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Consensus Statements on Tinnitus Assessment and Treatment Outcome Evaluation: A Delphi Study by the Korean Tinnitus Study Group

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ABSTRACT

Background: Tinnitus is a multifactorial condition with no universally accepted assessment guidelines. The Korean Tinnitus Study Group previously established consensus statements on the definition, classification, and diagnostic tests for tinnitus. As a continuation of this effort, this study aims to establish expert consensus on tinnitus assessment and treatment outcome evaluation, specifically tailored to the Korean clinical context.
Methods: A modified Delphi method involving 26 otology experts from across Korea was used. A two-round Delphi survey was conducted to evaluate statements related to tinnitus assessment before and after treatment. Statements were rated on a scale of 1 to 9 for the level of agreement. Consensus was defined as ≥ 70% agreement (score of 7–9) and ≤ 15% disagreement (score of 1–3). Statistical measures such as content validity ratio and Kendall's coefficient of concordance (W) were calculated to assess agreement levels.

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Disclosure

The authors have no potential conflicts of interest to disclose.

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Results: Of the 46 assessment-related statements, 17 (37%) reached consensus, though overall pre-treatment assessments showed weak agreement (Kendall's W = 0.319). Key areas of agreement included the use of the visual analogue scale, numeric rating scale, and validated questionnaires for pre-treatment evaluation. Five statements, such as the use of computed tomography, magnetic resonance imaging, and angiography for diagnosing pulsatile tinnitus, achieved over 90% agreement. For treatment outcome measurements, 8 of 12 statements (67%) reached a consensus, with moderate agreement (Kendall's W = 0.513). Validated questionnaires and psychoacoustic tests were recommended for evaluating treatment effects within 12 weeks. While standardized imaging for pulsatile tinnitus and additional clinical tests were strongly recommended, full consensus was not achieved across all imaging modalities.

Conclusion: This study provides actionable recommendations for tinnitus assessment and treatment evaluation, emphasizing the use of standardized tools and individualized approaches based on patient needs. These findings offer a practical framework to enhance consistency and effectiveness in tinnitus management within Korean clinical settings.

Keywords: Tinnitus; Delphi Study; Consensus; Tinnitus Assessment; Treatment Outcome

INTRODUCTION

Tinnitus is a conscious perception of an auditory sensation without a corresponding external stimulus, described as various sounds or noises such as clicking, buzzing, or hissing.[1-3] It is estimated that 10% to 25% of the adult population is affected by tinnitus, with increasing prevalence in the younger population in recent years.[4,5] Although the impact of tinnitus on one's daily life may greatly vary among patients, tinnitus can be highly troublesome and may bring significant adverse effects. Many previous studies verify that tinnitus is clinically associated with diverse psychiatric disorders, mainly anxiety, depression, reduced concentration, and impaired sleep.[6-8]

Various theories and mechanisms have been proposed as the cause of tinnitus. These theories include peripheral and central auditory system dysfunction, neural synchrony and neuroplasticity, neurotransmitter imbalances, vascular conditions, psychological factors, and somatosensory involvement.[9-11] Tinnitus is believed to be a multifactorial disorder resulting from the involvement of more than one system in the body. Therefore, tinnitus assessments before and after treatments must cover various systems objectively and subjectively. Previously, tinnitus was primarily assessed through patient-reported questionnaires.[12] However, with recent progress in uncovering the pathophysiological mechanism of tinnitus, many objective measures are also being used to evaluate tinnitus. Some of these tests range from classical auditory function tests to psychoacoustic measures, as well as more recent, neuroimaging.[13-16]

Multitudinal evidence-based clinical practice guidelines were proposed by tinnitus interest groups from the United States, Germany, Denmark, the Netherlands, Sweden, and Japan to help physicians diagnose and treat tinnitus.[17] Although these guidelines offer a general agreement of experts worldwide, uncertainties persist due to differences in the medical environments and healthcare systems across countries. Thus, our goal for this study was to establish a consensus among Korean tinnitus experts regarding on the assessment of tinnitus and treatment outcome evaluation, tailored for Korea. This is the second part of a three-part

consensus statement conducted by the Korean Tinnitus Study Group, summarizing the result of a two-round Delphi survey with a systematic review of the literature.

METHODS

Study design

Similar to our previous study, the consensus statements on tinnitus were determined through the Delphi technique.[2] The basic aim of the Delphi methodology is to evaluate an epistemological issue and develop an expert-based judgment.[18] In our study, we applied a modified Delphi process to achieve consensus on tinnitus assessment both before and after intervention. A two-round Delphi survey was processed among clinical experts with experience in managing tinnitus (**Fig. 1**).[18]

Systematic review of literature

Before the initial Delphi survey, the selection of articles and collection of data was proceeded by two reviewers using the online search engine PubMed until December 2022. A total of 48 relevant articles on the clinical assessment of tinnitus both before and after receiving intervention were reviewed. Then, a list of potential consensus statements was given to the participants recruited for the Delphi study.

