Cervical Nerve Projections to the Auditory Pathway in Tinnitus

Henk M. Koning1*

ABSTRACT

Introduction: Cervical spinal nerves project to the auditory system and take part in the pathology of tinnitus.

Objectives: The intention of our research was to estimate the outcome of treatment of C6 and C7 to lessen tinnitus intensity and to find criteria for a long-term success.

Design: Subjects were 78 tinnitus patients who were treated with infiltration of the sixth and seventh cervical nerve. Clinical data form these patients were reviewed retrospectively. An independent perceiver evaluated the long-term effect of the therapy by telephone interview.

Results: In a cohort of tinnitus patients, 18% had less tinnitus after treatment of C6 and C7. The majority of the patients announced a moderate easing of their tinnitus. At 2,5 months, half of the patients with a positive response still had benefit. The combination of hearing loss at 8 kHz and the highness of the intervertebral disc at C4-C5 forecasted a beneficial result of therapy of C6 and C7 with a longer period of relief.

Conclusions: Treating afferent cervical nerves can lessen tinnitus. Therapy of C6 and C7 caused less tinnitus for 18% of the tinnitus patients. Especially patients with no hearing loss at 8 kHz and no disc degeneration at C4-C5 forecasted a beneficial result of therapy of C6 and C7 on tinnitus with a longer period of relief.

Keywords: Tinnitus, cervical spine, sixth and seventh cervical nerve, auditory-somatosensory integration

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INTRODUCTION

Cross-modal interactions between auditory and non-auditory systems such as the somatosensory system exist within the pathway of the auditory system\(^1\). Cervical spinal nerves project to the auditory system and take part in the pathology of tinnitus\(^2\)-\(^5\). In previous studies, the outcome of therapy of the second (C2)\(^2\), third and fourth (C3 and C4)\(^3\), fifth (C5)\(^4\), and eighth (C8)\(^5\) cervical nerves were assessed in tinnitus patients. However, the sixth and seventh (C6 and C7) cervical nerves have not been studied yet. The intention of our research was to estimate the outcome of treatment of C6 and C7 to lessen tinnitus intensity and to find criteria for a long-term success.

MATERIALS AND METHODS

Subjects

The Ethic Committees United (Nieuwegein, the Netherlands) gave permission for the study. All patients who had therapy of C6 and C7 to lessen their tinnitus in a three-year period (October 2016 - October 2019) were incorporated.

Therapy of C6 and C7

Two 23-gauge needles were situated at the foramen C5-C6 and C6-C7. A mix of 1 ml bupivacaine 0.5% and 0.5 ml dexamethasone was infused. Patients were assessed again 7 weeks after therapy.

Data Assessment

Data included the self-reported benefit at 7 weeks postoperative and the duration of relief. Patients with a positive result after therapy and without a relapse, were interviewed by an independent perceiver to assess the interval of relief.

Statistical Methods

Statistical analyses were realized with Minitab 18 (Minitab Inc., State College, PA, USA), using survival analysis and multiple regression analysis.

RESULTS

In a three-year period, 78 patients underwent therapy of the sixth and seventh cervical nerves for their tinnitus. On follow-up, fourteen of seventy-six patients (18%) responded with an easing of their tinnitus. There were 2 non-responders. The successful responders graded the relief from their tinnitus (36% good, and 64% moderate). Adverse effects of the infiltration of the sixth and seventh cervical nerves were reported in six of the seventy-six patients (8%) at 7 weeks of follow-up. One patient experienced dizziness (1%) and five patients had an aggravation of their tinnitus (7%).

Figure 1 shows the likelihood of permanent tinnitus relief after a successful nerve root infiltration of the sixth and seventh cervical nerve. At 2.5 months, half of the tinnitus patients still had benefit. Patients with benefit from therapy of the sixth and seventh cervical nerve on their tinnitus were set side by side with non-responders (Table 1). A positive effect of therapy of C6 and C7 was associated with bilateral tinnitus, better hearing at the audiogram from 250 Hz till 8 kHz, and less signs of cervical spine degeneration.

Statistical analysis specifies that the combination of hearing loss at 8 kHz and the highness of the intervertebral disc at C4-C5 predicted a beneficial result of therapy of C6 and C7 with a longer period of relief (Figure 3).

DISCUSSION

In a cohort of tinnitus patients, 18% had less tinnitus after treatment of C6 and C7. The majority of the patients announced a moderate easing of their tinnitus. At 2.5 months, half of the patients with a positive response still had benefit. The combination of hearing loss at 8 kHz and the highness of the intervertebral disc at C4-C5 forecasted a beneficial result of therapy of C6 and C7 with a longer period of relief.

Table 1: Clinical characteristics of the patients with tinnitus.

