women,

Table 1. Patients' demographics and baseline voice analysis of EMG-guided group and endoscopic-guided group.

	EMG group	Endoscopic group	*P* - value
Mean ages (years)	43.0 ± 6.1	50.3 ± 6.0	0.21
MPT (sec)	19.8 ± 11.7	13.2 ± 11.2	0.52
Jitter (%)	1.7 ± 2.1	0.2 ± 0.1	0.29
Shimmer (%)	1.4 ± 1.0	2.4 ± 1.5	0.38
F0 (dB)	251.9 ± 84.0	214.0 ± 32.2	0.51
VHI	88.2 ± 16.5	74.3 ± 9.5	0.28

Data were reported as mean ± SD. EMG electromyography; MPT, maximum phonation time; F0, fundamental frequency; VHI, voice handicap index.

Table 2. Voice analysis of EMG group following Botulinum toxin injection.

	Baseline	Post-treatment 1 month	*P* - value	Post-treatment 3 months	*P* - value
MPT (sec)	19.8 ± 11.7	18.9 ± 11.5	0.4	17.1 ± 4.1	0.8
Jitter (%)	1.7 ± 2.1	0.6 ± 0.2	0.5	1.3 ± 1.1	0.5
Shimmer (%)	1.4 ± 1.0	2.8 ± 0.6	0.4	4.5 ± 3.1	0.5
F0 (dB)	251.9 ± 84.0	285.1 ± 81.9	1.0	278.2 ± 88.5	0.6
VHI	88.2 ± 16.5	63.5 ± 34.7	0.2	90.0 ± 28.3	0.6

Data were reported as mean ± SD. MPT, maximum phonation time; F0, fundamental frequency; VHI, voice handicap index.

Table 3. Voice analysis of endoscopic-guided group following botulinum toxin injection. (mean ± SD).

	Baseline	Post-treatment 1 month	*P* - value	Post-treatment 3 months	*P* - value
MPT (sec)	13.2 ± 11.2	16.4 ± 9.2	0.21	13.2 ± 7.5	0.96
Jitter (%)	0.2 ± 0.1	0.4 ± 0.1	0.13	0.9 ± 1.1	0.87
Shimmer (%)	2.4 ± 1.5	2.0 ± 0.6	0.55	1.0 ± 0.2	0.19
F0 (dB)	214.0 ± 32.2	218.2 ± 45.4	0.75	233.0 ± 10.7	0.29
VHI	74.3 ± 9.5	60.8 ± 18.8	0.09	74.3 ± 3.1	0.41

Data were reported as mean ± SD. MPT, maximum phonation time; F0, fundamental frequency; VHI, voice handicap index.

and almost all had received previous treatment with botulinum toxin injection. Only one patient in the EMG group was newly diagnosed with spasmodic dysphonia. **Table 1** shows the demographic data and baseline voice analysis results of patients in both the EMG and endoscopic groups. The mean age was 43.0 ± 6.1 years in the EMG group and 50.3 ± 6.0 years in the endoscopic group. There were no statistically significant differences between the groups in terms of age, pre-treatment voice analysis, or VHI.

Table 2 presents the voice analysis results for the EMG group. Maximum phonation time (MPT) decreased from baseline at both 1 and 3-months post-injection. In contrast, shimmer increased from baseline at both 1 and 3-months post-injection. Jitter decreased at 1-month post-injection but almost reached baseline at 3-months post-injection. Fundamental frequency increased at 1-month post-injection but decreased to near baseline at 3-months post-injection. VHI decreased at 1-month and then increased at 3-months post-injection.

Table 3 presents the voice analysis results for the endoscopic group. MPT increased from baseline at 1-month and returned to baseline at 3-months post-injection. Jitter increased at 1-month post-injection and increased further at 3-months post-injection. In contrast, shimmer decreased from baseline at both 1 and 3-months post-injection. Fundamental frequency increased at both 1 and 3-months post-injection and approached baseline at 3-months post-injection. VHI decreased at 1-month and increased at 3-months post-injection, as in the EMG group.

Table 4. Differences of voice analysis in EMG group and endoscopic group following botulinum toxin injection 1-month and 3-months.

