

Cervical Nerve Projections to the Auditory Pathway in Tinnitus

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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 from 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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Paper submitted on September 07, 2020; and Accepted on September 26, 2020

INTRODUCTION

Cross-modal interactions between auditory and non-auditory systems such as the somatosensory system exist within in the pathway of the auditory system¹. Cervical spinal nerves project to the auditory system and take part in the pathology of tinnitus²⁻⁵. 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

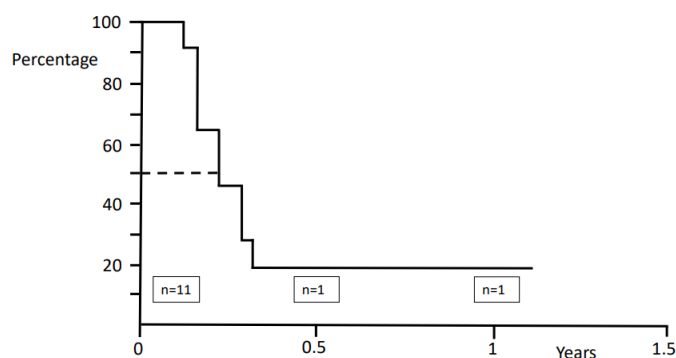


Figure 1: Kaplan-Meier plot to show probability of sustained tinnitus relief in successfully treated patients (n=11) after an infiltration of the sixth and seventh cervical nerve.

Table 1: Clinical characteristics of the patients with tinnitus.

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

dB: decibel; Hz: Hertz; KHz: Kilohertz; Q1 – Q3: Inter-Quartile Range.

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 the therapy of C6 and C7 on tinnitus at 7 weeks (Figure 2). The identification used in Figure 2 has a sensitivity of 91% and a specificity of 76% in forecasting a beneficial result of treating C6 and C7 to lessen tinnitus. The positive and negative predictive values were 43% and 98% respectively. Patients with this indication had a better result of therapy (good for 50% compared to good for 0% with no indication) and 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.

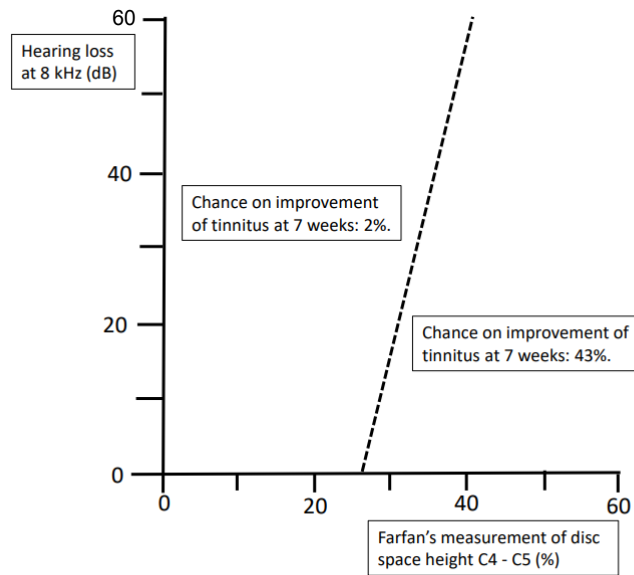


Figure 2: The combination of hearing loss at 8 kHz and the highness of the intervertebral disc at C4-C5 predicted a beneficial result of the therapy of C6 and C7 on tinnitus at 7 weeks (Proportion Correct=0.788). For instance, if a patient has 40 dB hearing loss at 8 kHz and an Farfan's measurement of intervertebral disc at C4-C5, there is a 43% chance of improvement of their tinnitus.

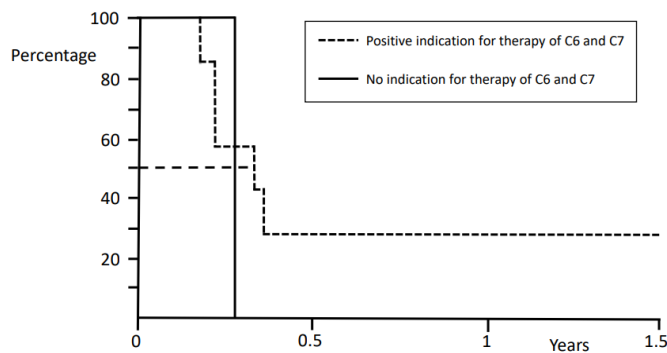


Figure 3: Kaplan-Meier plot to show probability of sustained tinnitus relief in successfully treated patients after an infiltration of C6 and C7 for patients with an indication for therapy and for patients with no indication.

The somatosensory system can cause aberrant neuronal actions in the auditory pathways, which can become aware as tinnitus⁶. 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 tinnitus²⁻⁶. 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)³.

Auditory-somatosensory fusion takes place in auditory nuclei⁷. This phenomenon has been found for the cervical nerves C3, C4, and C5 in patients with tinnitus^{3,4}. 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 loss². 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 damage⁸. Damage to the cochlea enhances the firing rate of neurons in auditory structures⁹. 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)^{10,11}. For the cervical nerves C3, C4, and C5, there is the same association with frequencies of 1 or 2 kHz at the audiogram^{3,4}. Successful therapy of the cervical nerves C2, C6, and C7 are not related to hearing loss². 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. C2, C5

Table 2: Patients with a positive effect of therapy of the C6 and C7 nerve roots on their tinnitus at 7 weeks were compared with non-responders.

	Positive effect of therapy of nerve C6 and C7 (n=14)			No effect of therapy of nerve C6 and C7 (n= 62)			P-value	
	Prev.	Mean	SEM	Prev.	Mean	SEM		
Gender (male)	64%			77%			0.320	
Unilateral tinnitus	7%			40%			0.009	Sign.
Self-perceived hearing loss	50%			73%			0.110	
Cervical pain	79%			59%			0.159	
Age at the start of tinnitus (year)		44	2.7		47	1.7	0.298	
Hearing loss (dB) at:								
- 250 Hz		10	2.6		22	2.8	0.002	Sign.
- 500 Hz		8	2.9		23	2.7	0.001	Sign.
- 1 KHz		10	3.2		25	3.0	0.001	Sign.
- 2 KHz		11	3.3		30	2.8	0.000	Sign.
- 4 KHz		26	5.7		48	2.9	0.003	Sign.
- 8 KHz		33	8.2		57	3.3	0.017	Sign.
Angle between vertebrae C2 and C6 (degrees):		4	2.6		8	1.4	0.246	
Farfan's measurement of disc space height (%):								
- C2-C3		39	1.3		39	0.9	0.922	
- C3-C4		40	1.4		34	1.3	0.005	Sign.
- C4-C5		42	1.6		33	1.2	0.000	Sign.
- C5-C6		34	2.1		26	1.3	0.003	Sign.
- C6-C7		30	2.8		25	1.3	0.145	
Size of anterior osteophyte (%) at:								
- C3		4	1.2		7	0.8	0.099	
- C4		8	1.4		11	1.2	0.068	
- C5		14	2.1		18	1.2	0.121	
- C6		10	1.6		14	0.9	0.037	Sign.

dB: decibel; Hz: Hertz; KHz: Kilohertz; Prev.: prevalence; SEM: Standard Error of the Mean; Sign: Significant.

and C8 are the most prominent cervical nerves related to the pathogenesis of tinnitus²⁻⁵. Of these cervical nerves, auditory-somatosensory integration is found in C5⁴. Successful therapy of C8 is associated with less hearing at 500 Hz and successful therapy of C5 with less hearing at 1 kHz^{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 kHz².

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.

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