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Effects of Greater Occipital Nerve Block on Tinnitus and Dizziness

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Abstract: We analyzed relationships among tinnitus relief, dizziness, and results of vertical autocorrelation studies of head movement to investigate the effect of greater occipital nerve block on the sensory and motor system in 2 patients with abnormal head movement. Tinnitus improved in 14 (52%) of 28 tinnitus patients after occipital nerve block. The percentage of patients reporting tinnitus improvement (54%, or 7 patients) among 13 patients without a history of trauma was not significantly higher than among 12 patients with trauma (33% or 4 patients). However, tinnitus improvement in patients with dizziness but without trauma was more frequent than that reported by nontraumatic tinnitus patients without dizziness ($p < .05$). Vertical autocorrelation results while stepping in place were better in patients with tinnitus relief than in those not reporting tinnitus relief ($p = .001$). Dizziness improved in 8 of 13 patients (62%) with trauma, similar to improvement in 8 of 14 patients without trauma (57%). Improved word perception test results in the presence of noise suggested that improvement in tinnitus and dizziness after occipital nerve block was related to improved attention.

Keywords: autocorrelation, dizziness, head movement, occipital nerve block, sleep disorders, tinnitus

Greater occipital nerve block (GONB) initially was performed to treat neck and posterior head pain associated with head trauma [1]. Presently, GONB also is used for treating dizziness and tinnitus, again mainly when associated with head and neck trauma [2]. This range of effects suggests that GONB may act on both sensory and motor systems. Decreased dizziness after GONB could be explained partly by effects of local anesthetics on linkage between α and γ efferents. Matthews and Rushworth [3] reported that γ fibers controlling muscle tension are more sensitive to local anesthetics than are α fibers. Such a finding might help to explain improvement in locomotion after GONB. Relief of tinnitus, however, cannot be explained by effects on α-γ linkage. An interesting comparison is the manner in which GONB acts on the sensory system in the case of tinnitus and effects that may involve the motor system in dizziness.

In a preliminary report, we showed that a system detecting head movement using magnetic sensors was useful in evaluating disequilibrium during stepping in place, and we found that vertical autocorrelation of head movement during stepping was related to degree of dizziness [4]. The magnetic measurement system shows good reproducibility and is very sensitive to balance difficulties, even showing some degree of disequilibrium in many patients who do not perceive dizziness [4].

We compared relationships among tinnitus, dizziness, and results of vertical autocorrelation analysis of head movement in this study to investigate the effects of GONB on the sensory and motor systems. In studies involving electrical stimulation of the ear, relief of tinnitus was accompanied by improved selective attention [5], and patients with tinnitus relief after GONB sometimes noted improved attention. Accordingly, sentence competition tests were performed before and after GONB to evaluate changes in attention.

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This study was presented at the Twenty-Fifth International Congress of the Neurootological and Equilibriometric Society, March 19–22, 1998, Bad Kissingen, Germany.

METHODS

Patients

We studied 27 patients who ranged in age from 38 to 74 years (mean age 58.3) and who for more than 6 months sometimes felt dizziness recurring during walking. Etiologies of dizziness included head trauma (n = 12), vertebrobasilar insufficiency (n = 4), temporomandibular joint disorders (n = 1), and peripheral vestibular disorders (n = 10).

In five patients (positive trauma history, 3; tinnitus only, 1; chronic otitis media, 1), selective attention was evaluated before and after occipital nerve block by presenting 20 grammatically correct four-segment sentences mixed with noise [5]. Thirteen tinnitus patients without dizziness, ranging in age from 38 to 72 years, also were investigated before and after GONB.

We used GONB for treating tinnitus and dizziness in patients reporting tenderness over the skin in the area to be blocked. During the treatments, patient with abnormal vertical head movement and tenderness were selected for our study.

Measurement of Head Movement

The system is composed of a three-space ISOTRAK apparatus and a personal computer (PC-98, NEC, Tokyo). The source coil was placed at the vertex of a helmet, and the sensor coil was installed at a wooden post. The parameter tested was vertical autocorrelation of head movement during stepping in place. Sampling frequency was 30 Hz, and duration of recording was approximately 17 seconds (511 data points). Patients were instructed to step in place at a comfortable speed. GONB was performed by injecting a local anesthetic (1% lidocaine [Xylocaine], 5–10 ml) into the tender area near the greater occipital nerve.

