TINNITUS MASKERS AND HEARING AIDS FOR TINNITUS

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There is no universal treatment for patients with tinnitus. Because tinnitus is a symptom that represents several different underlying etiologies, it should not be expected that one form of treatment will work for everyone. One approach that helps some patients is to present a noise that either entirely masks the tinnitus (Jones and Knudsen, 1928), rendering it inaudible, or that partially masks the tinnitus, decreasing its loudness. Because none of the treatments for tinnitus has a well-documented high success rate, it is important that clinicians be aware of the potential usefulness of tinnitus maskers. In this article we shall briefly review what is known about masking tinnitus and discuss some strategies for fitting tinnitus maskers.

MASKING TINNITUS

Tones

The masking of tinnitus by pure tones can provide insight into the frequency specificity of tinnitus masking. When a pure tone is presented at a low level, the patient can hear both the pure tone and the tinnitus. At higher pure-tone levels, the tone can usually mask or render the tinnitus completely inaudible. In this case the patient hears only the pure tone and no longer hears the tinnitus. Different types of tinnitus masking patterns, the masker level plotted as a function of pure-tone frequency, have been noted by Feldman (1971), Mitchell (1983), and Tyler and Conrad-Armes (1984). In one group of patients, a high sensation level masker was required to mask the tinnitus, independent of the masker frequency. In another group, low-sensation level maskers were sufficient to mask the tinnitus throughout the frequency range. In a third group, mid-intensity levels were required to mask the tinnitus. In some patients the tinnitus could not be masked at all. In other cases, the sound pressure level (SPL) required to mask the tinnitus was actually lower at frequencies far removed from the tinnitus pitch-match frequency than it was for tones

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close to the pitch-match frequency. Figure 1 shows some tinnitus-masking patterns.

These tinnitus masking patterns are generally unlike those obtained when a pure tone masks another pure tone (Tyler and Conrad-Armes, 1984). In tone-on-tone masking, very high masker levels are required for masker frequencies away from the signal, but low masker levels are required for maskers close to the signal frequency. The differences between tone-on-tone masking and tinnitus masking are important. They suggest that the site of tinnitus masking is likely not in the peripheral auditory system (since tone-on-tone masking can largely be explained by cochlear mechanics). These results also indicate that different individuals may have very different acoustic requirements for tinnitus masking. Furthermore, the masking noise may not have to be centered around the tinnitus pitch-match frequency to be effective.

Noise

Noise can also mask tinnitus. Shailer et al. (1981) measured the relationship between the bandwidth of a narrowband noise (NBN) masker and the level required to mask the tinnitus. The center frequency of the NBN was equal to the frequency obtained from a pitch match to each individual's tinnitus. The eight patients that they tested showed large individual differences. For some patients, particular noise bandwidths required less sound pressure to mask the tinnitus than other narrower or wider bandwidths. This suggests that tailoring the spectrum of a tinnitus masker noise may be desirable.

Tyler and Conrad-Armes (1983a) noted in many patients that the SPL of a masker required to mask the tinnitus was similar in either ear, even when patients reported that they heard the tinnitus in only one ear. This suggests that tinnitus masking takes place centrally. In a few patients who heard the tinnitus in one ear, masking in that ear resulted in the patient suddenly perceiving the tinnitus in the opposite ear. This suggests that the tinnitus may have been present in both ears, but was lateralized to one because it was louder there.

There are at least two clinical implications of this research. Tinnitus maskers should be tried on each ear, even in patients who report hearing tinnitus in only one ear. In patients with either a unilateral or a bilateral perception of the tinnitus, it may be necessary to use a masker on each ear.

Duration Effects

One fascinating aspect of tinnitus is that when a masker is turned off, tinnitus can remain inaudible for some time. This postmasking effect has sometimes been called 'residual inhibition' (Feldman, 1971). Figure 2 schematizes five general perceptual descriptions of tinnitus following the masker termination. After the masker is turned off, the tinnitus is either completely inaudible or is decreased in loudness. After some period of time, the tinnitus typically returns to its premasking loudness. Note that in some patients the tinnitus actually

