Local Steroid Injection via the Cricothyroid Membrane in Patients With a Vocal Nodule

Sang-Hyuk Lee, MD, PhD; Jang-Ok Yeo, MD; Jeong-Im Choi, SLP; Hee-Jin Jin; Jin-Pyeong Kim, MD, PhD; Seung-Hoon Woo, MD; Sung-Min Jin, MD, PhD

Objective: To analyze the usefulness and safety of a steroid injection into vocal nodules via the cricothyroid membrane. Local administration of steroid directly into the larynx has been reported in many laryngeal diseases with different methods.

Design: Prospective case series at an academic tertiary care hospital.

Patients: Eighty patients with vocal nodules were enrolled between December 2008 and May 2010.

Interventions: Triamcinolone acetonide was injected through the cricothyroid membrane with a transnasal flexible laryngoscope to patients in a sitting position.

Main Outcome Measures: Vocal nodules were evaluated before and 2 and 4 weeks after the injection; improvement was assessed both objectively and subjectively.

Results: The nodules disappeared in 35 patients by the fourth week after the injection (44%), and 39 patients showed improvement (49%). Jitter, shimmer, maximum phonation time, and mean voice handicap index also improved significantly after the steroid injection (P < .05 for all). Six patients with voice-related occupations showed improvement at the second week (8%), but the nodules had recurred after 4 weeks. Four patients experienced mild vocal fold atrophy, and 2 patients showed a white plaque formation on the vocal fold that resolved spontaneously 1 to 2 months after the injection.

Conclusions: A local steroid injection via the cricothyroid membrane is a useful and safe treatment option for vocal nodules. However, vocal nodules are caused mainly by excessive voice use; therefore, nodules can recur unless the voice use pattern changes. Further study of this treatment technique, including long-term follow-up, is needed.


Vocal nodules are small subepithelial lesions occurring on both sides of the vocal fold. Usually they occur symmetrically on the border of the anterior and middle third of the vocal fold. They are confined to the superficial layer of the lamina propria and are immobile during phonation.1 Vocal nodules are the most common abnormality in patients with chronic dysphonia and are generally caused by voice abuse. Histologically, they have stromal edema with fibroblast proliferation and dilated vasculature.2 Conservative management such as voice therapy and pharmacotherapy are used as the primary treatment techniques.3 The main purpose of voice therapy is to identify and reduce voice misuse to achieve the optimal voice. When conservative therapy is ineffective, resection by laryngeal microsurgery can be performed under general anesthesia. However, the role of surgery is very limited.

Many studies have reported that voice therapy is effective for improving voice quality in patients with vocal nodules, in particular small and early nodules.3,4 Holmberg et al1 reported that voice therapy has a positive effect on voice quality, vocal status, and vocal function for most patients with vocal nodules. But complete resolution may not be possible in all patients. Furthermore, as patients with vocal nodules often have voice-related occupations, voice rest and voice therapy are sometimes difficult, which makes it hard to carry out the treatment.5,7

A local steroid injection directly into the vocal nodule has recently come to the forefront as another treatment option. Tateya et al.8 and Tateya9 reported good results after a transoral vocal fold steroid injection in 28 patients with vocal nodules. Mortenson and Woo10 reported that most benign lesions of the larynx improve after a transoral steroid injection; in particular, 4 cases of vocal nodules all showed improve-
ment. However, the transoral technique using a long, curved catheter and needle makes precise injection difficult owing to the length of the injection catheter and the triggering of the patient’s gag reflex. But the percutaneous injection technique solves the problem in many ways. Hsiu et al reported good results following a percutaneous corticosteroid injection for vocal fold polyps using a flexible laryngoscope via the contralateral side of the cricothyroid membrane. However, to our knowledge, no previous study has evaluated steroid injection into a large number of vocal nodules through the cricothyroid membrane. The aim of the present study was to use objective and subjective assessments to evaluate the efficiency and safety of a local steroid injection via the cricothyroid membrane in patients with vocal nodules.