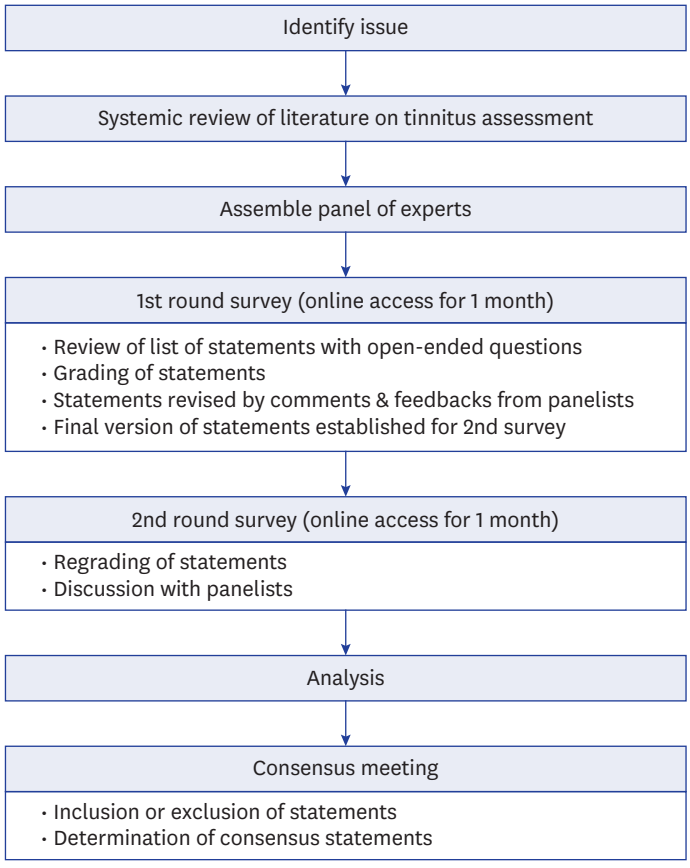

Fig. 1. Process of the modified Delphi Study on tinnitus assessment.

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Recruitment of panelists

In 2021, otologists recognized as clinical experts in managing tinnitus in Korea were selected as panelists for the Delphi survey. The Delphi survey was conducted from October 2021 through December 2021. Initially, invitation emails were distributed to members of the Korean Tinnitus Study Group, affiliated with the Korean Otological Society. A list of statements and questionnaires were sent to the clinical experts who agreed to participate in our study.

The Delphi survey

The modified Delphi survey consisted of a long list of statements and multiple-choice questions regarding tinnitus assessment and treatment outcome measurements. The survey was administered via online links distributed through personalized email, and the responses were presented anonymously. Demographic characteristics of the participants, including gender, age, affiliation, years in profession, and workplace environment, were gathered.

In the first round, 26 otology experts participated to rate the level of agreement of potential consensus statements for tinnitus assessment. Participants scored each statement on a scale of 1–9; 1–3 indicated high disagreement for tinnitus assessment, 4–6 indicated practical but not critical, and 7–9 indicated high agreement for tinnitus assessment.[19] All the participants were permitted to provide additional opinions and comments on each statement in free text.

After receiving all the responses from the first survey, an online meeting was held with all the participants. Feedback on the results was given to the participants, and statements were revised through thorough discussion. The purpose of the online meeting was to let participants receive controlled feedback, provide suggestions from their peers, and reevaluate the statements for the second-round survey.

The second-round survey was also proceeded via online links using the revised statements. A total of 26 experts participated in the survey, and their responses were reviewed and analyzed.

Consensus meeting

Following the second-round survey, a consensus meeting was conducted online to establish the level of agreement obtained from responses to the Delphi process. A consensus criterion on tinnitus assessment was defined when more than 70% of the participants scored a scale of 7–9 (indicating agreement), and less than 15% scored a scale of 1–3 (indicating disagreement). A strong recommendation for exclusion was defined when over 70% of the participants scored a scale of 1–3 and less than 15% scored a scale of 7–9.

Level of agreement

The content validity ratio (CVR) and Kendall's coefficient of concordance (W) were measured to validate the scores obtained from the Delphi survey. A high level of agreement was indicated when the value of CVR was ≥ 0.37 ($P < 0.05$). According to Kendall's W, which ranges from 0 to 1, a value closer to 1 implies a higher convergence level of opinion. In detail, the W of 0.9 represents unusually perfect agreement; 0.7, strong agreement; 0.5, moderate agreement; 0.3, weak agreement; and 0.1 represents very weak agreement with no confidence in ranks.[20]

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RESULTS

The Delphi survey was conducted from October 2021 to December 2021 with 26 experts in diagnosing and treating tinnitus. In the first round, a list of statements for assessment tests and clinical methods to determine treatment effects for tinnitus was reviewed. Participants were given a month to revise the statements with additional opinions. After the first round of online surveys, an online meeting proceeded for open discussion about the potential consensus statements. Similar statements were merged and controversial contents were clarified, resulting in 46 statements and 11 multiple-choice questions for the second-round survey (**Table 1**).[21-64]