Evaluation of Attention

To evaluate selective attention, 20 grammatically correct but nonsensical four-segment sentences were presented together with multiple voices recorded on a compact disk. The material was delivered to the tested ear at a comfortable level via a headphone. The signal-to-noise ratio was 0 dB. The test involved sentence competition. Four patients among the 27 with dizziness and 1 patient of the 13 patients with tinnitus only were requested to repeat what they had heard. Scores were compared for each segment in 20 sentences before and after occipital nerve block. A representative grammatically correct, nonsensical four-segment sentence was, "Red dog cow barks" in Japanese word order; the English meaning would be, "A red dog barks cow."

Correcting for Improvement Due to Practice

Considering the possibility of adaptation to the sentence competition test, we calculated the improvement as mean plus 1 standard deviation (SD) in the number of incorrect words in each segment of the sentences between a first and second test in 18 patients without treatment (mean age, 64.3 years) [5]. The interval between the two trials was approximately 5 minutes. Only 3% of untreated patients among those tested improved more than 2 SD from the original mean. Therefore, when the number of incorrect words for each segment decreased over two, three, or four words, respectively, word perception was considered improved [5].

RESULTS

Figure 1 shows representative head movement in a patient with improvement on the competing word test and in the complaint of tinnitus. Before treatment, the patient appeared to stagger during the stepping test. Head movement deviated to the left and largely moved forward. Deviation decreased after treatment. Figure 2 shows horizontal and vertical autocorrelation results with respect to the movement shown in Figure 1. Horizontal autocorrelation was normal, indicating that the patient could step rhythmically. However, prior to treatment, vertical autocorrelation was abnormal because the frequency of vertical head movement was less than twice the horizontal head movement. After treatment, vertical autocorrelation for head movement became normal.

Dizziness and autocorrelation of vertical head movement were classified as better, unchanged, or worse after treatment. Seventeen of the 27 patients (63%) improved with respect to dizziness (Fig. 3). Sixteen of the 17 patients (94%) with improvement in dizziness showed better autocorrelation after treatment, but a patient reporting decreased dizziness with treatment showed worse autocorrelation. In all, three patients (including this one) declined in terms of autocorrelation after treatment.

Figure 4 shows results in the word perception test from a patient with tinnitus relief and a patient reporting no tinnitus relief. Improved word perception in the presence of noise was observed in three patients with improved tinnitus but was not observed in two patients without improved tinnitus. Two of the three patients with improved word perception were under treatment after traffic accidents, and the other had only tinnitus without dizziness. Two patients who had no improvement in word perception had a history of trauma. Overall, the results suggest that tinnitus relief after GONB may be related to improved attention. The apparent etiology of tinnitus in both patients in Figure 4 was the so-called whiplash syndrome.

