TINNITUS: A NEW MANAGEMENT.*†

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ABSTRACT.

Tinnitus Clinic was established at the University of Oregon Medical School and the result of treatment for 158 patients is discussed. Patients received three forms of masking as treatment: masking from hearing aids, masking from the Tinnitus Masker, and FM-Masking. Conditions leading to each kind of recommendation are discussed. The examination procedures used in the Tinnitus Clinic are presented. The phenomenon of residual inhibition is explained and discussed in relation to possible long-term or permanent relief of tinnitus. Future plans for the clinic and needs of tinnitus patients are presented.

INTRODUCTION.

The problem and ubiquitous nature of tinnitus is well known to all who see patients with hearing problems. In the words of Heller,[1] ". . . tinnitus is *the most* common symptom associated with hearing impairment." To that statement we would add that tinnitus is also prevalent where there is no demonstrative hearing impairment.

Estimates as to the incidence of tinnitus are difficult to obtain and the only authorative statement available is that of the last National Health Survey conducted by the National Institutes of Health in 1962.[2] They found 36 million American adults with tinnitus. Of that number 20% or 7.2 million, had tinnitus in its severe or extreme form.

The next national health survey to be conducted in 1977 will contain new and additional questions about tinnitus. In all likelihood it will reveal an increase in the number of tinnitus sufferers judging from the alarming increase in incidence of induced hearing loss.

Many things conspire to complicate and confuse the matter of tinnitus. In the first place, tinnitus is a subjective experience for which objective indicators are lacking. It is also confusing that it can arise from a great variety of insults ranging from concussion of the brain, whiplash, and excessive noise to disease states such as otosclerosis, diabetes, hypertension, Ménière's disease and the like. A very high proportion of noise and drug induced hearing loss is accompanied with tinnitus and yet the extent of the hearing loss is not clearly related to the severity of the tinnitus.

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Indeed, we have found that many tinnitus patients deny any hearing loss only to have testing reveal extensive high frequency losses.

Another puzzling feature of tinnitus is the frequent occurrence of episodic tinnitus. Most all patients report some modest swings in the awareness of tinnitus. For example, virtually all our patients indicate their tinnitus is worse when they are tense or nervous. They also indicate it is worse when they are relaxed. Reports such as these are most likely due to altitudinal changes and/or altered states of awareness. The more confusing case is the patient who experiences radical fluctuations in tinnitus, going from periods of very severe tinnitus to times when it is all but absent, without any discernable reason.

An exhaustive exposition as to the confusions about tinnitus is not our intent, but it is our aim to make more people aware of tinnitus and the fact that something can be done in many cases. It is our belief that tinnitus indicates structural physiological dysfunction, that it is not a matter of imagination, and further that it is amenable to treatment.

A TINNITUS CLINIC.

In March 1976, we started the Tinnitus Clinic[3] to which patients with severe tinnitus could be referred by otolaryngologists. Each patient was subjected to three different sets of examination: 1) ear, nose, and throat physical examination along with a tinnitus questionnaire; 2) an audiological examination which utilizes continuous and pulsed tone audiograms speech discrimination in and out of noise, and tone decay, ABLB test of recruitment and tympanometry when indicated; and 3) tinnitus testing which includes matching procedures to duplicate the tinnitus as nearly as possible as to frequency, region, and intensity. The kind and amount of sound needed to produce complete masking of the tinnitus is determined as well as measuring the resulting residual inhibition (explained below). The loudness of tinnitus presents special problems for which the reader is referred to a more detailed consideration.[4]

The results of the three kinds of examination are discussed with the patient, and procedures for relief are recommended. If a hearing aid or a Tinnitus Masker is recommended the patient is sent to one special hearing aid dispenser who works closely with the clinic. The patient is fitted and then followed for the ensuing month. All patients are encouraged to maintain weekly contact with the clinic in order to seek advice, report progress, and/or to provide information.

RESIDUAL INHIBITION.

Early on in the testing of tinnitus patients we were surprised to find that the removal of a masking sound did not immediately reinstate the tinnitus. Instead there was usually a brief period of quiet followed by a period of gradual recovery of the tinnitus. As it turned out, Josephson[5] was the first to discover the temporary disappearance of tinnitus after a period of masking. This "period of silence" was later commented upon and studied by Feldmann.[6] Feldmann had considered masking to be a form of inhibition, thus in recognition of his work we coined the term *residual inhibition* to describe the silent period and the return of tinnitus.

