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Review

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Somatic Modulation of Tinnitus: A Review and Some Open Questions

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ABSTRACT

Tinnitus modulation by movements of the temporomandibular joint, head and neck musculoskeletal structures and the eye can be found in one to two thirds of tinnitus sufferers; unfortunately this condition is often overlooked by otolaryngologists. Although somatic modulation has been initially hypothesized as a fundamental characteristic of tinnitus, there is increasing evidence of a tight connection with disorders of non-auditory regions. The structure that mostly modulates tinnitus is the temporomandibular joint, which mainly causes an increase in tinnitus loudness, followed by head and neck movements that may result in an increase or decrease of loudness and eye movements (gaze-evoked tinnitus). Besides loudness, somatic movements can also modulate tinnitus pitch and localization. Somatosensory tinnitus is a relatively new finding that leaves several open questions: are there individual predisposing factors to somatic modulation? How strong is the association between the capability to somatically modulate tinnitus and an underlying non-auditory disorder? Why patients that have concomitant hyperacusis also have higher chances of tinnitus modulation? Further basic science and clinical research is required to address these and many other questions about somatosensory tinnitus.

KEYWORDS: Somatic modulation of tinnitus; Temporomandibular joint disorder; Somatosensory tinnitus.

INTRODUCTION

Tinnitus is a widely spread symptom affecting over 16 million subjects in the US with consequences, sometimes severe,[1] on the overall quality of life of affected individuals.[2,3] Estimated prevalence ranges between 12 and 16%.[4] Tinnitus can derive from age-related or hereditary hearing loss,[5] acute or chronic acoustic trauma,[6-8] ototoxic drugs including aminoglycosides, cisplatin and high doses of salicylate,[9,10] other hearing disorders as well as from psychological factors such as depression, anxiety, obsessive compulsive, mood, conversion, somatoform and other psychiatric disorders.[11,12]

The pitch and loudness of tinnitus can be modulated and even evoked or silenced for a short time in some individuals by movements of the temporomandibular joint, head and neck muscles and the eyes due to interactions between the auditory and the somatosensory systems. This type of tinnitus, called somatosensory tinnitus, could be a direct consequence of a disorder of non-auditory musculoskeletal structures, a fundamental characteristic of tinnitus as hypothesized by Levine[13] or, most probably, an attribute of tinnitus favored by an underlying somatic disorder that triggers existing neural connections between somatosensory and auditory pathways. So far, even if clinical experience suggests a direct connection, there is a lack of studies that prove an association between modulation and a somatic disorder and, to date, no statistically significant association between somatic disorders and higher prevalence of tinnitus modulation following somatic maneuvers has been described.[14,15]

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The knowledge of the pathophysiologic basis of somatosensory tinnitus is constantly increasing thanks to basic research studies on animal models. Data from animal studies indicates the relay of afferent somatosensory information by the trigeminal and dorsal root ganglia; somatosensory input causes changes in the firing rate and synchrony in dorsal cochlear nucleus neurons that may be at the base of somatic tinnitus.[16,17]

The modulation of tinnitus by somatic movements is widely diffused among acute and chronic tinnitus sufferers and has been reported to involve one to two-thirds of them with different patient series ranging between 65% and 83%.[18-22] Several authors have developed sets of maneuvers to modulate tinnitus; a detailed description of these maneuvers has been published by Won in 2013 comparing the prevalence and characteristics of somatic modulation found in six previous studies.[22]

SOMATIC MODULATION OF TINNITUS

Temporomandibular Joint

The temporomandibular joint appears to be the region that mostly modulate tinnitus. Several authors reported a prevalent increase of tinnitus loudness following jaw maneuvers[14,18-20]; this could be explained by the mainly excitatory input of trigeminal nerve stimulated by temporomandibular movements. Rubinstein reported modulation of tinnitus in one-third of studied subjects following jaw movements or pressure on the temporomandibular joint.[23] In 2003, Levine reported that up to 80% of the subjects could somatically modulate tinnitus, mainly with jaw maneuvers.[19] In a following study by Simmons, the authors investigated patients who could modulate tinnitus by movements of the jaw: 90% indicated that their tinnitus became louder with a jaw clench, 41% reported that clenching caused their tinnitus loudness to double, 26% to triple. In the same patient series, a large portion of the subjects reported that jaw movements could also alter the pitch of the tinnitus, mainly increasing it to a higher frequency (91%).[21] In a smaller sample, Kapoula report that 61% of the examined patients (14/23 subjects) could modulate tinnitus with jaw movements.[24] In a recent analysis of 163 patients at the National University of Seoul, South Korea, Won reported that all jaw maneuvers, especially clenching of teeth and opening of the jaw with or without pressure increased tinnitus loudness.[22]

Head and Neck Musculoskeletal System

Daily fluctuations in perception of tinnitus have been reported, with some patients describing louder tinnitus upon awakening in the morning, while others reported absence of tinnitus in the morning, which returns during the day. Also, some tinnitus sufferers have reported experiencing louder tinnitus upon awakening from a nap in the sitting position; this could be explained by somatic factors like cervical spine muscle relaxation during the night or stretching of the neck muscles when the head passively falls forward while sleeping in a sitting position.[25]