### METHODS

Between December 2008 and May 2010, 80 patients with vocal nodules were prospectively enrolled in this study. All patients were diagnosed via stroboscope as having vocal nodules. Patients were given the option of voice therapy or steroid injection, and those who opted for voice therapy were excluded. Patients who had previous laryngeal surgery were also excluded. Of the 80 patients, 73 were female and 7 were male. The patient's mean age was 40.3 years (range, 16-67 years). Among them, 71% had a voice-related occupation (n=57). Demographic data of the patients are listed in Table 1. The study protocol was approved by the Kangbuk Samsung Hospital institutional review board, and all patients provided informed consent.

<table>
<thead>
<tr>
<th>Characteristic</th>
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<tr>
<td>Sex</td>
<td>Male 7</td>
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<tr>
<td></td>
<td>Female 73</td>
</tr>
<tr>
<td>Age, mean, y</td>
<td>40.3</td>
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<tr>
<td>Symptom duration, mo</td>
<td>8.3</td>
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<tr>
<td>Voice-related occupation</td>
<td>71%</td>
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<tr>
<td>Seller</td>
<td>25</td>
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<td>Counselor</td>
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<td>Teacher</td>
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*Unless otherwise indicated, data are reported as number of patients.*

### OBJECTIVE ASSESSMENT

A transoral videostroboscopic examination was performed in all patients before and at the second and fourth week after injection as a morphologic evaluation. The findings were analyzed and sorted into 3 categories (disappeared, improved, or no change) by comparing the size of the vocal nodules at the follow-up visit with that observed before the procedure. All analysis was done by 2 senior laryngologists (S.-H.L. and S.-M.J.). Acoustic recordings and phonatory function studies were performed on patients. A voice sample of the patients phonating a sustained vowel “aaa” sound for 3 seconds in a conversational pitch and loudness was acquired. All voice inputs were recorded and sampled with a multidimensional voice program (MDVP) (Model 4500; Kay Elemetrics Corp, Lincoln Park, New Jersey) for voice analysis. Four MDVP parameters were used in this study: average fundamental frequency (F0), jitter (jitt%), shimmer (shim%), and noise to harmony ratio (NHR). The aerodynamic study was conducted with a computerized system (Phonatory Aerodynamic System, model 6600; Kay Elemetrics). During a vowel “a” emission, the maximum phonation time (MPT) was expressed in seconds.

### SUBJECTIVE ASSESSMENT

The voice handicap index (VHI) before and at the fourth week after injection was the subjective outcome measure. Three domains (functional, physical, and emotional) are included in the index, and each contains 10 questions requiring a response choice to indicate how frequently patients experienced each situation. The response to each question was graded from 0 to 4, depending on the perceived degree of handicap.

### STATISTICAL ANALYSIS

The data were analyzed using the SPSS software, version 15.0 statistical program (SPSS Inc, Chicago, Illinois). The acoustic analysis data before and after injection were compared using the paired t test. Statistically significant differences in VHI be-

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### Table 1. Patient Demographic Data

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### Table 2. Postoperative Videostroboscopic Findings

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<th>Patients, No. (%)</th>
<th>Week 2</th>
<th>Week 4</th>
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<tr>
<td>Nodule disappeared</td>
<td>16 (20)</td>
<td>35 (44)</td>
<td></td>
</tr>
<tr>
<td>Nodule improved</td>
<td>57 (71)</td>
<td>39 (49)</td>
<td></td>
</tr>
<tr>
<td>No change</td>
<td>7 (9)</td>
<td>6 (8)</td>
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fore and after injection were determined with the Wilcoxon signed-rank test. The differences were considered statistically significant at $P < .05$.

**RESULTS**

Eighty patients enrolled in the study, and all received a percutaneous steroid injection at the nodule site via the cricothyroid membrane under topical anesthesia. All patients successfully received the injection within 15 minutes, and the average volume of injected material was 0.2 mL per vocal fold.