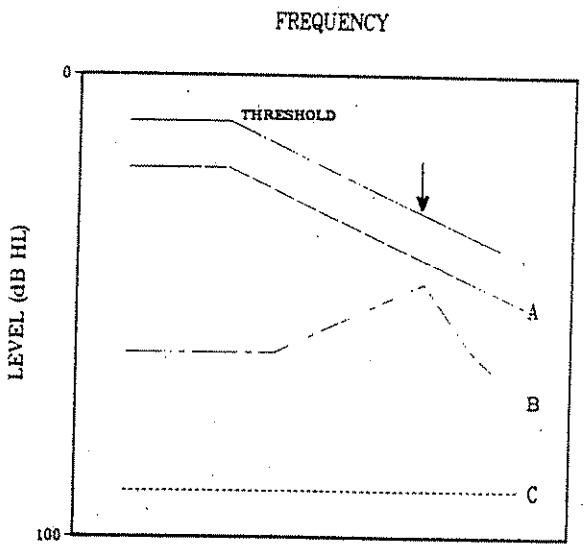

Figure 1. A schematic of three different general types of tinnitus masking patterns. The threshold audiogram is shown by a solid line. The tinnitus pitch-match frequency is shown with an arrow. Three general patterns of masking, the minimum level of pure tones required to mask the tinnitus, are shown as A, B and C. (Adapted with permission from Tyler and Conrad-Armes, 1984.)

becomes louder than the original perception after the masking noise is turned off.

The implication of these effects for tinnitus maskers is threefold. First, after several hours of masker use, some patients may receive several hours of reduced or absent tinnitus. This, of course, would be highly desirable. The presence and magnitude of this effect vary greatly among individuals and there is no priori way to predict the direction or magnitude of the effect. Terry et al. (1983) tested ten subjects with a 10-minute noise presented 10 dB above the minimum level to produce masking. The average duration for the tinnitus to return to its original loudness was about 3 minutes (individual data were not shown). Hazell et al. (1983) reported on 210 patients wearing tinnitus maskers; about 9 percent noted some period of total absence of the tinnitus following masker use and about 34 percent noted a quieter tinnitus. It was apparently common for patients to report that this relief lasted for several hours, even days. However 51 percent did not experience any change in the tinnitus following masker use.

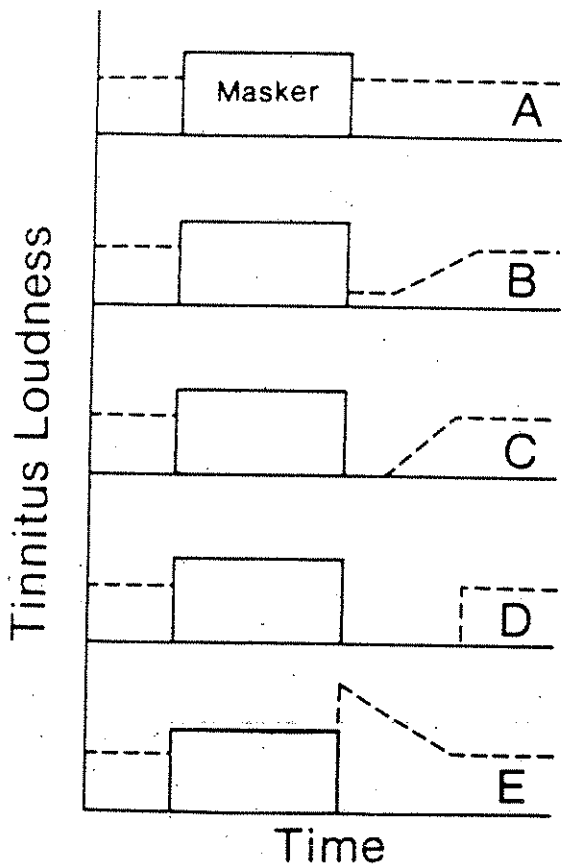

Figure 2. Schematic representations of some postmasking effects on tinnitus loudness. (Reprinted with permission from Tyler, Conrad-Armes, and Smith, 1984.)

The second implication of the postmasking results shown in Figure 2 is that some patients who obtained relief from the tinnitus while the masker is on could have an exacerbated tinnitus after the masker is turned off. These patients may not be able to use tinnitus maskers because the annoying aftereffects more than offset the temporary relief. Hazell et al. (1985) reported that 7 percent of their patients noted a louder tinnitus following masker use.

Thirdly, the postmasking reduction of tinnitus loudness raises the possibility that intermittent maskers may be effective. For example, a masker could be on for 10 minutes and then off for 10 minutes. Since rapidly pulsed sounds (for example, 1 second on and 1 second off) are more annoying than continuous sounds, rapid pulsing appears to have little merit. However, pulsing with much longer on and off durations might be acceptable to the patient and produce less interference with speech. An intermittent masker also has less potential to damage the auditory system. The actual masker duration and duty cycle would presumably have to be tailored carefully to match the residual inhibition characteristics of the individual.