Table 1. List of statements of second round Delphi survey

No.	Assessment of tinnitus before & after treatment	1–3 (Dis-agree)	4–6	7–9 (Agree)	Ref.[a]
1	VAS or NRS is used to evaluate tinnitus before treatment.	0.0%	0.0%	100.0%	**21**
2	At least one validated questionnaire is used to evaluate tinnitus before treatment.	3.8%	0.0%	96.2%	**22**
3	Surveys regarding the patient's psychological status and comorbid conditions that may affect tinnitus are required during the patient's first hospital visit.	0.0%	19.2%	80.8%	**23,24**
4	The approach to tinnitus treatment should vary depending on the results of questionnaires regarding the patient's psychological status and comorbid conditions that may affect tinnitus.	3.8%	7.7%	88.5%	**25-28**
5	The severity and prognosis of tinnitus can be predicted from the results of questionnaires regarding the patient's psychological status and comorbid conditions that may affect tinnitus.	3.8%	30.8%	65.4%	**27,28**
6	Results of specific tinnitus questionnaires should be prioritized over questionnaires related to psychological status or comorbid conditions in assessing treatment outcomes for tinnitus.	7.7%	26.9%	65.4%	**29**
7	Auditory system damage evaluated by auditory tests aids diagnosis and treatment plans for tinnitus.	0.0%	3.8%	96.2%	**11,30**
8	The frequency of maximal hearing loss or edge frequency evaluated from pure tone audiometry is closely related to tinnitus frequency assessed by psychoacoustic evaluation.	0.0%	26.9%	73.1%	**30-34**
9	Extended high-frequency audiometry is useful for evaluating tinnitus with normal hearing.	3.8%	34.6%	61.5%	**35-37**
10	It is ideal to measure extended high-frequency audiometry up to 16 kHz.	7.7%	34.6%	57.7%	**38**
11	It is ideal to measure extended high-frequency audiometry up to 20 kHz.	7.7%	50.0%	42.3%	**38**
12	ABR is applicable in diagnosing underlying conditions such as acoustic neuroma associated with tinnitus.	3.8%	23.1%	73.1%	**39**
13	OAEs are useful for diagnosing cochlear abnormalities that cannot be detected by pure-tone audiometry in tinnitus patients with normal hearing.	0.0%	11.5%	84.6%	**40**
14	Psychoacoustic assessment assists diagnosis and treatment strategies for tinnitus.	3.8%	15.4%	80.8%	**22,33,41**
15	Pitch matching tests using pure tone or narrow band noise is a reliable method to measure tinnitus pitch.	0.0%	42.3%	57.7%	**22,33,42**
16	The psychoacoustic intensity of tinnitus measured through loudness matching tests is reliable.	0.0%	34.6%	65.4%	**41,43-46**
17	The results of the residual inhibition test can assess the possibility of tinnitus masking.	0.0%	46.2%	53.8%	**47-49**
18	The residual inhibition test stimulates approximately 10 dBSL of masking noise (based on minimal masking level) for 60 seconds using narrow-band noise.	0.0%	15.4%	84.6%	**9**
19	Performing somatic modulation in tinnitus is helpful for the diagnosis and treatment of somatosensory tinnitus.	0.0%	34.6%	65.4%	**50**
20	To evaluate tinnitus before treatment, a questionnaire for hyperacusis, such as the HQ, is required for all tinnitus patients.	7.7%	57.7%	34.6%	**51-54**
21	To evaluate tinnitus before treatment, a questionnaire for hyperacusis, such as the HQ, is required for tinnitus patients associated with hyperacusis.	3.8%	11.5%	84.6%	**51-54**
22	To evaluate tinnitus before treatment, loudness discomfort level or uncomfortable loudness level should be assessed for all the patients with tinnitus.	3.8%	53.8%	42.3%	**51-54**
23	To evaluate tinnitus before treatment, loudness discomfort level or uncomfortable loudness level should be assessed in tinnitus patients associated with hyperacusis.	0.0%	3.8%	96.2%	**22,51,54**
24	Pure tones frequencies used in the loudness discomfort level test should be configured identically to those used in pure-tone audiometry.	3.8%	15.4%	80.8%	**51,54**
25	Pure tones frequencies used in the loudness discomfort level test should exclude 8 kHz used in pure-tone audiometry.	15.4%	53.8%	30.8%	**51,54**
26	CT, MRI, and angiography can improve diagnostic accuracy and broaden the range of treatment options for patients with pulsatile tinnitus.	0.0%	3.8%	96.8%	**55**
27	Selection of imaging evaluation should be based on clinical symptoms, and MRI is required to examine the inner ear of tinnitus patients accompanied by vertigo or hearing loss.	0.0%	11.5%	88.5%	**55,56**
28	Selection of imaging evaluation should be based on clinical symptoms, and MR venography is recommended when idiopathic intracranial hypertension (IIH) is suspected.	0.0%	38.5%	61.5%	**55,57**

(continued to the next page)