In the clinic we now perform a standardized test for residual inhibition. The test consists of completely masking the patient's tinnitus for one minute (using a noise in the tinnitus frequency region) after which the dura-

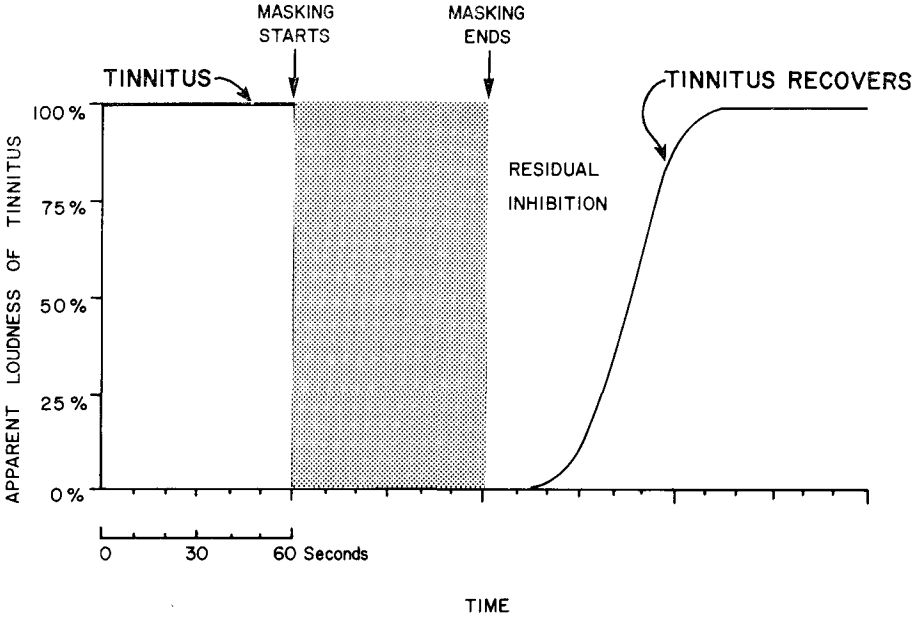

Fig. 1. Schematic representation of residual inhibition. The patient's awareness of tinnitus is reduced from 100% to 0% by presence of masking. The masking is maintained for 60 seconds after which tinnitus is absent for about 20-35 seconds after which it gradually returns in the subsequent 30-35 seconds.

tion of the silent phase of residual inhibition, if present, is measured. Usually this is a matter of 20-35 seconds. Seldom is it less but not infrequently it is greater. Next the period of recovery is measured and it is usually 30-35 seconds. Typical residual inhibition is schematically illustrated in Figure 1.

There are several variations on the theme of residual inhibition. First of all not all patients display it, that is, upon removal of the masking their tinnitus is instantaneously present in its accustomed form. There are others for whom residual inhibition is only partial. That is, upon removal of the masking their tinnitus is immediately present but at a reduced intensity and then that proceeds to gradually return to its normal level. There are some for whom residual inhibition is prolonged and others for whom it is exceedingly brief. In one case the tinnitus was temporarily elevated. In short, there is probably a greater variety of forms of residual inhibition than we have yet seen.

One additional comment about residual inhibition. It may not be obvious but it is, nevertheless, usually the case that masking of tinnitus can be applied contralaterally as well as ipsilaterally. It may be the case that contralateral masking requires some additional intensity to achieve the same level of masking. The surprising thing is that contralateral masking does not produce residual inhibition.

With not a great deal of experience as yet with residual inhibition, we have come to the tentative conclusion that residual inhibition may indicate how well a patient will respond to relief procedures. It seems that patients who display residual inhibition usually do gain substantial relief from whatever relief procedure is appropriate for them.

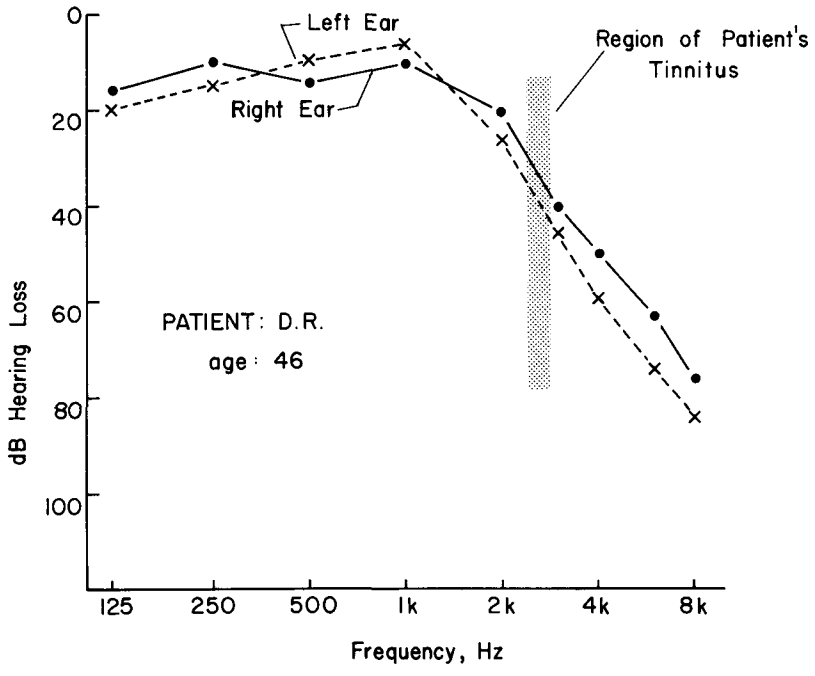

Fig. 2. Typical tinnitus patient, audiogram and location of tinnitus. Patient "D. R." has a bilateral hearing loss, probably noise induced, but unilateral tinnitus. Utilization of hearing aids relieved tinnitus and improved hearing.