Penner et al. (1981) found that the noise level required to mask tinnitus (in six patients with noise-induced hearing loss) had to be increased over several minutes in order to keep the tinnitus inaudible. Penner et al. interpreted this result as implying that the masker was adapting, whereas the tinnitus was not. A second interpretation might be that the masking noise is exacerbating the tinnitus, making it increase over time (Tyler et al., 1984). In any case, some patients using tinnitus maskers might find that the maskers have to be frequently readjusted and are ineffective after several hours of use. For other patients, the masking noise may simply worsen the tinnitus

(Tyler and Baker, 1983). This decrease in masker effectiveness over time might be overcome by turning the masker off occasionally. Alternatively, changing the masker level or spectrum might also help. An intermittent masker could presumably be set to avoid the decrease in effectiveness altogether. Coles (personal communication) has observed that lower-level maskers set to reduce the tinnitus partially (as opposed to complete mask) sometimes overcomes this problem.

Summary of Masking Studies

These studies have several important implications for the fitting of tinnitus masking. Tinnitus maskers can be tailored to the individual. Certain masker bandwidths will require less masker SPL than other bandwidths to mask the tinnitus. The studies on tonal masking imply that the masker does not necessarily have to be located in the frequency region of the tinnitus-pitch match. It seems desirable to try maskers on either ear and both ears, even when the person only hears the tinnitus in one side of the head. Some patients may have to increase the masker level after several minutes or hours of use. However, this can sometimes be avoided by occasional rest from the masker or changing the masker level or spectrum.

It is noteworthy that tinnitus masking occurs at all. When one sound is masked by another sound, the nervous system cannot distinguish the activity produced by the signal. This can occur peripherally, when the signal and masker are presented to the same ear, or centrally, when the signal and masker are presented to opposite ears. However, a direct analogy with tinnitus is difficult because the nerve fiber activity responsible for tinnitus has not been identified. Attempts to use animal models with induced hearing losses have occasionally resulted in increases in spontaneous activity (Evans and Borerwe, 1982). However, more frequently a decrease in spontaneous activity has been observed (Salvi and Ahroon, 1983; Tyler, 1984). It has been proposed that tinnitus originates from an increase or a decrease of spontaneous activity, or at an edge between no activity and normal activity (Kiang et al., 1970). However, because the physiological correlates (there are likely several sites) of tinnitus are unknown, it is impossible to identify the masking mechanism. There may also be a distraction effect. The masker may serve to focus attention away from the tinnitus. This would not be considered masking in the traditional sense, but could still produce a desirable result.

The physiological mechanisms responsible for the postmasking effects are also unknown. In a normal cat ear, auditory nerve fiber responses have been observed during and after 13 minutes of tonal stimulation (Kiang et al., 1965). Following stimulation, there was a period of reduced spontaneous activity that lasted about a minute. This auditory nerve adaptation effect is likely caused by a depletion of neurochemical transmitters at the hair cell synapse junction. Although tinnitus may originate centrally in many cases (Tyler, 1981; Penner, 1984), poststimulus adaptation of this type may partially account for residual inhibition.

Terry et al. (1983) noted a temporary threshold shift in some tinnitus subjects that corresponded to a decrease in the loudness of the tinnitus following the presentation of a noise. Although this observation is intriguing and suggests a common mechanism between temporary threshold shift and residual inhibition, further investigation is necessary.

QUANTIFYING TINNITUS

Tinnitus can be quantified in several ways, but the relationship that these measurements have on the design and fitting of tinnitus maskers is unclear. The frequency and level of a tone can be adjusted so that it is similar to the most prominent pitch of the tinnitus (Tyler and Conrad-Armes, 1983b; Penner, 1984; Burns, 1984) and to its loudness (Goodwin and Johnson, 1980; Tyler and Conrad-Armes, 1983a; Hinch-

cliffe and Chambers, 1983; Penner, 1984). We have already noted that the pitch-match frequency may not necessarily be the frequency region where the lowest SPL masker is located. The level of the noise required to mask the tinnitus in each ear and both ears together could be useful in decisions about which ear or ears to try a masker. The SPL of NBN required to mask the tinnitus, as a function of NBN frequency, could be used to recommend high- or low-frequency emphasis maskers. In a few cases, certain NBN maskers might be identified that masked the tinnitus at much lower SPLs than for other NBN center frequencies. The presence or absence of residual inhibition, and its relationship to the design or success of residual inhibition, is unclear.