<table>
<thead>
<tr>
<th>Prevalence</th>
<th>Median</th>
<th>Q1 – Q3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>57</td>
<td>50 – 66</td>
</tr>
<tr>
<td>Gedern (male)</td>
<td>74%</td>
<td></td>
</tr>
<tr>
<td>Unilateral tinnitus</td>
<td>33%</td>
<td></td>
</tr>
<tr>
<td>Self-perceived hearing loss</td>
<td>67%</td>
<td></td>
</tr>
<tr>
<td>Cervical pain</td>
<td>64%</td>
<td></td>
</tr>
<tr>
<td>Period of tinnitus (year)</td>
<td>4.0</td>
<td>1.5 – 17.3</td>
</tr>
<tr>
<td>Hearing loss (dB) at:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 250 Hz</td>
<td>15</td>
<td>5 – 20</td>
</tr>
<tr>
<td>- 500 Hz</td>
<td>15</td>
<td>5 – 24</td>
</tr>
<tr>
<td>- 1 KHz</td>
<td>15</td>
<td>5 – 27</td>
</tr>
<tr>
<td>- 2 KHz</td>
<td>20</td>
<td>10 – 35</td>
</tr>
<tr>
<td>- 4 KHz</td>
<td>43</td>
<td>24 – 57</td>
</tr>
<tr>
<td>- 8 KHz</td>
<td>55</td>
<td>29 – 70</td>
</tr>
</tbody>
</table>

dB: decibel; Hz: Hertz; KHz: Kilohertz; Q1 – Q3: Inter-Quartile Range.
The somatosensory system can cause aberrant neuronal actions in the auditory pathways, which can become aware as tinnitus. Consequently, treatment of tinnitus can involve modulating somatosensory innervation of the auditory system and treating the afferent cervical nerves can be warranted in tinnitus patients. In our previous studies, C2, C5 and C8 were the most prominent cervical nerves related to the pathogenesis of tinnitus. The cervical nerves C3, C4, C6 and C7 have less influence as therapy of these nerves are characterized by a low success rate (18-19%), moderate reduction after successful therapy, and a low half time of the success (2.5-3.8 months). Auditory-somatosensory fusion takes place in auditory nuclei. This phenomenon has been found for the cervical nerves C3, C4, and C5 in patients with tinnitus. The results of therapy of these cervical nerves depends on local cervical degeneration and a hearing loss at 1 or 2 kHz. However, this phenomenon did not take place for the cervical nerves C2, C6 and C7 as therapy of these cervical nerves was not related to cervical degeneration and hearing loss. Less cervical degeneration especially at intervertebral disc at C4-C5 and less hearing loss at 8 kHz associated with better result of therapy of C6 and C7. Persistent tinnitus is typically associated with hearing loss and cochlear damage. Damage to the cochlea enhances the firing rate of neurons in auditory structures. However, there is a distinction with which hearing frequency is hampered. Successful therapy of the jaw joint, the ganglion cervical superior, and the cervical nerve C8 in tinnitus patients was associated with hearing loss at the low frequencies (250-500 Hz). For the cervical nerves C3, C4, and C5, there is the same association with frequencies of 1 or 2 kHz at the audiogram. Successful therapy of the cervical nerves C2, C6, and C7 are not related to hearing loss. Instead, therapy of C6 and C7 had a better prognosis if there is no hearing loss, especially at 8 kHz.

From our studies concerning the therapy of specific cervical nerves in patients with tinnitus, we conclude that there is a distinctive pattern of auditory response for each cervical nerve in patients with tinnitus.
and C8 are the most prominent cervical nerves related to the pathogenesis of tinnitus\textsuperscript{2-5}. Of these cervical nerves, auditory-somatosensory integration is found in C5\textsuperscript{4}. Successful therapy of C8 is associated with less hearing at 500 Hz and successful therapy of C5 with less hearing at 1 kHz\textsuperscript{4,5}. For cervical nerve C2 there is no evidence of auditory-somatosensory integration and the involvement of this nerve is associated with no hearing loss at 8 kHz\textsuperscript{2}.

A number of limitations must be acknowledged. The retrospective implementation, self-reported treatment and outcome estimations, and the total patients are subject of discussion. In future studies, researchers should focus on a prospective study with more patients and a clear patient selection, based on the diagnostic criteria described in this study (Table 2).

**CONCLUSION**

Treating afferent cervical nerves can lessen tinnitus. Therapy of C6 and C7 caused less tinnitus for 18% of the tinnitus patients. Especially patients with no hearing loss at 8 kHz and no disc degeneration at C4-C5 forecasted a beneficial result of therapy of C6 and C7 on tinnitus with a longer period of relief.

**CONFLICT OF INTEREST**

The authors declare no potential conflict of interest on publishing this paper.

**REFERENCES**