Table 1. (Continued) List of statements of second round Delphi survey

No.	Assessment of tinnitus before & after treatment	1–3 (Dis-agree)	4–6	7–9 (Agree)	Ref.[a]
29	MR/CT angiography is primarily assessed when a dural arteriovenous fistula is suspected.	0.0%	3.8%	96.2%	**55,58,59**
30	If the sound of pulsatile tinnitus disappears or diminishes by jugular vein compression, venous-origin tinnitus can be considered.	0.0%	11.5%	88.5%	**60**
31	Non-enhanced TBCT should be performed primarily when venous-origin pulsatile tinnitus is suspected.	11.5%	19.2%	69.2%	**55,60**
32	Enhanced TBCT should be performed primarily when venous-origin pulsatile tinnitus is suspected.	11.5%	38.5%	50.0%	**55,60**
33	Blood tests for anemia are helpful in the diagnosis of pulsatile tinnitus.	0.0%	42.3%	57.7%	**27,61**
34	Thyroid function blood tests are helpful in the diagnosis of pulsatile tinnitus.	0.0%	30.8%	69.2%	**27,62**
35	VAS or NRS questionnaires are required to evaluate symptom changes after tinnitus treatment.	0.0%	3.8%	96.2%	**22**
36	After treatment for tinnitus is completed, at least one validated questionnaire on tinnitus is required to evaluate the effectiveness of the treatment.	0.0%	7.7%	92.3%	**22**
37	Validated questionnaires used to evaluate the effectiveness of tinnitus treatment are equal to the ones used before treatment.	0.0%	0.0%	100.0%	**22**
38	After tinnitus treatment (e.g., medication, sound therapy, psychotherapy), a follow-up evaluation using a validated questionnaire is required within 4 weeks of treatment.	11.5%	34.6%	53.8%	**63**
39	After tinnitus treatment (e.g., medication, sound therapy, psychotherapy), a follow-up evaluation using a validated questionnaire is required within 12 weeks of treatment.	0.0%	3.8%	96.2%	**63**
40	After treatment for tinnitus, questionnaires regarding the patient's psychological status and comorbid conditions that may affect tinnitus are required.	0.0%	26.9%	73.1%	**24,64**
41	The results of questionnaires assessing the patient's psychological status and comorbid conditions during follow-up reflect the effectiveness of tinnitus treatment.	0.0%	23.1%	76.9%	**41,43**
42	A questionnaire for hyperacusis is recommended to evaluate the effectiveness of tinnitus treatment.	7.7%	42.3%	50.0%	**41,43**
43	A psychoacoustic test is performed to evaluate the effectiveness of tinnitus treatment.	0.0%	26.9%	73.1%	**41,43**
44	The Loudness matching test is a reliable method to evaluate changes in psychoacoustic discomfort caused by tinnitus after treatment.	3.8%	53.8%	42.3%	**41,43,44**
45	Minimal masking levels can be used as reliable data to determine the masking effect of tinnitus by masking noise.	0.0%	53.8%	46.2%	**41,43**
46	Uncomfortable loudness levels can accurately evaluate changes in hyperacusis associated with tinnitus after treatment.	0.0%	26.9%	73.1%	**26,51,54**

VAS = visual analogue scale, NRS = numeric rating scale, ABR = auditory brainstem response, OAE = otoacoustic emission, HQ = Hyperacusis Questionnaire, CT = computed tomography, MRI = magnetic resonance imaging, TBCT = temporal bone computed tomography, Ref. = Reference.
[a]Indicates corresponding reference number(s) in the Reference list supporting each statement.

Of 46 statements on tinnitus assessments, 17 statements (37.0%) met the standardized assessment criteria for consensus, while 29 (63.0%) did not. Regarding statements for tinnitus assessment before treatment, 17 of 34 statements reached a consensus (**Table 2**). Statement 1, visual analogue scale (VAS) or numeric rating scale (NRS) is used to evaluate tinnitus before treatment, reached a unanimous consensus. Five statements showed more than 90% agreement including: Statement 2, At least one validated questionnaire is used to evaluate tinnitus before treatment; Statement 7, Auditory system damage evaluated by auditory tests aids diagnosis and treatment plans for tinnitus; Statement 23, To evaluate tinnitus before treatment, loudness discomfort level or uncomfortable loudness level should be assessed in tinnitus patients associated with hyperacusis; Statement 26, computed tomography (CT), magnetic resonance imaging (MRI), and angiography can improve diagnostic accuracy and broaden the range of treatment options for patients with pulsatile tinnitus; and Statement 30, If the sound of pulsatile tinnitus disappears or diminishes by jugular vein compression, venous-origin tinnitus can be considered.

Eight of 12 statements related to treatment outcome measurements achieved a consensus (**Table 3**). Most of the participating experts agreed to use scales and validated questionnaires on tinnitus for assessment after intervention (Statements 35–37). Statement 39, After tinnitus treatment (e.g., medication, sound therapy, psychotherapy), a follow-up evaluation using a validated questionnaire is required within 12 weeks of treatment, reached a general consensus, informing an adequate period to evaluate treatment outcomes. Responses also