Levine conducted a study on 70 patients and reported that 68% of the subjects could somatically modulate their tinnitus with head or neck maneuvers.[13] This finding was confirmed by Sanchez and colleagues with similar results (65%).[18] Kapoula reported that 10 patients out of 23 (43%) were able to modulate their tinnitus with head movements, 9 (39%) with muscle pressure.[24]

Discordant results in terms of increase or decrease of tinnitus loudness have been reported following head and neck maneuvers: Levine reported that 41% of the subjects could increase their tinnitus, 17% could decrease tinnitus loudness and 10% could either increase or decrease tinnitus loudness depending upon the maneuver.[13] On the contrary, Won reported a consistent increase in all jaw maneuvers and a consistent decrease in all head and neck maneuvers.[21]

Eye (Gaze-Evoked Tinnitus)

Movements of the eye have often been reported inducing a change in tinnitus pitch and loudness (gaze-evoked tinnitus). This was initially reported by Whittaker in 1982 in a patient experiencing tinnitus shifting eye gaze from straight to side gaze in right and left directions as a complication of acoustic neuroma surgery.[26] Simmons found that 77% of patients who had undergone acoustic neuroma surgery developed gaze-evoked tinnitus. In most cases tumor removal resulted in total loss of hearing in the affected ear; patients could hear tinnitus in the side of the acoustic neuroma. Interestingly, pre-existing tinnitus was a major risk factor associated with the development of gaze-evoked tinnitus in patients who had undergone acoustic neuroma resection.[21]

Other Structures

Besides temporomandibular joint, cranio-cervical muscle and eye movements, other structures have been also reported modulating tinnitus. They include limb,[13,18-20] cutaneous stimulation of the hand and face,[27,28] finger movements,[29] thrusting of the tongue in the midline, to the left, and to the right, and movements of facial expression such as eye closure, eyebrow raise, puffing the cheeks, baring the teeth, and pursing the lips.[21]

DISCUSSION

Tinnitus modulation by somatic movements is a relatively new finding that still requires basic science and human studies to better understand its pathophysiologic basis and clinical correlations. However, it has been reported that up to two-thirds of subjects with tinnitus have some form of somatic modulation; therefore this type of tinnitus certainly needs to be taken into account in future research directions.[30] Also, under a clinical point of view, somatosensory tinnitus is still widely overlooked by otolaryngologists when approaching tinnitus patients, missing the opportunity to highlight the presence of a disorder external to the auditory pathways that if correctly identified and treated

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could help in obtaining satisfactory results.

To date, there are several open questions about somatosensory tinnitus to be addressed:

1. Modulation of tinnitus is present in some subjects and is absent in others; are there predisposing factors to it? The identification of possible factors, such as gender, age, Tinnitus Handicap Index score, type of sound and tinnitus age, that increase the chance of tinnitus modulation could be an interesting information to facilitate patient selection for further somatic testing. Studies on larger patient series are required to address this question.

2. Is there, and how strong it is, an association between the capability to modulate tinnitus and an underlying pathological disorder of the involved region? Modulation seems to be favored when a musculoskeletal disorder is present,[31] but can also happen in its absence. The identification of a possible relationship between higher prevalence of positive tinnitus modulation following somatic maneuvers and a disorder of the corresponding region (mainly for temporomandibular joint and cranio-cervical regions) could facilitate the diagnosis of potentially overlooked temporomandibular joint or cranio-cervical dysfunctions responsible for the somatic origin of the tinnitus and therefore indicate a treatment of these disorders increasing chances of tinnitus improvement.

3. Changes that occur after somatic maneuvers are in most cases transitory and last for the time the maneuver is performed or for a short-time afterwards. However, some patients reported that tinnitus changes experienced during the maneuver, especially in loudness, last for longer periods of time after manipulation. This is consistent with patients who report tinnitus disappearance after a nap or in the morning, mainly linked to head and neck positions, and could represent a basis for a long-lasting effect of manual therapies.

4. Hyperacusis has been recently associated to higher modulation of tinnitus with somatic maneuvers of temporomandibular joint and head and neck. In a large retrospective analysis, Schecklmann reported that 27% of tinnitus patients were positive to somatic modulation, compared to 38% of patients with tinnitus and hyperacusis.[32] This could be linked to a higher sensitivity to somatic input in tinnitus patients with hyperacusis that could follow a generally increased sensitivity to sensory input. It would be certainly interesting to further explore this and highlight the basis of such potential hypersensitivity that could be useful for future therapeutic approaches.

In the authors opinion, tinnitus modulation should always be investigated when approaching tinnitus patients. In positive cases, a multidisciplinary approach aimed to identify underlying non-auditory disorders should always be sought to increase chances of tinnitus improvement. Clinical research to investigate the strength of the connection between modulation and somatic disorder, as well as possible predisposing factors is certainly needed. Further understanding of the pathophysiologic basis of somatic modulation of tinnitus and, especially, more studies on larger patients series are required to address these and many other questions about somatosensory tinnitus.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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