Voice parameters	Δ 1 month, EMG group	Δ 1 month FOL group	*P* - value	Δ 3 month, EMG group	Δ 3 month, FOL group	*P* – value
MPT	3.6 ± 0.8 (- 3.8, 11.0)	4.7 ± 4.5 (- 6.3, 15.8)	0.7	1.9 ± 8.3 (- 72.7, 76.4)	0.1 ± 3.2 (- 7.8, 8.1)	0.8
Jitter	- 1.8 ± 2.6 (- 25.2, 21.7)	0.1 ± 0.1 (- 0.1, 0.3)	0.3	- 4.1 ± 5.1 (- 49.5, 41.3)	- 0.1 ± 0.03 (- 0.2, - 0.1)	0.2
Shimmer	0.9 ± 0.9 (- 7.2, 9.0)	- 0.4 ± 1.0 (- 3.0, 2.1)	0.3	3.1 ± 4.6 (- 38.0, 44.2)	- 1.4 ± 1.3 (- 4.6, 1.7)	0.2
F0	- 3.0 ± 3.0 (- 29.6, 23.5)	4.1 ± 19.3 (- 43.8, 52.1)	0.7	- 10.0 ± 9.7 (- 96.2, 76.5)	18.7 ± 22.5 (- 37.3, 74.6)	0.2
VHI	- 24.0 ± 11.3 (- 125.7, 77.7)	- 29.0 ± 16.5 (- 70.0, 12.0)	0.7	2.5 ± 5.0 (- 42.0, 47.0)	- 15.3 ± 26.0 (- 80.0, 49.3)	0.4

Data were reported as mean difference and SD with 95% confidence interval.
EMG, electromyography; MPT, maximum phonation time; F0, fundamental frequency; VHI, voice handicap index.

Table 5. Results of duration of aspiration, duration of breathiness, and satisfaction score in two groups.

	EMG group	Endoscopic group	*P* - value
Total dosage of Botulinum toxin (unit)	5.0	5.0	-
Duration breathiness (weeks)	3.0 ± 1.4	4.3 ± 3.5	0.66
Duration aspiration (weeks)	1.5 ± 0.7	3.7 ± 1.5	0.17
Mean effective duration (weeks)	8.0 + 0.0	10.0 ± 3.5	0.50
Patient satisfaction score	8.8 ± 0.1	7.9 ± 2.6	0.69

Data were reported as mean ± SD

Table 4 shows Jitter decreased in 1-month post-injection and increased almost reached baseline in 3-months post-injection. There were no statistically significant differences in voice parameters between the EMG and endoscopy groups. However, VHI at 1-month post-treatment was decreased in both groups.

The mean effective duration between the EMG group and the endoscopic group was not significantly different. All cases were treated with the same dose of botulinum toxin (2.5 units/side, total 5 units). The mean duration of aspiration was 1.5 ± 0.7 weeks for the EMG group and 3.7 ± 1.5 weeks for the endoscopic group. The mean duration of breathiness was 3.0 ± 1.4 weeks for the EMG group and 4.3 ± 3.5 weeks for the endoscopic group. Although the endoscopic group showed longer periods of aspiration and breathiness, there was no statistically significant difference between the two groups in terms of duration of aspiration or breathiness.The satisfaction score did not differ between the EMG and endoscopic groups. **(Table 5).**

Patient No. 1

A 51-year-old female with underlying hypertension who had been diagnosed with adductor spasmodic dysphonia for 2 years. She had a history of botulinum toxin injection about 1 year and 1-month prior to enrollment in the endoscopic group, where she was treated with a total dose of 5-units of botulinum toxin. She reported an effective duration of approximately 6 weeks, with a duration of aspiration of 2-weeks and a duration of breathiness of 1 week. Regarding her voice parameters, MPT increased from 1.9 to 11.4 seconds at 1-month post-treatment, while her VHI decreased from 67 to 39.

Patient No. 2

A 44-year-old female who had been diagnosed with adductor spasmodic dysphonia for five years and had a history of botulinum toxin injection more than three months prior to enrollment in the endoscopic group, where she was treated with a total dose of 5 units of botulinum toxin. She reported an effective duration of

approximately twelve weeks, with a duration of aspiration of four weeks and a duration of breathiness of five weeks. Regarding her voice parameters, her MPT did not change significantly pre-treatment, 1-month post-treatment, and 3-months post-treatment, with values of 24.25, 25, and 24.23 seconds, respectively. The results for other parameters (Jitter, F0) were similar, but her Shimmer decreased from 1.2 to 0.9 at 3-months post-treatment. Her VHI decreased from 85 to 72 at 1-month post-treatment and further decreased to 71 at 3 months post-treatment.