Table 2. Statements of inclusion criteria: tinnitus assessment before treatment

No.	Tinnitus assessment before treatment	Mean[a]	CVR
1	VAS or NRS is used to evaluate tinnitus before treatment.	8.6	1.000
2	At least one validated questionnaire is used to evaluate tinnitus before treatment.	8.4	0.923
3	Surveys regarding the patient's psychological status and comorbid conditions that may affect tinnitus are required during the patient's first hospital visit.	7.8	0.615
4	The approach to tinnitus treatment should vary depending on the results of questionnaires regarding the patient's psychological status and comorbid conditions that may affect tinnitus.	7.9	0.769
7	Auditory system damage evaluated by auditory tests aids diagnosis and treatment plans for tinnitus.	8.6	0.923
8	The frequency of maximal hearing loss or edge frequency evaluated from pure tone audiometry is closely related to tinnitus frequency assessed by psychoacoustic evaluation.	7.4	0.462
12	ABR is applicable in diagnosing underlying conditions such as acoustic neuroma associated with tinnitus.	7.0	0.462
13	OAEs are useful for diagnosing cochlear abnormalities that cannot be detected by pure-tone audiometry in tinnitus patients with normal hearing.	7.7	0.692
14	Psychoacoustic assessment assists diagnosis and treatment strategies for tinnitus.	7.3	0.615
18	The residual inhibition test stimulates approximately 10 dBSL of masking noise (based on minimal masking level) for 60 seconds using narrow-band noise.	7.3	0.692
21	To evaluate tinnitus before treatment, a questionnaire for hyperacusis, such as the HQ, is required for tinnitus patients associated with hyperacusis.	7.8	0.692
23	To evaluate tinnitus before treatment, loudness discomfort level or uncomfortable loudness level should be assessed in tinnitus patients associated with hyperacusis.	8.3	0.923
24	Pure tones frequencies used in the loudness discomfort level test should be configured identically to those used in pure-tone audiometry.	7.1	0.615
26	CT, MRI, and angiography can improve diagnostic accuracy and broaden the range of treatment options for patients with pulsatile tinnitus.	8.5	0.923
27	Selection of imaging evaluation should be based on clinical symptoms, and MRI is required to examine the inner ear of tinnitus patients accompanied by vertigo or hearing loss.	7.7	0.769
29	MR/CT angiography is primarily assessed when a dural arteriovenous fistula is suspected.	8.2	0.923
30	If the sound of pulsatile tinnitus disappears or diminishes by jugular vein compression, venous-origin tinnitus can be considered.	7.7	0.769

CVR = content validity ratio, VAS = visual analogue scale, NRS = numeric rating scale, ABR = auditory brainstem response, OAE = otoacoustic emission, HQ = Hyperacusis Questionnaire, CT = computed tomography, MRI = magnetic resonance imaging.
[a]Mean score of participants' responses to each statement.

Table 3. Statements of inclusion criteria: tinnitus treatment outcome measurements

No.	Tinnitus treatment outcome measurements	Mean[a]	CVR
35	VAS or NRS questionnaires are done to evaluate symptom changes after tinnitus treatment.	8.4	0.923
36	After treatment for tinnitus is completed, at least one validated questionnaire on tinnitus is required to evaluate the effectiveness of the treatment.	8.4	0.846
37	Validated questionnaires used to evaluate the effectiveness of tinnitus treatment are equal to the ones used before treatment.	8.4	1.000
39	After tinnitus treatment (e.g., medication, sound therapy, psychotherapy), a follow-up evaluation using a validated questionnaire is required within 12 weeks of treatment.	7.9	0.923
40	After treatment for tinnitus, questionnaires regarding the patient's psychological status and comorbid conditions that may affect tinnitus are required.	7.2	0.462
41	The results of questionnaires assessing the patient's psychological status and comorbid conditions during follow-up reflect the effectiveness of tinnitus treatment.	7.1	0.538
43	A psychoacoustic test is performed to evaluate the effectiveness of tinnitus treatment.	7.2	0.462
46	Uncomfortable loudness levels can accurately evaluate changes in hyperacusis associated with tinnitus after treatment.	6.9	0.462

CVR = content validity ratio, VAS = visual analogue scale, NRS = numeric rating scale.
[a]Mean score of participants' responses to each statement.

emphasized the importance of assessing the patient's psychological status and comorbid conditions outcomes of tinnitus treatment (Statements 40, 41, and 43).

The level of agreement was analyzed by CVR (**Tables 2** and **3**) and Kendall's W (**Table 4**). Moderate agreement (Kendall's W = 0.513) was reached with statements related to treatment outcome measurements, and weak agreement (Kendall's W = 0.319) was achieved regarding tinnitus assessment before treatment. The overall value of Kendall's coefficient showed weak agreement (Kendall's W = 0.356) with potential consensus statements of tinnitus assessment before and after treatment (**Table 4**).

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Table 4. Kendall's W

Contents	Kendall's W
Overall	0.356
Tinnitus assessment before treatment	0.319
Tinnitus treatment outcome measurements	0.513

W = coefficient of concordance.

The participants were asked to answer 11 multiple-choice questions for tinnitus assessment (**Fig. 2**). For assessment with VAS, participants highly agreed to evaluate loudness, awareness, and annoyance caused by tinnitus before and after intervention (Q1 and Q10). Among validated tinnitus questionnaires, only the Tinnitus Handicap Inventory (THI) reached a unanimous agreement to assess tinnitus (Q2). Also, the Beck Depression Inventory (BDI) was recommended to detect tinnitus patients' psychological status and comorbid conditions with 92.3% of agreement (Q3). Regarding auditory tests in tinnitus assessment total agreement was reached with pure tone audiogram and speech audiometry. The majority of participants also agreed with measuring loudness discomfort level and distortion product otoacoustic emissions (DPOAEs) with 92.3% and 84.6% of agreement (Q4). For psychoacoustic evaluation in tinnitus, measurements of pitch and loudness matching presented with unanimous agreement (Q5). While blood tests and other clinical laboratory tests revealed various responses (Q6), imaging studies in cases of pulsatile tinnitus, focal neural deficits, and asymmetrical hearing loss were highly recommended (Q7). In patients with pulsatile tinnitus, 3 types of physical examination, including otoscopic examination, assessing changes in tinnitus after jugular vein compression, and assessing changes in tinnitus after head rotation, reached 100% agreement (Q8).