These measurements can be used to quantify tinnitus more objectively and, therefore, assess its treatment (Tyler, 1986). They may eventually lead to a better understanding of the causes and, therefore, the treatment of tinnitus. Tinnitus is likely caused by several different disease processes, and the quantification of tinnitus may result in different subcategories. Some of these subcategories of tinnitus may respond better to certain treatments.

HEARING AIDS TO MASK TINNITUS

Hearing aids amplify speech, background noise, and produce their own internal noise. It is possible that these amplified external sounds or the internal noise of the hearing aid could mask the tinnitus. Therefore, it is desirable for patients (even with a mild hearing loss) to try a hearing aid to mask the tinnitus. This could result in improved speech recognition in addition to providing tinnitus relief. Successful hearing aid use may reduce stress, which could also reduce the tinnitus (Surr et al., 1985).

In some patients with normal hearing or mild hearing losses, it may be desirable to select hearing aids with high levels of internal noise. These internal noises of the hearing aid are specified as the equivalent input noise level. These levels are usually less than 25 dB SPL overall and will therefore only be helpful in masking tinnitus for patients who have near-normal thresholds in at least one frequency region between 125 and 4000 Hz. Although considered undesirable for speech perception, high levels of internal noise may be desirable for patients with tinnitus.

The hearing aid can be fitted according to the individual's speech perception and comfort needs. The usual 30-day hearing aid trial period should be sufficient time to determine if this will decrease the tinnitus. Surr et al. (1985) questioned 124 new hearing aid users who experienced tinnitus. Approximately one-half reported that their hearing aid reduced (26 percent) or eliminated (29 percent) the tinnitus. About 5 percent said the tinnitus became worse. Nine patients (7 percent) reported at least a 15-minute change in the tinnitus (the investigators interpreted this as residual inhibition). One patient noted that the change in tinnitus lasted 6 hours.

TINNITUS MASKERS

Some tinnitus patients cannot use or do not need a hearing aid. For others, a hearing aid will not adequately mask the tinnitus. In these cases a tinnitus masker may be required (Saltzman and Ersner, 1947; Vernon, 1977). Tinnitus maskers are devices that look like conventional hearing aids (may be behind the ear or in the ear), but they do not amplify sound (see Appendix A for a list of manufacturers). They serve only as noise generators, with the patient controlling the level. In some cases the spectrum of the noise can be adjusted.

Before discussing tinnitus-masking fitting, it is important to be aware of two related issues, the possibility that the masker may interfere with speech understanding or may damage hearing.

SPEECH INTERFERENCE

It is possible that tinnitus can interfere with the perception of speech due to a dis-

tracting effect or due to a direct masking effect of tinnitus on speech (Tyler and Baker, 1983). However, there is no direct test for this assumption. The presence of the masker will also mask some of the components of speech. Spitzer et al. (1983) noted that normal-hearing listeners had difficulty hearing words while wearing tinnitus maskers (with open earmolds) when the words were presented in the presence of an additional background noise. Therefore, to limit the amount of noise in the speech frequency regions, it is desirable to use maskers with low levels of energy between 500 and 3000 Hz. High levels of low-frequency noise could have undesirable upward-spread-of-masking effects on speech perception (Florentine et al., 1980; Tyler et al., 1982).

If a tinnitus masker is effective in either ear, it may be reasonable to put the masker on the ear that results in the best binaural speech understanding. If it is desirable to put a masker on one ear and a hearing aid on the other, sound-field speech recognition tests could be used to determine the choice of ears.

Damage to Hearing

Some tinnitus maskers produce intense noise that has the potential to damage hearing. The potential damage will depend largely on the intensity of the masker and the duration that it is used. Hazell et al. (1985) measured hearing thresholds in 210 tinnitus patients before and after a minimum of 6 months of experience using a masker, and likewise, in 66 combination masker and aid users and 66 hearing aid users. Although they found that the average thresholds got poorer by one 1 or 2 dB in all three groups, some patients showed as much as a 30 dB four-frequency average loss of hearing. However, because of the possibility of a progressive hearing loss, the data are somewhat difficult to interpret. Furthermore, the data from ears using the maskers and not using maskers were averaged together, results were averaged across frequencies, and the nonmasked ear was not used as a control.