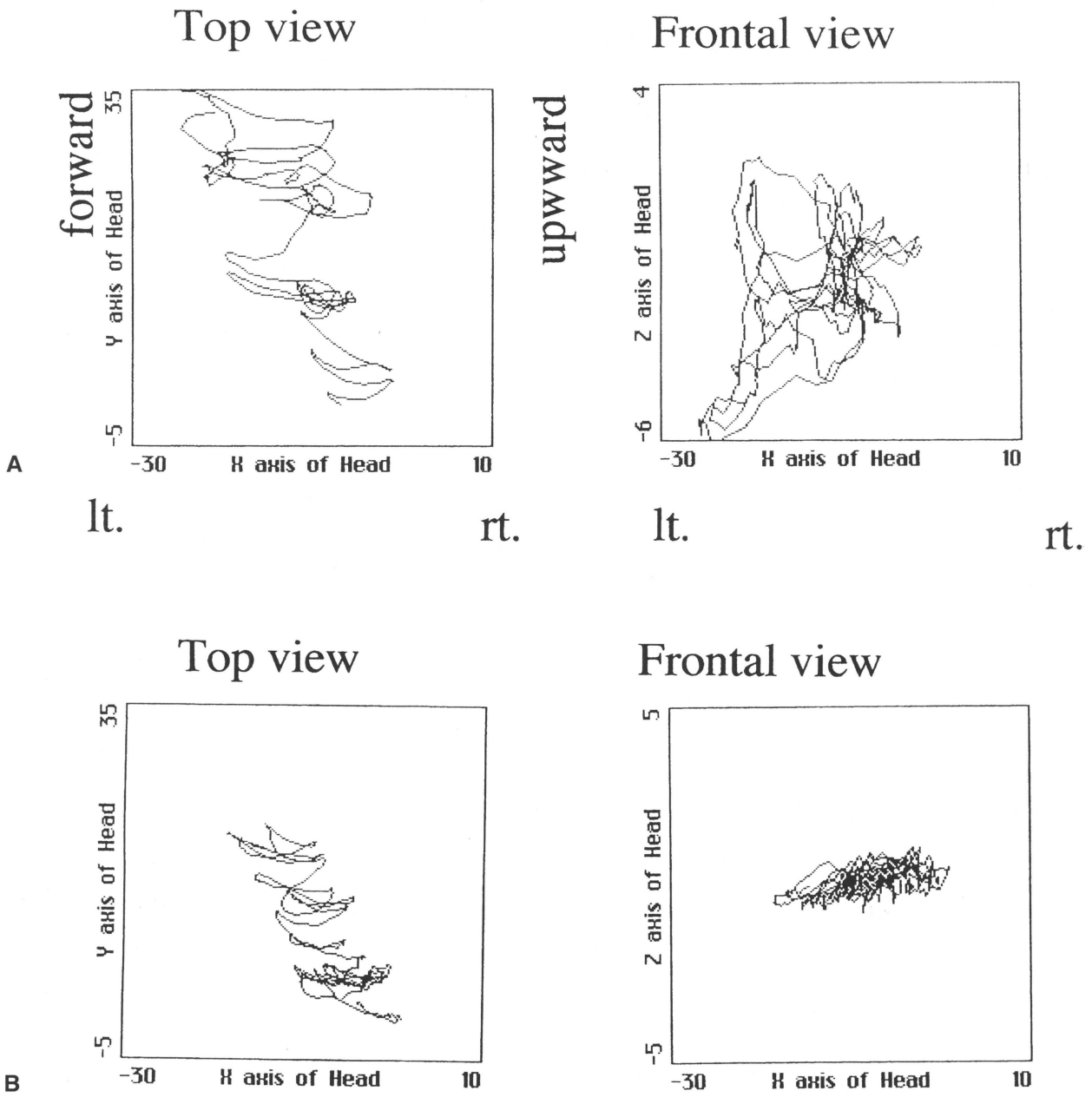

Figure 1. Head movement in a patient with improved competing word test and tinnitus relief. (A) Head movements while stepping in place before treatment; (B) Movements after treatment. Units are centimeters. Note that the head moves more rhythmically than before treatment.

Table 1 summarizes effects of occipital nerve block on autocorrelation, dizziness, and tinnitus. No significant difference was referable to the block ($p > .05$) regarding improvement in autocorrelation among patients with dizziness and trauma, such patients without trauma, and tinnitus patients without dizziness. Of patients in whom dizziness was improving with the block, no significant difference in improvement was evident between 8 of 13 patients with trauma (62%) and 8 of 14 patients with no trauma (57%; $p > .05$), suggesting that indications for the trial of GONB in dizziness were not specific to patients with dizziness and trauma. Tinnitus improved in 11 of 25 patients with dizziness (44%) and in 2 of 13 patients with tinnitus only (15%; $p < .05$). The percentage of patients reporting tinnitus improvement (54%) in 13 patients without trauma was not higher ($p > .05$) than that (33%) in 12 patients with trauma. Thus, indications for GONB to treat tinnitus were not trauma-specific. However, tinnitus improvement in patients with dizziness but no trauma was more