Although Statement 26, CT, MRI, and angiography can improve diagnostic accuracy and broaden the range of treatment options for patients with pulsatile tinnitus, accepted as an inclusion criterion, participants were not able to reach a high agreement (61.5%) in selecting the accurate imaging test for pulsatile tinnitus (Q9). On the other hand, in evaluating the usefulness of individual imaging tests for specific conditions, MR/CT angiography for suspected dural arteriovenous fistula reached consensus. While slightly falling short of full agreement (69.2% agreement and 11.5% disagreement), non-enhanced temporal bone computed tomography (TBCT) is also recommended when venous-origin pulsatile tinnitus is suspected. In contrast, enhanced TBCT for venous-origin pulsatile tinnitus and MR venography for suspected idiopathic intracranial hypertension did not reach agreement.

DISCUSSION

The modified Delphi technique is a structured and systematic process intended to help a group of experts reach a consensus on a specific issue. It requires a systemic review of the literature, in-depth discussion of stakeholders, iterative surveys, and judgment of experts.[65] The present study used a two-round modified Delphi method to establish a consensus on tinnitus assessment and treatment outcome measures.

A standardized method to assess tinnitus or measure its treatment outcomes has not yet been reached an agreement. Thus, the present study aimed to reach a consensus on tinnitus assessment and treatment outcome measurements and inform clinical practice guidelines leading to the prognosis of tinnitus treatment.