The Occupational Safety and Health Administration (OSHA, 1983) has determined maximum allowable noise levels (in dBA) for various exposure times. Some masking units now available are capable of producing a noise level in excess of what is considered safe for full-time use. Some patients may use their maskers 10 hours a day (some even sleep with it on) for 7 days a week. This could result in a greater exposure than that experienced by most industrial workers. Therefore, it will be advisable in some cases to use the lowest SPL noise masker that reduces or eliminates the tinnitus. The patient should be warned of the potential harmful effect of the masker and be encouraged to turn the masker off frequently for rest periods.

Prefitting Counseling

Nearly every tinnitus patient requires counseling. At the very least, a general discussion of tinnitus, its causes and treatments, is required. It is usually comforting to the patient to learn that tinnitus is a very common symptom and that tinnitus does not usually represent a symptom of a life-threatening disease (the patient requires an otological and audiological examination for site-of-lesion diagnosis; see Tyler and Babin, 1986). The patient should be told that there is no known universal cure.

Some prefitting counseling about tinnitus maskers is also desirable. The concept of maskers can be introduced by noting that some sounds cover up other sounds, and that often tinnitus can be covered by other sounds. Tinnitus maskers are simple devices that produce noise. The maskers can be adjusted either to cover the tinnitus partially, or to mask the tinnitus completely. In some patients this helps considerably. This masking noise might be easier to listen to than the tinnitus. Some patients report that they prefer the masker because it is a real, external sound, it is under their control, and it provides an alternative sound. In some instances the

tinnitus may be gone even after the masker is turned off.

The patient should be told that there is no way to predetermine if someone will benefit from a tinnitus masker. Since a trial period is the only way of knowing whether the masker will be beneficial, it is critical to convince the patient to try the masker. Because the introduction of an external sound is generally distracting and undesirable, the prefitting counseling session is extremely important. Sometimes a masker can reduce the tinnitus loudness or annoyance, even though the tinnitus remains audible. The patient should be shown the instrument and its intensity and frequency controls (if available) before it is placed in the ear. The audiologist can put on the tinnitus masker to show the patient how it is worn. Cosmetic acceptance of the device is as important as it is with hearing aids.

Selecting a Tinnitus Masker

The tinnitus maskers available have different frequency spectra and different output levels. At present, there is no scheme for deciding on the appropriate masker characteristics (for example, its spectrum) based on hearing or tinnitus measurements. If the masker noise is not above threshold, it is unlikely to benefit the patient. It could be useful to determine the minimum NBN level to mask the tinnitus as a function of NBN frequency. Frequency regions where low sound pressure and sensation levels of NBN can mask the tinnitus could be identified, as could the ear that required the lowest masker sound pressure and sensation levels. Caution is needed, however, because the relationship between the NBN levels required to mask the tinnitus and the wideband noise levels required to mask the tinnitus (that would typically be available in wearable maskers) may be unpredictable (Shailer et al., 1981). Since a broadband noise will generally be less annoying than a NBN (Kryter and Pearsons, 1963), a broadband noise with increased energy in specific regions may be desirable.

Figure 3 shows some of the spectra provided by different manufacturers. It is useful to have maskers available with different spectra, so that alternatives can be compared directly.

Selecting an Ear

There is no a priori way to determine which ear is to be masked. Although it would seem reasonable to mask the ear with the tinnitus (in unilateral cases), the tinnitus might be masked with equal sensation levels or SPLs in the contralateral ear. Therefore, in all cases it is desirable to try tinnitus maskers on each ear alone, then