The morphologic results from stroboscopic findings are detailed in **Table 2**. Vocal nodules disappeared in 16 patients (20%) and improved in 57 patients (71%) at the second week after the injection. The remaining seven patients were noted not to be improved at the 2-week postoperative visit (9%) but showed improvement at the 4-week postoperative visit. More vocal nodules had disappeared at the 4-week assessment in 19 patients who showed previously decreased size in their nodules at the week 2. Overall, vocal nodules disappeared in 35 patients (44%) and improved in 39 patients (49%) by the 4-week postoperative visit. **Figure 1** shows the preinjection and postinjection appearance of the vocal fold nodule in a representative case. Six patients who showed improvement at the second week had a recurrence by the fourth week (8%), and their vocal nodule had returned to preinjection size. The recurrent cases were associated with persistent voice abuse.

The preoperative and postoperative acoustic and aerodynamic parameters improved significantly as well. The $F_0$, jitt%, shim%, NHR, and MPT values before and after treatment are listed in **Table 3**. Mean jitt% was improved from 2.456 at baseline to 0.925 at week 4. Mean shim% was improved from 0.515 at baseline to 0.272 at week 4. Mean NHR was improved from 6.410 at baseline to 8.197 at week 4. A clear and significant improvement was visible for the mean values of jitt% ($P < .001$), shim% ($P < .001$), and MPT ($P < .05$). The mean VHI score also showed a significant improvement for all domains after injection ($P < .001$) (**Table 4**).

Complications such as mild vocal fold atrophy and white plaque formation were found in a minority of patients. Four patients who showed improvement on videostroboscopic findings at 2 weeks complained of a breathy voice after 1 month. Their videostroboscopic findings showed a mild decrease in the vocal fold mucosal wave and vocal fold bowing, which was diagnosed as vocal fold atrophy (**Figure 2**). These findings improved by about the 2-month follow-up visit. Two patients showed white plaque formation, which was thought to be a precipitate of the triamcinolone acetonide suspension. These findings resolved spontaneously after 1 to 2 months (**Figure 3**).
Phonotrauma causes injury to the superficial layer of the lamina propria and microvasculature, leading to breakdown of the connection between the epithelial layer and basement membrane.10 As the wound-healing process continues, the basement membrane regenerates; however, if not enough time is allowed for regeneration before the next phonotrauma, fibrotic scar tissue with hyaline material will replace the basement membrane.11 In a recent study, Czerwonka et al12 reported that vocal fold intravascular pressure is likely to rise significantly during vocal fold vibration and may lead to the type of injury seen in benign vocal fold lesions. Resulting edema and increased intravascular pressures may lead to capillary failure and leakage of erythrocytes.12 This tissue remodeling process is thought to be the pathogenesis of a vocal nodule.

The treatment for vocal nodules focuses mainly on voice therapy. Since the primary cause of vocal nodules is voice overuse, the most important component of therapy is to prevent the voice abuse. Voice therapy typically consists of education regarding vocal fold mechanics and etiologic factors as well as modification of specific vocal practices.13 Several reports show voice therapy outcome in cases of vocal nodule. In 1 previous study, for example, the authors found elimination and/or a reduction rate of over 70% in their voice therapy group.7 McCrory14 demonstrated that over 80% of patients presented with either normal voice quality or a mild degree of dysphonia. In another study of voice therapy outcome in vocal nodule cases, Holmberg et al15 demonstrated that nodules had decreased in size after therapy for all patients but 1. Thus, the efficacy of voice therapy in treatment of vocal nodules is already well established, and we agree that voice therapy is first-line treatment for vocal nodules. However, a proportion of recalcitrant nodules cannot be successfully resolved by conservative management alone.15 Voice therapy can be effective in improving voice quality and tissue health, and while it does not necessarily result in complete resolution of the abnormality, it should always be considered as a part of the treatment regimen for patients with vocal nodules.13

However, patients with vocal nodules usually have voice-related occupations, and so voice rest is often difficult.3 Steroids potently reduce inflammation and edema and are used in diverse diseases in the otolaryngologic

**Figure 2.** Videostroboscopic findings of vocal fold atrophy 2 weeks after the steroid injection. A, Full abduction of the vocal folds best shows the free margin of the vocal folds and reveals the disappearance of vocal nodule. B, The adduction phase best illustrates mild vocal fold bowing and decreased mucosal wave.