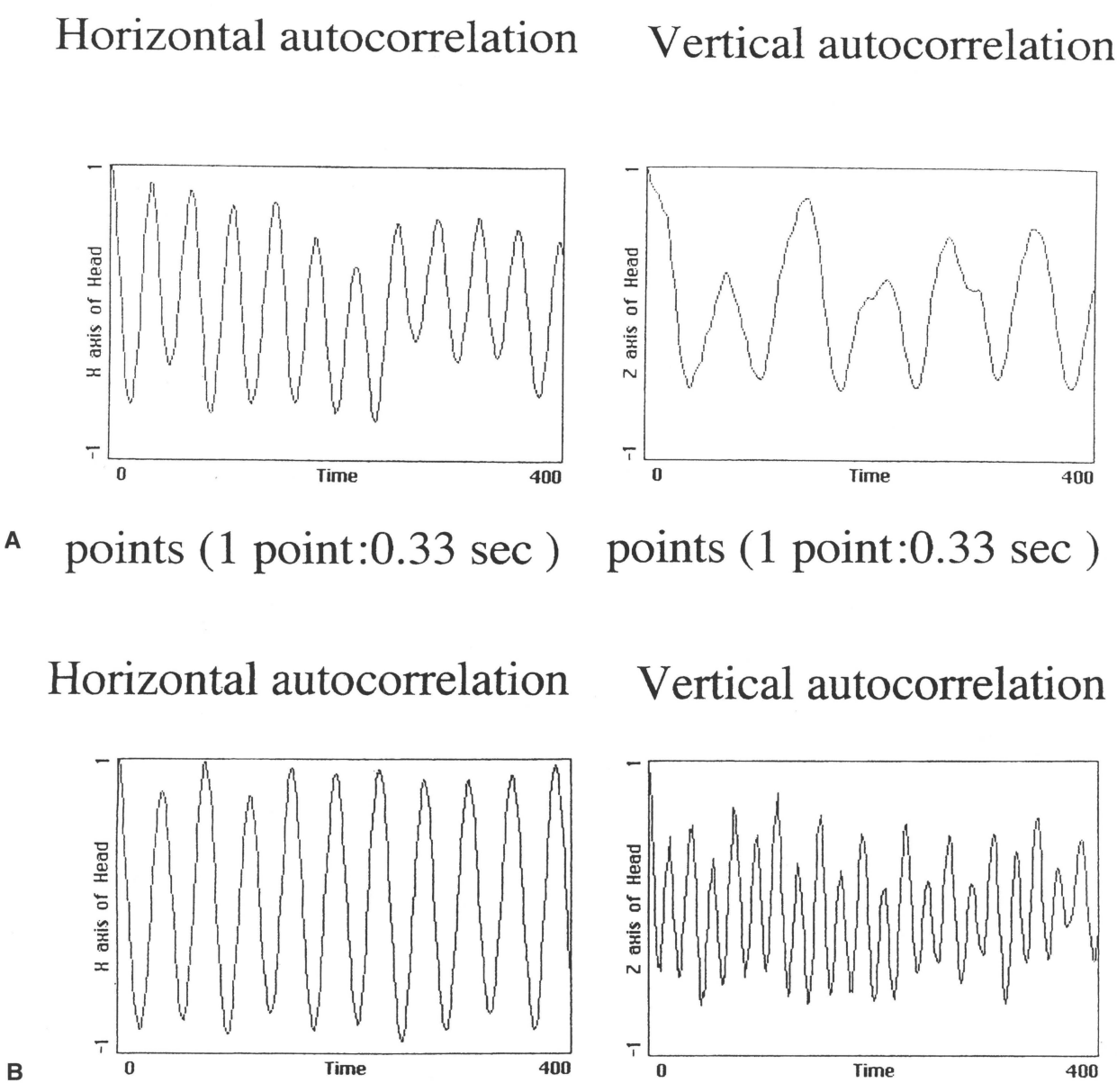

Figure 2. Horizontal and vertical autocorrelation corresponding to those in Figure 1. Horizontal and vertical autocorrelation before treatment are shown in the upper panels and are shown after treatment in the lower panels. The ordinate shows values for autocorrelation, and the abscissa shows time. Of the latter, one point equals 0.33 seconds. Note that the frequency of vertical autocorrelation after treatment is twice that of horizontal wave, showing normal findings.

frequent than in nontraumatized tinnitus patients without dizziness ($p < .05$).

Table 2 shows relationships between tinnitus and vertical autocorrelation. On the basis of effect of treatment, tinnitus and autocorrelation of vertical head movement were classified as better, unchanged, or worse. The percentage of improved autocorrelation in patients reporting tinnitus relief was significantly higher than that in patients with no tinnitus relief ($p = .001$). Tinnitus relief was associated with greater improvement in vertical autocorrelation of head movement than that in association with no tinnitus relief ($p = .001$). One of 14 patient with tinnitus relief (7%) showed worse vertical autocorrelation, and 4 of 24 patients without tinnitus relief (17%) showed worse vertical autocorrelation. The percentage of patients with worse vertical autocorrelation results showed no significant difference ($p > .05$).