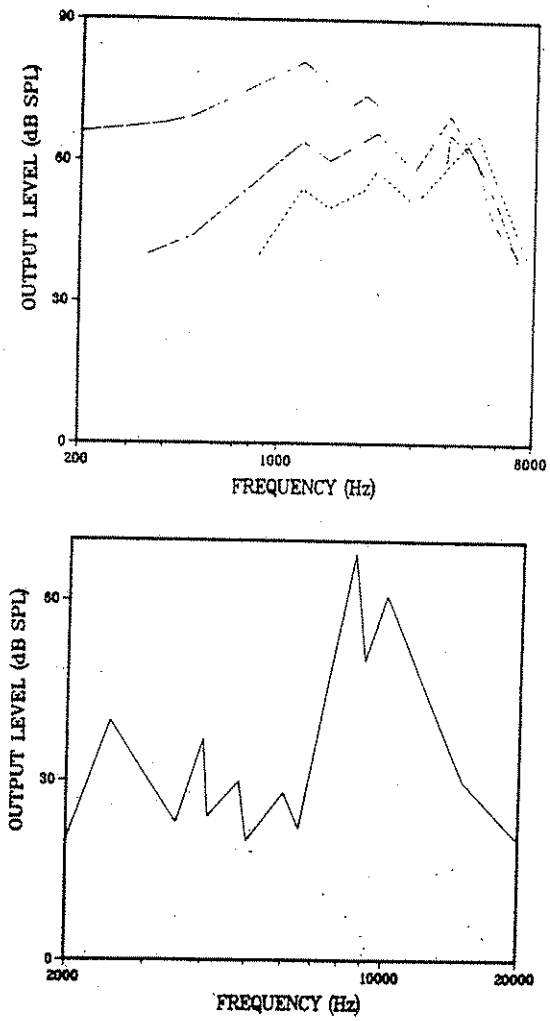

Figure 3. Spectra of two different tinnitus maskers. The top shows a masker with a broadband noise that is adjustable. The bottom shows a masker with a narrowband, high-frequency noise.

on both ears. The patient can be given two maskers and asked to try one masker for the first week on one ear, the second masker for the next week on the other ear, and then one masker on each ear simultaneously for the third week. Keeping a diary can help the patient remember which is the best configuration and can help in discussing the results with the audiologist.

Selecting the Earmold

Since the earmold will influence the acoustic spectrum of the masker, it is desirable for the patient to have earmolds made before a trial of the tinnitus masker. Several stock earmolds may also provide some flexibility in manipulation of the masker spectrum. For maskers in which electrical modification of the spectrum is not possible, modification of the earmold allows the patient to try different spectra.

Either a closed or nonoccluding earmold may be used. In cases in which there is good low-frequency hearing, an open earmold may be desirable. As noted in the discussion of pure-tone tinnitus masking, in some patients it may be difficult to mask the tinnitus with low-frequency sounds. A nonoccluding mold would attenuate the ineffective low-frequency noise reaching the eardrum (Hazell and Wood, 1981). In cases in which there is no usable hearing in this ear or in cases in which a more intense tinnitus masker is desirable, closing off the ear canal will increase the SPL of the masker (and alter the masker spectrum). It will also make the noise less noticeable to others. However, this may be undesirable in cases in which there is evidence that overamplification has caused deterioration in hearing. If a hearing aid with high levels of internal noise is desirable, then a closed earmold may also be appropriate.

Trying the Masker on the Patient

After the patient is familiar with the masker and earmold, it can be fitted on the patient. There are basically three factors involved in masker fitting: the ear, the level, and the frequency spectrum. These three should be manipulated so that the masker: (1) reduces to an acceptable level or eliminates the tinnitus; (2) is comfortable to listen to; (3) requires a low SPL; and (4) has little effect on speech understanding. It may not be possible to optimize these four factors simultaneously. For example, a low SPL masker may actually be louder and more annoying than another masker of higher SPL (in the other ear or having a different spectrum). Therefore, a compromise must be reached that is acceptable to the patient.

As already mentioned, try the maskers on each ear separately and then together. Generally, noise below 500 Hz and above 3000 Hz will be less interfering with speech than noise in the region between 500 and 3000 Hz. If masking tests have identified frequency regions or an ear in which lower masker SPLs can be used, then maskers could be tried first with these factors in mind. It might be useful to allow patients to try at least three different masker spectrums, a low-frequency emphasis, a high-frequency emphasis, and a relatively flat, broadband masker.

The masker intensity should be increased gradually until the patient hears the masker. The patient should be allowed to get used to this low-level sound for about 1 minute. The intensity can then be increased in two or three small steps, with the patient allowed to listen for a minute at each level. It can be useful to talk to the patient about something else, distracting him from focusing his attention on the masker. Then the patient can be asked whether the tinnitus is less noticeable. Is it less intense or has it stayed about the same? It can be useful to try two different noise levels, one in which the tinnitus is partially masked and one in which it is completely masked.

The patient should be encouraged to walk around using the masker (perhaps visit a cafeteria). The patient should return in 30 to 60 minutes to discuss the masker further and to be allowed the opportunity to ask questions.

A trial period from 3 to 4 weeks is recommended, probably with two maskers,

one for each ear. The patient can be asked to try the masker levels set to mask the tinnitus completely on one day, and then set the masker level to reduce the tinnitus only partially on another day. Some patients may prefer to use the maskers only in the evening, or only when they are in quiet surroundings (Hazell and Wood, 1981). The patient should be told that if a decrease in hearing or worsening of the tinnitus occurs, he or she should stop using the tinnitus masker immediately and return to the clinic as soon as possible.