Patient No. 3

A 46-year-old female who was newly diagnosed with adductor spasmodic dysphonia. She had been treated for gastroesophageal reflux disease (GERD) with proton pump inhibitors for three months but had never received botulinum toxin injection. The patient was enrolled in the EMG group and was treated with a total dose of 5 units of botulinum toxin. She reported an effective duration of approximately eight weeks, with a duration of aspiration of 2-weeks and a duration of breathiness of only one week. Regarding her voice parameters, her MPT significantly increased from 6.5 to 10.7 and then to 14.3 seconds in the pre-treatment, 1-month post-treatment, and 3-months post-treatment, respectively. The VHI was at its lowest at 1-month post-treatment, decreasing from 71 to 39, but returned to baseline at 3-months post-treatment.

Patient No.4

A 56-year-old female who was diagnosed with adductor spasmodic dysphonia more than three years ago. She received her last Botulinum toxin injection approximately 3-years prior to the study. The patient was enrolled in the endoscopic group and received a total dose of 5-units of Botulinum toxin. According to her report, the treatment was effective for a duration of 12-weeks, with a 4-week duration of aspiration and an 8-week duration of breathiness. The voice parameters, including the MPT seemed to be longer at 1-month post-treatment (13.4, 17.3, and 10.4, respectively). However, no significant changes were observed in the other parameters. The VHI scores showed a decrease both 1 and 3-months post-treatment (71 and 75, respectively), compared to the pre-treatment score of 117.

Patient No.5

A 47-year-old female with a diagnosis of adductor spasmodic dysphonia more than 10 years ago was treated with Botulinum toxin injection and was enrolled in the EMG group. She received a total dose of 5-units of botulinum toxin but was lost to follow-up after treatment. When she was contacted, she reported an effective duration of 8-weeks, with a duration of aspiration lasting only 2-weeks and a duration of breathiness lasting four weeks. The maximum phonation time showed slight changes at 1 and 3-months post-treatment (24, 27, and 20 seconds, respectively). The VHI score was at its lowest at 1-month post-treatment and returned to baseline at 3-months post-treatment. However, the parameters of Jitter, Shimmer, and F0 did not significant change.

Discussion

Currently, Botulinum toxin injection guided by EMG is widely regarded as the "gold standard" treatment for Adductor spasmodic dysphonia, supported by a plethora of studies. As an additional treatment, voice therapy can aid in relaxation and respiration training, providing patients with insight and control over their laryngeal tension during speech. [11, 12] A retrospective study reported that recurrent laryngeal nerve (RLN) resection or avulsion resulted in little or no symptoms in patients after 5 - 14 years. However, 15.0% of patients experienced mild to moderate spasticity recurrence within 6 - 24 months of RLN section. Consequently, the approach has been largely abandoned by most laryngologists in favor of Botulinum toxin injection, which is considered to be more reliable.[13]

Numerous published studies have explored the use of Botulinum toxin in treating spasmodic dysphonia across various axes, including the disorder type (adductor-type / Abductor-type), unilateral versus bilateral injection, technique procedure, and injection location.[14] Percutaneous injection with endoscopic guidance has several advantages over EMG guidance, primarily its convenience. Unlike EMG guidance, it does not require a special instrument such as an EMG machine or EMG needle. Additionally, physicians who perform the procedure do not require skills to interpret the EMG signal, as they can visualize the vocal folds during the procedure. Moreover, endoscopic guidance

demonstrates high reliability, as it allows for the confirmation of needle location. As a result, more precise injections to the thyroarytenoid muscle may result in a better outcome, such as an improvement in voice quality.

In the field of laryngeal injections, particularly for spasmodic dysphonia, several approaches have been developed, each with unique benefits. The cricothyroid approach is commonly used for injection laryngoplasty, especially in vocal paralysis cases, but it limits visual tracking of the needle to the vocal fold.[15] The thyrohyoid approach, modified for better needle stabilization and consistent placement, is advantageous in office-based vocal fold injections.[16] Each technique presents a balance between accessibility, precision, and patient-specific requirements. In this study, we chose the cricothyroid approach due to the laryngologist's familiarity with it.

The results of this study show no statistically significant difference in voice analysis between the two groups. The primary outcome of this study is the fundamental frequency (F0). All of the fundamental frequencies were within the normal range (200 - 300 Hz for adult women). The other voice parameters, Jitter and Shimmer, which were secondary outcomes of this study, yielded interesting results.

Jitter is a parameter of frequency variation from cycle to cycle, with a normal range of 0.5% - 1.0%. An increase in Jitter indicates a more pathological result. The study results indicate that Jitter levels became normal at one month after treatment in the EMG group, whereas the endoscopic group demonstrated normal Jitter levels at 3 months post-treatment. This demonstrates the effect of Botulinum toxin.