DISCUSSION

Our study showed that patients who had dizziness and had tinnitus relief after GONB also experienced de-

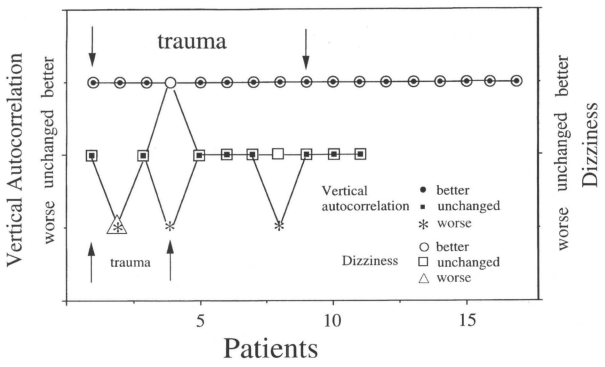

Figure 3. Relationship between dizziness and autocorrelation of vertical head movement. Note that decreased dizziness was accompanied by a better finding of vertical autocorrelation of head movement (trauma = patients with trauma).

Table 1. Effects of Occipital Nerve Block on Dizziness and Tinnitus

	With Trauma[a]	Without Trauma[b]	Tinnitus Only
Improved autocorrelation	7 of 13[c]	8 of 14[c]	6 of 13[c]
Decreased dizziness	8 of 13[d]	8 of 14[d]	—
Relief of tinnitus	4 of 12[e,g]	7 of 13[f,g]	2 of 13[e,f]

[a]Includes one patient with temporomandibular joint dysfunction; one patient had no tinnitus.
[b]One patient was free of tinnitus.
[c]$p > .05$.
[d]$p > .05$.
[e]$p > .05$.
[f]$p < .05$.
[g]$p > .05$.
Note: No significant difference in decrease in dizziness and tinnitus between patients with and without trauma was observed. Decrease in tinnitus in patients with dizziness was significantly higher than in patients without dizziness but with tinnitus only.

creased dizziness. However, in another study, injection of local anesthetics into the deep muscles in normal subjects produced rotatory vertigo, deviation to the injected side during stepping, and a tendency to fall to the injected side [6]. Only one patient in our study (2.5%) complained of worse dizziness after GONB, whereas two other patients (5%) showed worse autocorrelation without reporting worse dizziness. A discrepancy is evident between improved dizziness in our study and worse dizziness in other studies [6]. Xylocaine-induced GONB acts directly on the α-γ linkage, so we found it necessary to consider the effects of spinal reflexes on head movement. However, injection of Xylocaine into the superficial layer of muscle produces little imbalance [7] because muscle spindles are sparser than in deeper muscles [8]. Receptors mediating the oculocervical reflex are distributed densely in the capsules of the upper cervical joints. The area infiltrated in an occipital nerve block includes the attachments of the semispinalis and trapezius muscles. As these muscles belong to the superficial layer, Xylocaine injected at this site has little effect on balance.

How does injected Xylocaine improve dizziness? Our previous report showed tinnitus relief after electrical stimulation of the ear to be related closely to improved head-movement control (unpublished data). This newer study showed that tinnitus relief almost always was accompanied by better autocorrelation of head movement. The percentage of improved autocorrelation in patients with tinnitus relief is significantly higher than that seen in patients with no tinnitus relief ($p = .01$), as shown in Table 2. In our previous report, we found that improved autocorrelation suggested improved dizziness [4]. Therefore, we speculated that tinnitus relief could be related to decreased dizziness. Answering how tinnitus relief after GONB might be associated with decreased dizziness necessitates consideration of actions of GONB on the neck. The greater occipital nerve is a sensory branch of the second cervical nerve; the major aim of GONB is to relieve occipital muscle tension headache and muscle stiffness. We injected Xylocaine into the area with tenderness. Continuous noxious stimuli from the neck muscles would

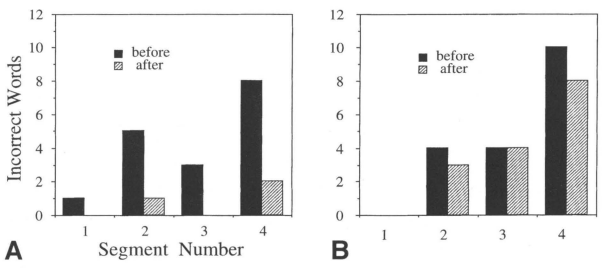

Figure 4. Result of competing word perception test. (A) Result of the competing word perception test in a patient with tinnitus relief. (B) Result in a patient without tinnitus relief. The abscissa shows segment number in the sentence, and the ordinate shows incorrect words. *Before* and *after* refer to treatment.