FOLLOW-UP

After approximately 1 month of use, the patient should return to the clinic. The hearing should be retested. If there is any deterioration in hearing, it should be ascertained whether this is due to the tinnitus masker. If only one masker was used, the deterioration in hearing can be compared on the masked and unmasked ears. The tinnitus masker might be discontinued for a month. If the hearing continues to worsen, then the cause is likely something other than the masker. However, if the hearing stabilizes, then noise-induced hearing loss produced by the masker cannot be ruled out.

If the patient claims that the masker is ineffective, then it might be worthwhile to consider an alternative masking spectrum or a different level. It may also be worthwhile to encourage the patient to try other forms of treatment, such as medication, relaxation therapy, or electrical stimulation. Psychological counseling should be an integral part of every visit. When tinnitus masking does not seem to be effective, the patient could be asked to return again in a year to try a masker again (allowing for the possibility that the tinnitus may change in a manner that makes it easier to mask).

HEARING AIDS AND MASKERS WITHIN A SINGLE DEVICE

For some patients, a hearing aid may be insufficient to mask the tinnitus, but a hearing aid is required on the same ear that requires masking. In this case a combination unit, with a masker built into a hearing aid, can be used. It is important that there are separate controls for the hearing aid and for the masker (not available on all devices), allowing the patient to turn off either the masker or the hearing aid, independently, in some situations. Adjusting the hearing aid and the masker on the same ear presents some unique complications. It is possible that the speech amplified by the hearing aid will influence the masking effectiveness of the noise, and the presence of the noise may influence the optimal characteristics of the hearing aid. Therefore, it may be necessary to adjust the characteristics of one device (the masker or the hearing aid) and then the other, and repeat this process several times. The guidelines for such a procedure have not been established and will depend to some extent on the philosophy for selecting the hearing aid gain requirements.

NONWEARABLE MASKERS

Other methods of providing a source of masking noise have evolved over the years. Some have found that tuning FM radio between stations, thereby creating a static noise, is effective in eliminating tinnitus. This can be done when they are going to sleep, in the workplace, or in the office. Others find relief by choosing an office with high levels of background noise instead of a quiet one. Some manufacturers (see Appendix B) are marketing bedside tinnitus maskers. These small radio-sized devices provide adjustable volume control and a limited variation of the masker spectrum. Some attempt to simulate environmental sounds, such as waves lapping up against the shore. Some include a speaker to be placed under the pillow, so as not to disturb a sleeping partner. Automatic timers, to turn off the device after a few hours, are also available.

SUCCESS RATE

It is of interest to know what percentage of patients that have tinnitus can expect

to be helped by hearing aids, tinnitus maskers, or combination units (masker plus hearing aid in the same unit). Before one can specify these success rates, it is essential to define the patient group, the techniques used to fit the device, and how success is defined.

First, the patient characteristics (selection criteria) should be clearly outlined. One group might be all patients who complain about the tinnitus (that is, it is clinically significant). Another relevant group would be only those who have been recommended for wearing maskers and hearing aids for treatment, provided that the exclusion criteria can be clearly defined.

A second issue that should be clarified is what techniques are used to fit the devices. What procedures are used to recommend a low- versus high-frequency tinnitus masker or one versus two maskers? A study evaluating hearing aids to help speech communication would be inappropriate if all the aids had the same frequency response. Therefore, tinnitus maskers should be set individually according to a specified strategy.

The third factor that must be addressed is how success is determined. Is it measured by masker purchase, or use (for example, at 3 months or at 1 year after initial fitting)? Success could be either partial or total relief.

Schleuning et al. (1980) reported on 105 patients seen in 1979. Of these, maskers were recommended for 34 percent, combination units for 24 percent, and hearing aids for 16 percent. No recommendations were made for 26 percent. Although not made clear, these latter patients apparently had tinnitus that could not be masked or found the masker unacceptable. Overall, 83 percent of those who purchased the device reported partial (68 percent) or total (15 percent) relief (determined by a questionnaire) (see McFadden, 1982 for a review of the Oregon group results). Their fitting strategy was not well defined. Success was determined by a questionnaire (time of masker use not specified).