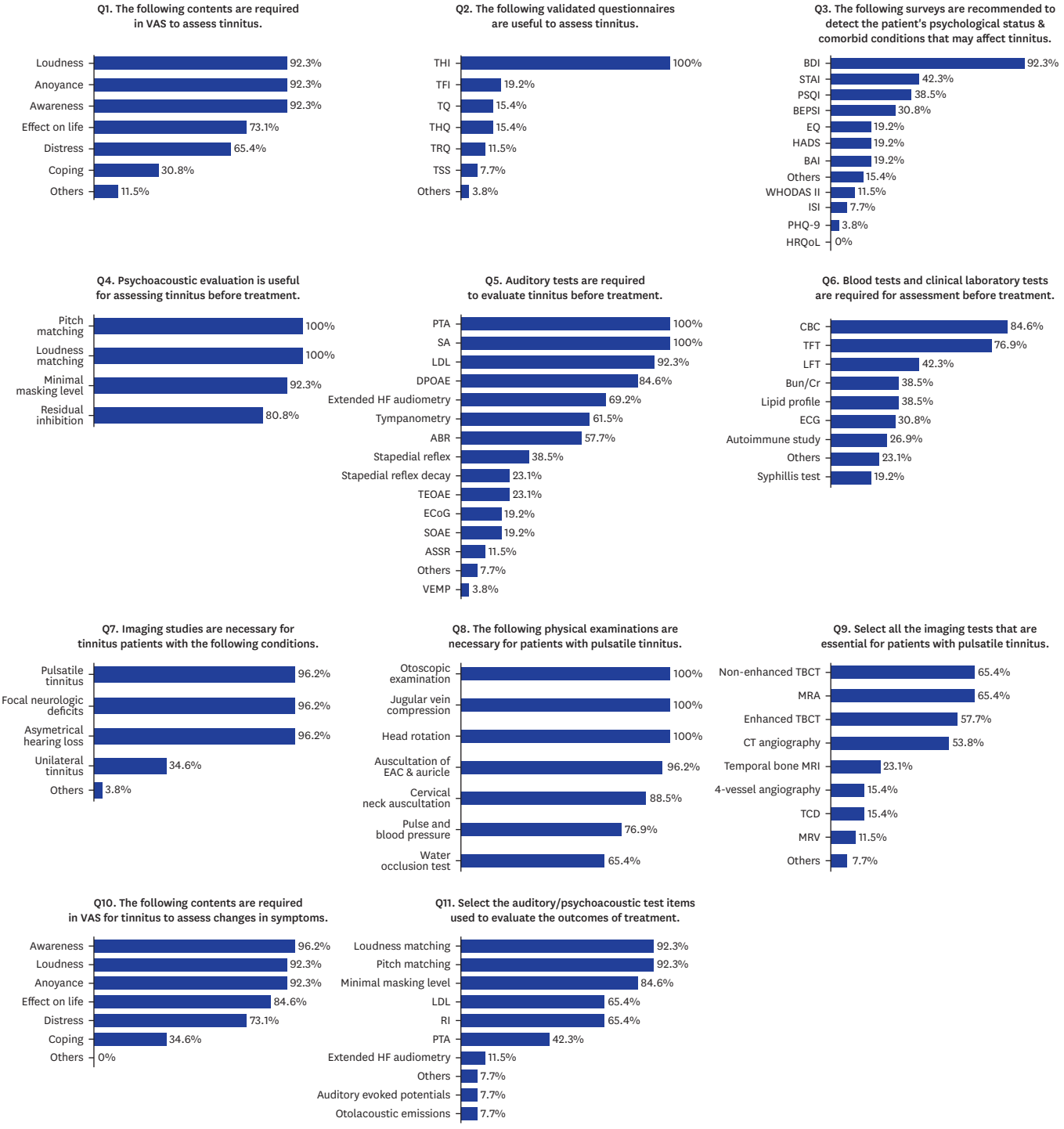

Fig. 2. Responses of 11 multiple-choice questions related to clinical assessment and treatment outcomes measurements of tinnitus.
VAS = Visual analogue scale, THI = Tinnitus Handicap Inventory, TFI = Tinnitus Functional Index, TQ = Tinnitus Questionnaire, THQ = Tinnitus Handicap Questionnaire, TRQ = Tinnitus Reaction Questionnaire, TSS = Tinnitus Severity Scale, BDI = Beck Depression Inventory, STAI = State-Trait Anxiety Inventory, PSQI = Pittsburgh Sleep Quality Index, BEPSI = Brief Encounter Psychosocial Instrument, EQ = Emotional Quotient, HADS = Hospital Anxiety and Depression Scale, BAI = Beck Anxiety Inventory, WHODAS = World Health Organization Disability Assessment Schedule, ISI = Insomnia Sleep Index, PHQ-9 = Patient Health Questionnaire-9, HRQoL = Health-related Quality of Life, PTA = Pure Tone Audiometry, SA = Speech Audiometry, LDL = Low-density Lipoprotein, DPOAE = Distortion Product Otoacoustic Emission, ABR = Auditory Brainstem Response, TEOAE = Transientevoked Otoacoustic Emission, ECoG = Electrocochleography, SOAE = Spontaneous Otoacoustic Emission, ASSR = Auditory Steady State Response, VEMP = Vestibular-evoked Myogenic Potential, CBC = Complete Blood Count, TFT = Thyroid Function Test, LFT = Liver Function Test, ECG = Electrocardiogram, TBCT = Temporal Bone Computed Tomography, MRA = Magnetic Resonance Angiography, CT = Computed Tomography, TCD = Transcranial Doppler, MRV = Magnetic Resonance Venography, RI = Residual Inhibition.

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Various assessment methods have been applied for tinnitus assessment, including scoring scales for severity, validated questionnaires of tinnitus, a wide range of audiometry tests, psychoacoustic tests, imaging studies in cases related to vascular origin and neural deficits, evaluations of blood tests or clinical laboratory tests, and additional evaluation for psychological status and associated conditions related to tinnitus. This is probably due to the complex mechanisms of tinnitus, various subjective symptoms within tinnitus patients, and/or the involvement of different organs and pathways.[66]

Evaluating tinnitus through surveys and questionnaires has been commonly used in the clinical field especially during the patients' first hospital visit. VAS is a simple and valid measurement tool, and has been suggested to be useful for initial assessments. VAS has also been used in several tinnitus studies as a reliable screening tool to obtain quick information on tinnitus.[21] Participating experts of our study also fully agreed with using VAS as an assessment tool for including loudness, awareness, and annoyance of tinnitus being the 3 major components to be included in the scales. In 2006, a consensus on validated questionnaires highly recommended THI, Tinnitus Handicap Questionnaire (THQ), Tinnitus Reaction Questionnaire (TRQ), and Tinnitus Questionnaire (TQ) as assessment measurements.[22] Our multiple-choice questions resulted with unanimous agreement (100%) to evaluate tinnitus through THI, but lower than 20% of the participants agreed with THQ, THQ, TRQ, and Tinnitus Functional Index (TFI).

As tinnitus is associated with other conditions and the patients' psychological status affects the treatment approach for tinnitus, several studies have also recommended questionnaires that can detect these findings.[24,64] A previous study indicated that anxiety sensitivity was related to tinnitus severity, especially with annoyance.[28] Another study presented the effect of antidepressants in tinnitus patients which was more beneficial to tinnitus patients with depression and insomnia.[25] Although participating experts of our study also reached an agreement with this statement, the majority of the participants only recommended the BDI questionnaire excluding questionnaires assessing anxiety, insomnia, stress, and quality of life.

Many clinicians proceed with auditory evaluation for tinnitus assessment before initial treatment. Pure tone audiometry for detecting hearing loss is required in all patients with tinnitus. Also, high-frequency audiometry is highly recommended, along with OAEs tests, tympanometry, and assessment of loudness discomfort level. Auditory evoked potentials are also optional, especially to exclude vestibular schwannoma.[22] An updated clinical guideline for tinnitus management presented in 2014, highly recommended audiologic examination in tinnitus patients with unilateral tinnitus, associated with hearing loss, or persistent tinnitus symptoms of more than 6 months. Routine audiological examinations in other tinnitus cases were only optional.[45]

Various studies have aimed to determine the relationship between edge frequency or frequency of maximal hearing loss and tinnitus pitch.[35-37] The edge frequency results from an imbalance of lateral inhibition at the boundary between the regions of normal and impaired hearing. A previous study of 11 subjects with mild-to-moderate hearing loss who suffered from tinnitus revealed a definite relationship between the pitch of single-tone tinnitus and edge frequency. After training to minimize octave errors during pitch matches, the edge frequency was close to the mean matching frequency.[32] In 2012, an observational study investigated the relationship between audiometric slope and tinnitus pitch with 286 patients. This large sample study compared tinnitus pitch with the edge frequency of the

audiogram and the frequency of maximum hearing loss. Interestingly, it was concluded that tinnitus pitch showed a significant relationship with maximum hearing loss but not with the edge frequency. This may suggest that tinnitus results from homeostatic mechanisms that aim to compensate for reduced sensory input by increased facilitatory or reduction of inhibitory mechanisms rather than an imbalance of lateral inhibition.[33] The majority of the participating experts in our study also agreed with the close relationship between edge frequency or frequency of maximal hearing and tinnitus frequency.