Shimmer is a parameter that represents glottic resistance and is related to the presence of noise emission and breathiness. A value of less than 3.0% in adults is considered pathologic. In the EMG group, the Shimmer post-treatment at 1 month increased and became within the normal limit at 3 months post-treatment. This suggests that glottic resistance may improve after one month of injection. This correlates with longer adverse effects of Botulinum injection, such as aspiration time and breathiness time, in the endoscopic group compared to the EMG group. This study shows that the endoscopic group had a longer duration of aspiration, about two weeks, and longer duration of breathiness, about one week. However, the mean effective duration time of the endoscopic group was longer than that of the EMG group, over two weeks. All patients were injected with the same dosage of Botulinum toxin, which could be the result of the accuracy of injection into the Thyroarytenoid muscle. The endoscopic technique helps the laryngologist to monitor the needle tip position before and during the release of the Botulinum toxin into the Thyroarytenoid muscle.

Elmiyeh B, *et al* and Dharia I, *et al*. reported on the duration of the effect, ranging between 14.7 and 18.0 weeks. However, in this study, the mean effective duration of the EMG group was 8 weeks and 10.0 ± 3.5 weeks for the endoscopic group. The difference in outcome may be due to the subjectivity of the outcome and the lack of clarification of the outcome assessment in previous studies. In this study, data were collected from patient self-reports, and the definition of effective duration was the duration of time that patients experienced an improved voice.[17, 18]

Both the EMG group and the endoscopic group showed similar results in terms of the VHI. The VHI decreased at 1 month and increased to baseline at 3-month post-injection, which can be explained by the duration of Botulinum toxin, which typically lasts for about 3 - 4 months. The decrease in the VHI score at 1-month post-treatment was around 20 - 30 points in both groups, but this was not statistically significant.

Our results did not show a statistically significant difference between the two methods, which is slightly different from the study by Kim JW, *et al*., which reported voice parameter analysis of the EMG and endoscopic groups, respectively. In their study, the average values for MPT, jitter, shimmer, harmonics-to-noise ratio (HNR), and fundamental frequency did not change significantly following botulinum toxin injection in either the EMG or endoscopic group. However, the mean VHI value was significantly improved following injection in the EMG group. The mean VHI value was also significantly improved in the endoscopic group following injection.[19]

Although the lack of statistical significance, the improvement in voice quality and quality of life following botulinum toxin injection in both groups was clinically significant. All five patients who were included in this study reported that their quality of voice had improved, and they experienced a better quality of life after treatment. They were more confident in communicating with others and were more outgoing. One patient, who had always been ashamed of her voice, had avoided going to the market due to fear of

annoying others with her voice problem. However, after treatment with botulinum toxin, she reported an improvement in her social skills. However, there was no significant difference in patient satisfaction scores between the two groups. One patient who experienced both techniques and was enrolled in the EMG group preferred the endoscopic-guided technique because it took a shorter time to perform the procedure with the same result. In contrast, one patient reported a low satisfaction score (5 points) due to discomfort during insertion of the endoscope.

The limitations of this study should be noted. All patients in the study had prior experience with Botulinum toxin injections, potentially biasing their satisfaction scores. This familiarity may lead to differing expectations and perceptions compared to individuals undergoing treatment for the first time. Additionally, the study was constrained by a relatively small sample size, which may have limited its ability to detect subtle differences between the EMG-guidance and endoscopic techniques, especially in terms of voice analysis outcomes. Furthermore, the recruitment process occurred during the COVID-19 endemic period, which could have influenced patient participation and healthcare access patterns, potentially affecting the study population's characteristics and outcomes. Therefore, further studies with a larger number of subjects are recommended to provide more reliable and robust results.

Conclusion

There was no significant difference in voice analysis outcomes between the EMG-guidance technique and the endoscopic technique. Patients reported similar levels of satisfaction with both techniques. Botulinum toxin injection under endoscopic guidance may be considered an alternative technique for the treatment of adductor spasmodic dysphonia when EMG equipment is unavailable or unaffordable. Endoscopic guidance is a simple and inexpensive device that is readily available in every ENT unit and facilitates the procedure. However, we suggest that the choice of injection technique should be based on the surgeon's training, equipment availability, and personal preferences.

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Conflict of interest statement
All authors have completed and submitted the International Committee of Medical Journal Editors Uniform Disclosure Form for Potential Conflicts of Interest. None of the authors disclose any conflict of interest.

Data sharing statement
The present review is based on the references cited. All data generated or analyzed during the present study are included in this published article and the citations herein. Further details, opinions, and interpretation are available from the corresponding author on reasonable request

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