Table 2. Relationships Between Tinnitus and Vertical Autocorrelation

	Better	Unchanged	Worse	No.
Better	13[a]	0	1[b]	14
Unchanged	7[a]	13	4[b]	24
Worse	0	0	0	0

[a]$p = .01$.
[b]$p > .05$.
Note: Two other patients did not have tinnitus. Decrease in tinnitus was related to improved vertical autocorrelation.

induce stress, resulting in increased sympathetic nervous tone, which may evoke tightening of muscles around the neck and shoulders in response to noxious stimuli [9], disturbing head movement in patients. Relief of headache and muscle stiffness causes patients to feel comfortable and sometimes permits them to turn their heads with greater ease. In some other patients with tinnitus relief after GONB, digital blood flow increased, suggesting increased parasympathetic nerve tone [10]. This sequence indicated that injected Xylocaine may act on the autonomic nervous system.

Tinnitus mimics bothersome noise exposure in some tinnitus patients. Such a distracting, internal noise induces the high activity in stress-susceptible areas [11], accompanied by increased sympathetic nerve tone. Our previous report showed that electrical stimulation of the ear increased cutaneous digital blood flow in patients who reported tinnitus relief [12]. These findings suggest the possibility of increased sympathetic tone in tinnitus patients. Hinoki et al. [13] suggested that the effectiveness of GONB in patients with posttraumatic dizziness correlates with results of equilibrium tests with adrenaline loading, showing increased sympathetic nerve tone in the occipital muscles in patients with decreased dizziness. Increased sympathetic nerve tone involving the amygdala, hippocampus, hypothalamus, and equilibrium centers of the brainstem has been noted also in posttraumatic patients [4]. Increased sympathetic nerve tone in the equilibrium center would tend to induce disorders of eye movement and balance. Hinoki et al. [13] suggested that GONB reduced this sympathetic nerve tone in the occipital region in posttraumatic patients, resulting in decreased dizziness. GONB, however, decreased dizziness in roughly equal fractions of patients with and without trauma in our newer study. Therefore, especially in tinnitus patients without trauma, other mechanisms independent of the autonomic nervous system may be operating to relieve tinnitus.

Endorphins produced in the brain in reaction to noxious stimuli tend to suppress or blunt the noxious feeling of pain [10, 15]. GONB using Xylocaine may have a similar action on continuously noxious stimuli in the occipital region. Being free from noxious sensation after GONB may cause patients to feel relaxed, with resulting improved selective attention. We previously reported that improved attention after electrical stimulation of the ears may be associated with tinnitus relief [4]. Our study showed tinnitus relief to be associated with improved attention and improved head movement in tinnitus patients with dizziness.

Our previous report showed that tinnitus patients with severe sleep disorders showed abnormal head movement, even without a perception of dizziness [5]. Tinnitus relief after electrical stimulation is accompanied by improvement in sleep disorder symptoms and in head movement. We therefore speculated that the mechanism of external electrical tinnitus suppression may be due to relaxation (unpublished data), resulting in improved attention. The effectiveness of external electrical stimulation on tinnitus in 39 of 77 patients (51%) was significantly higher ($p = .01$) than that after GONB in tinnitus patients without dizziness (15%). However, effectiveness of tinnitus suppression in patients with no trauma after GONB (54%) was similar to that seen in patients after external stimulation. The discrepancy in effectiveness of tinnitus suppression between GONB and external electrical stimulation suggests that improved attention after GONB may not be of sufficient benefit for many tinnitus patients without dizziness to experience relief of tinnitus. The effectiveness of tinnitus suppression seen after GONB is similar between patients with dizziness and trauma and tinnitus patients with no dizziness, possibly reflecting central effects of trauma. GONB may be effective only for patients experiencing noxious stimuli that disrupt attention. When noxious stimuli in patients with disturbed head movement were relieved after GONB, increased parasympathetic nerve tone and improved attention would cause decrease of dizziness and tinnitus. Although external electrical stimulation is the first choice for treating tinnitus at our clinic, GONB remains an option for tinnitus patients with occipital tenderness and dizziness.

CONCLUSIONS

Our study showed that effectiveness of GONB on dizziness and tinnitus was not specific to patients with trauma. However, the percentage of patients showing improved autocorrelation among those reporting tinnitus relief was significantly higher than the percentage among patients without tinnitus relief ($p = .001$). Therefore, we speculate that tinnitus relief is related to decrease in dizziness. A word perception test suggested that improved attention after GONB was related to relief of tinnitus and dizziness.

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