Other studies also emphasized the importance of measuring high-frequency audiometry to assess tinnitus. It has been indicated that tinnitus patients with normal hearing in conventional pure tone audiograms showed higher incidences of high-frequency hearing loss and higher scores on tinnitus surveys than patients with normal high-frequency hearing regardless of age.[35-37] On the contrary, our study did not align with this statement. Moreover, the ideal frequency measurement for high-frequency audiograms did not reach a consensus. Instead, other auditory tests including auditory brainstem response (ABR), OAE, and psychoacoustic tests for tinnitus assessment were accepted as inclusion criteria. ABR interpretations in patients with tinnitus are known to aid in detecting underlying diseases such as acoustic neuroma and vascular conflict syndromes.[39] Furthermore, OAE results can detect organohalogenochromism and cochlear damage in tinnitus patients with normal pure-tone audiogram results.[40] A recent study detected reduced DPOAE levels and changes in DPOAE input/output functions among tinnitus patients showing normal hearing compared to the control group.[67]

Psychoacoustic measurement of tinnitus consists of loudness, pitch, minimal masking level, and residual inhibition. These measures are not considered essential due to the inconsistent correlation with perceived tinnitus.[22] However, evaluation of loudness match and minimal masking level before and after intervention may imply treatment outcomes. Furthermore, these measures may provide important clinical data in tinnitus research.[41] Participating experts of our study also agreed with the psychoacoustic assessment for tinnitus but did not consider these measures as highly reliable data. This may indicate the necessity of establishing evidence-based valid test methods for psychoacoustic evaluation.

Several reports have studied the relationship between hyperacusis and tinnitus.[51,54,68] A study suggested that tinnitus may arise from an inability to adapt to the missing sensory input causing elevation of central neural gain, the amplification of auditory stimuli in the central auditory system. This condition includes altered tuning bandwidths and increased neural activity which may also contribute to hyperacusis.[52] Another research study using an active loudness model revealed that hyperacusis results from nonlinear gain, while tinnitus is caused by increased central noise suggesting that these two conditions have different mechanisms.[51] Although different results have been noted among related studies, a study using a self-reported assessment with 3,645 participants reported that hyperacusis was highly associated with the severity of tinnitus.[53] Thus, it may be necessary to evaluate hyperacusis including a hyperacusis questionnaire and loudness discomfort levels through audiogram in tinnitus patients. Participating experts in our study agreed to proceed with this assessment restricted to tinnitus patients associated with hyperacusis.

Routine imaging studies for patients with tinnitus are usually not recommended.[22,45] Imaging studies such as endovascular techniques, CT, and MRI are suggested in specific cases such as unilateral tinnitus, pulsatile tinnitus, focal neurological deficits, or asymmetrical hearing loss.[45,55,59] For pulsatile tinnitus, numerous evaluation methods

have been studied, yet no accurate assessment tool has been developed. Recently, a novel water occlusion test (WOT) was introduced to evaluate patients with pulsatile tinnitus.[60] By applying the air pulsation mechanism and turbulence conduction mechanism to WOT, the study provided a diagnostic algorithm to classify pulsatile tinnitus.

Other assessment methods, such as blood tests and clinical laboratory tests, have been suggested for tinnitus.[61,62] Several national studies have revealed associated factors with tinnitus, including gender, social history, hearing loss, stress, sleep, depression, thyroid disease, asthma, hyperlipidemia, osteoarthritis, and rheumatoid arthritis.[27] However, these assessment methods are still in debate, and participating experts from our study showed high agreement with complete blood count and thyroid function test for tinnitus assessment.

While the Delphi method is useful for achieving consensus on diverse clinical issues, it is subject to bias, which can stem from the survey-based conclusions of the expert panel. The recruitment of expert panel cannot be fully random but rather are chosen based on their 'expertise.' To minimize bias in this study, we established selection criteria for the panelists, considering factors such as subspecialty, years of experience, age, gender, and geographic location of clinical practice. The panel size was also determined according to the recommended optimal number.[69]

Despite most of the consensus statements align with international guidelines, weak consensus in tinnitus assessment before treatment (Kendall's W = 0.319) likely arises from diverse clinical practices, limited evidence supporting certain tools, and the multifactorial nature of tinnitus. While some assessments, such as the THI and VAS, achieved strong agreement, others, including high-frequency audiometry and psychoacoustic tests, showed variability due to inconsistent evidence and differing expert priorities. Along with this, our study was performed exclusively with Korean otology experts to establish consensus on tinnitus assessment. As a result, the current consensus statements may predominantly represent the views of Korean clinicians, and diverse opinions may likely exist among professionals in different countries.

Given this variability, clinicians are encouraged to focus on core tools with strong consensus, such as validated questionnaires and basic auditory assessments, for consistent baseline evaluations. At the same time, they should remain flexible, tailoring additional tests to the patient's individual presentation and needs. These findings provide a foundational framework for tinnitus evaluation in Korea while highlighting the need for further research to establish comprehensive, evidence-based protocols.

This study used the modified Delphi process to establish a consensus-based assessment guideline for tinnitus. A set of statements achieved consensus on tinnitus assessment before and after intervention. The inclusion criteria for tinnitus assessment and treatment outcome evaluation are anticipated to receive wide acceptance in the clinical field and provide practical clinical guidelines for managing tinnitus.

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