Another large-scale study has been carried out in Great Britain (Hazell et al., 1985). Three different centers participated, and different selection criteria were used at each center. Twenty-two percent of the subjects were not included in the analysis because they were invalid, but the reasons for exclusion are not clear (probably unexplained missing data or dropouts—R. Coles, personal communication). The results averaged across centers suggest that, of those fitted, 79 percent were successful (received partial or complete relief) with maskers, 73 percent with combination units, and 66 percent with hearing aids (obtained from a questionnaire 6 months after fitting).

However, one of the groups that participated in the Great Britain study (Stephens and Corcoran, 1985) published an independent report. For tinnitus patients with no hearing disability, there were no significant differences in tinnitus relief between patients fitted with a masker and those who received counseling only (a control group). For tinnitus patients with a hearing loss, there was "no dramatic differences in the results obtained" (p. 165) with a hearing aid alone (the control group), a masker, or a combination masker and hearing aid unit. However, maskers "were better than hearing aids in helping the patients to get to sleep and in reducing the loudness of the tinnitus" (p. 166).

Thus, the precise percentage of patients that could be helped by maskers is unknown. There is likely to be a strong placebo effect, that is, patients who receive maskers are likely to report benefit from the counseling and the attention they receive, whether or not the masker is helpful. It is also very likely that individual fitting skills and motivation of the audiologists play important roles.

SUMMARY

Tinnitus maskers can help many patients with this debilitating symptom. Therefore, maskers need to be considered as a viable treatment alternative. The re-

sults from experimental studies on tinnitus masking suggest that large differences exist across patients. Different patients will prefer different types of spectral characteristics of maskers. Noise presented to either ear can be effective in masking tinnitus even for those who report tinnitus in only one ear.

Although tinnitus can be quantified, the application of these measurements to tinnius maskers is unclear. They may have merit to subcategorize tinnitus for treatment evaluations, and they can be used to quantify changes in tinnitus over time. Hearing aids can mask tinnitus, since they amplify speech and background noise (and they also produce their own noise).

Tinnitus maskers should be adjusted to mask or partially mask the tinnitus, yet produce the lowest SPLs and the least interfence with speech. A vital ingredient of successful tinnitus-masker fitting is a positive attitude by the audiologist that encourages the patient to participate in a trial period with the masker.

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APPENDIX A

As of January 1986, the following manufacturers indicated that they are manufacturing tinnitus maskers or combination maskers and hearing aids in the United States:

Danavox, Inc. (adaption unit that fits on behind the ear aid)
6400 Flying Cloud Drive
Eden Prairie, MN 55344
(612) 941-0690

Rexton, International
768 Foster Avenue
Bensenville, IL 60106
(312) 860-3530; (800) 323-0232

Starkey Laboratories, Inc.
P.O. Box 9457
Minneapolis, MN 55440
(612) 941-6401; (800) 328-8602

Viennatone of America, Inc.
6000 NW 153 St., P.O. Box 9318
Miami Lakes, FL 33014
(305) 558-0800

APPENDIX B

Bedside maskers are produced by the following:

Hal-Hen Company
35-53 24th St.
Long Island City, NY 11106
(718) 392-6020

Sound Soother
The Sharper Image
Marpac Corporation
Box 3098
Wilmington, NC 28406

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ARTICLE SIX

SELF-ASSESSMENT QUESTIONS

1. It is possible that tinnitus can interfere with the perception of speech due to:
   (a) a distracting effect
   (b) direct masking effect from the tinnitus
   (c) not possible
   (d) a and b
2. Relative to determining appropriate noise spectrum for tinnitus maskers, narrow bands of noise are known to:
   (a) be the primary cause of tinnitus
   (b) be more annoying than broader bands of noise
   (c) be more pleasant to listen to than broader bands of noise
   (d) require higher sound pressure levels to mask tinnitus effectively
3. Some tinnitus maskers produce a noise that has the potential to damage hearing. The potential damage will depend largely on:
   (a) the center frequency of the narrow band masker
   (b) the existing degree of hearing loss
   (c) whether the unit is a standard masker or a combination unit
   (d) the intensity of the masker and the duration that it is used.
4. In some instances the tinnitus may be gone after the masker is turned off. This phenomenon is referred to as
   (a) residual inhibition
   (b) auditory localization
   (c) masking level difference
   (d) nonlinearity in audition
5. There is no a priori way to determine on which ear to place a tinnitus masker. The best approach would be:
   (a) mask only the ear with the tinnitus (in unilateral cases)
   (b) try masker on each ear separately and then both ears
   (c) implement binural fitting from the outset
   (d) mask the ear with the lesser hearing loss