**Figure 3.** Videostroboscopic findings of vocal fold white plaque. A, Two weeks after the steroid injection, a whitish material appeared in the subepithelial layer of right vocal fold. B, A spontaneous decrease in size was seen 4 weeks after the injection.
field. Steroids affect the synthesis and maturation of collagen, alter wound stiffness, inhibit fibroblast function, and suppress the antibacterial and phagocytic action of some defense cells; thus, they change the pattern and delay of wound healing. These steroid actions are thought to be effective for treating vocal nodules. Campagnolo et al have reported that corticosteroid treatment reduced collagen deposition during acute vocal fold wound healing in a corticosteroid injection experimental rabbit model of surgically induced vocal fold injury. Coleman et al evaluated the effects of triamcinolone injected into the vocal folds of dogs after introducing a lateral microflap. In that study, triamcinolone caused a 12-day delay in the vocal fold tissue response for the inflammatory infiltrate.

More recently, good results of direct steroid injections into vocal fold benign lesions have been reported using different methods. By injecting steroid directly into the vocal fold, it is possible to administer a potent drug locally and avoid the systemic adverse effects of the steroid. Yanagihara et al reported good results after injecting dexamethasone into vocal fold benign lesions under topical anesthesia using laryngeal mirrors. However, owing to technical difficulties, this technique has not been used widely. Mortensen and Woo have improved this technique by using a 70° rigid laryngoscope under topical anesthesia with a curved cannula and a curved injection needle via the oral cavity. Tateya et al and Tateya reported transoral steroid injections using a transnasal flexible fiberoptic laryngoscope with a curved injection needle. However, disadvantages of this technique are its difficulty in being mastered and poor patient tolerance. A recently introduced transcutaneous injection technique has many advantages for this problem. Hsu reported good results of percutaneous corticosteroid injection for vocal fold polyps using a flexible laryngoscope via the contralateral side cricothyroid membrane.

The transcutaneous injection approach through the cricothyroid membrane can be performed as an office-based method under local anesthesia, but there are technical difficulties accessing the vocal fold until the operator becomes adept. However, it is believed that this technique can be performed easily and precisely with knowledge of relevant anatomical information. A previous our study demonstrated anatomical references regarding transcutaneous injection laryngoplasty through the cricothyroid membrane. Moreover, this route is well tolerated by patients and is generally viewed as the most preferable and convenient technique. In particular, our technique has many advantages compared with other transcutaneous approaches. While needle advanced into the paraglottic space, we had tried to avoid intraluminal penetration, which is less irritating and resulting in reduced gag reflex or cough. Second, with our technique, the needle penetrates the paraglottic space directly into the subepithelial space of the vocal fold, which leaves no puncture site in the vocal fold mucosal layer. This way, we can achieve the least amount of injection material leakage from the puncture site.

A possible complication of a steroid injection is reduction in vocal fold mass and muscle atrophy. Tateya et al and Tateya described the possibility of vocal fold atrophy following steroid injection. However, they reported that it was not observed even 5 years after the injection. Sulica and Behrman described the possible complication of steroid injection: it can delay wound healing and promote scar formation. In our experience, we had 4 cases of mild vocal fold atrophy. Although the vocal nodules had disappeared by the second week after the steroid injection, all 4 patients complained of a mild breathy voice. In their stroboscopic findings, we observed decreased amplitude of mucosal wave and mild vocal fold bowing, so we defined these findings as vocal fold atrophy. Vocal fold atrophy was improved at about the 2-month follow-up visit. At that point, we thought that the condition was not a true muscular atrophy but an atrophy of mucosal glandular structure. Two patients in our study developed a white plaque. At the 2-week follow-up visit, they had a subepithelial white plaque at the triamcinolone injection site, which had reduced spontaneously by the fourth week. This plaque was believed to result from the chalky material present in the triamcinolone solution itself and did not have a negative impact on vibration of the vocal fold.

Six patients in our study showed a recurrence. Their stroboscopic findings showed improvement by the second week, but their vocal fold nodules had returned to the preoperative condition by the fourth week after injection. Particularly, the recurrences were directly related to the heavy vocal use demanded by their occupations. As mentioned in other reports, the basic cause of vocal nodules is voice misuse and overuse, and they may recur unless the vocal misuse and overuse habit is changed. Treatment should also involve postoperative voice abstinence, and vocal hygiene education to benefit the long-term effect of a vocal fold steroid injection.

In our study, we did not classify patients according to their nodule size. However, nodule size can affect the treatment response. Shah et al reported a relationship between voice quality and vocal nodule size. They concluded that other than pitch reduction, objective and subjective voice measurements are not statistically different in varying vocal nodule sizes. Parameters such as glottic pressure and airflow would be useful indicators of glottal insufficiency and can be applicable in assessing nodule size. Further study of the relationship between nodule size and treatment response will be helpful.

Some previous studies have reported on the prevalence of laryngopharyngeal reflux (LPR) and gastroesophageal reflux disease in patients with true vocal fold lesions (TVFLs) such as nodules, polyps and Reinke edema. Beltsis et al conducted a prospective study to verify the association of TVFLs and LPR. They further compared the pH-monitoring findings of smokers vs non-smokers. Their results study suggested that LPR is more prevalent in patients with TVFL and that nonsmokers with TVFLs are more likely to have LPR than smokers with TVFLs. Chung et al also reported a case-control study to determine the significance of LPR in benign mucosal lesions. They concluded that LPR might play a role as an etiologic factor in Reinke edema and vocal polyps. In their study the vocal nodule group was not significantly different from the control group.

In the present study, to evaluate the effect of smoking in treatment results, we noted patients with a his-
tory of smoking based on their medical records. However, there was no significant correlation between smoking status and treatment response in our study (P = .82). We did not analyze the correlation between LPR and treatment response. Further study will be needed to clarify the correlation between LPR and treatment response. These 2 concomitant conditions are highly prevalent in patients with vocal fold disease and are important to identify prior to instituting treatment.

Our main limitation was lack of a control group. If further study could be performed comparing steroid injection group vs voice therapy group, efficacy of steroid injection could be assessed more accurately. Subsequent investigation with a control group will be needed to assess the efficacy of the steroid injection. In our study, we used a 2- and 4-week follow-up period to evaluate treatment efficacy, which was relatively soon after injection. Although approximately 93% of our patients showed treatment efficacy, which was relatively soon after injection, improvement (n=74), more long-term results will be needed to confirm treatment permanence.

CONCLUSIONS

Our study showed that 93% of patients with vocal nodules showed improvement with no severe complications (n = 74). We found that local steroid injection via the cri- cothyroid membrane using a transnasal flexible laryngoscope in patients with vocal nodules was safe and may be a useful treatment. However, vocal nodules are caused mainly by excessive voice use. Therefore, even if a marked improvement was shown after injection, recurrence can occur unless the voice abuse habit is changed. Even if steroid injection may help eliminate vocal nodules in some patients, it cannot substitute for voice therapy. For consolidation of the treatment results and limitation of the potential recurrence, postoperative voice therapy may be needed.7 Treatment should also involve voice abuse reduction education to improve the long-term effect of a vocal fold steroid injection.

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Author Contributions: Dr Lee had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Lee, Yeo, Kim, Woo, and S.-M. Jin. Acquisition of data: Lee, Yeo, Choi, and H.-J. Jin. Analysis and interpretation of data: Lee, Yeo, and S.-M. Jin. Drafting of the manuscript: Choi, H.-J. Jin, Kim, and Woo. Critical revision of the manuscript for important intellectual content: Lee, Yeo, and S.-M. Jin. Statistical analysis: Lee, Yeo, and Choi. Obtained funding: Lee and S.-M. Jin. Administrative, technical, and material support: Lee, Yeo, and S.-M. Jin.


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REFERENCES