RELIEF PROCEDURES FOR TINNITUS.

The attempts to relieve tinnitus are all based on one or another form of masking. That is, there is an attempt to present sound stimuli to the patient in such a manner that it will mask his tinnitus. There are currently three ways in which this is attempted: by a hearing aid, by the Tinnitus Masker, and by FM-Masking. The selection of the method by which masking is provided depends upon the patient, his hearing ability, and the tinnitus.

THE HEARING AID FOR THE RELIEF OF TINNITUS.

The hearing aid has long been recommended for the relief of tinnitus. Saltzman[7] suggested such a procedure in 1949 for the tinnitus of otosclerosis patients. With the perfection of middle ear surgery the use of hearing aids for otosclerosis passed into disuse. Unfortunately the use of hearing aids for tinnitus also passed into disuse although hearing aid dispensers have repeatedly reported that properly fitted hearing aids can relieve tinnitus.

The typical situation is illustrated in Figure 2.

Note that patient "D.R." has a high frequency hearing impairment out of which his tinnitus arises. Note that the tinnitus is not in the region of maximal hearing loss which is presumably also the region of maximal damage. Instead tinnitus is usually found in the region about one third the way down the sloping function.

It is assumed in cases such as the above that amplification of ambient

environmental noises will provide masking sounds which will cover up the tinnitus. Patients such as illustrated above are fitted with an open tube configuration utilizing a free-field ear mold.[8] In this manner only the high frequencies are amplified.

To date we have recommended hearing aids to 82 tinnitus patients. Of that number 23 (28%) *did not* comply with the recommendation. Apparently that figure is consistent with the hearing aid industry across the country. Of the remaining 59 patients, 17 have had their hearing aids for too short a time to be evaluated. Of the 42 patients who have been evaluated 28 (67%) have obtained complete relief of their tinnitus. There were 14 (33%) who did not experience complete relief of tinnitus. All 14 of these patients did obtain a good hearing result and most have experienced some or partial relief of tinnitus and all continue to use their aids.

THE TINNITUS MASKER FOR RELIEF OF TINNITUS.

The presence of tinnitus in normally hearing patients has been noted in an earlier time by Fowler[9] and by Heller and Bergman.[10] Such people are seen in the Tinnitus Clinic where it has been clinically observed that these patients without hearing losses have usually had a history of viral illness, or fever, or postoperative exacerbation. Obviously the use of a hearing aid is not recommended to these patients. Instead we have developed the Tinnitus Masker which is worn like a behind-the-ear hearing aid and visually is indistinguishable from it. Masking as a relief for tinnitus was mentioned as early as 400 B.C. by Hypocrates. It was formally proposed by DeWeese and Vernon in 1975.[11,12]

The Tinnitus Masker generates a band of noise as illustrated in Figure 3. The intent was to provide a band of noise starting at frequencies above the speech freqencies and extending to as high a frequency region as possible. Technical limitations of equipment have restricted the Tinnitus Masker to an upper limit of 7,000 Hz. The Tinnitus Masker is equipped with a volume control which ranges from about 40 db to 85 db SPL. The desired level is set by the patient.

The noise band produced by the Tinnitus Masker is capable of masking in this region while at the same time it does not interfer with speech reception.

To date we have recommended the Tinnitus Masker to 38 patients and only 1 has failed to comply. Of the remaining 37 patients 5 have had their Masker too short a time to be evaluated. Of the 32 patients who have been evaluated 26 (81%) have obtained complete relief of their tinnitus. Six patients (19%) have not experienced complete relief of their tinnitus. Four of those patients have tinnitus located above 7,000 Hz so that the Masker's upper frequency limitation probably prevented adequate masking for them. These 4 patients continue to use the Masker.

A comment about the use of the Tinnitus Masker is in order. Tinnitus patients complain of hearing too much, thus it must seem strange to require them to listen to yet another sound. It is likely that the Masker produces a sound which not only masks the tinnitus, but a sound which is more acceptable than that of tinnitus. A band of noise is less unpleasant than the screech of a high pitched tone. Also the Masker is an external sound and as such perhaps it can be more easily suppressed or ignored than internally generated sounds. Thus it has been rare that a tinnitus patient objected to the sound produced by the Masker.

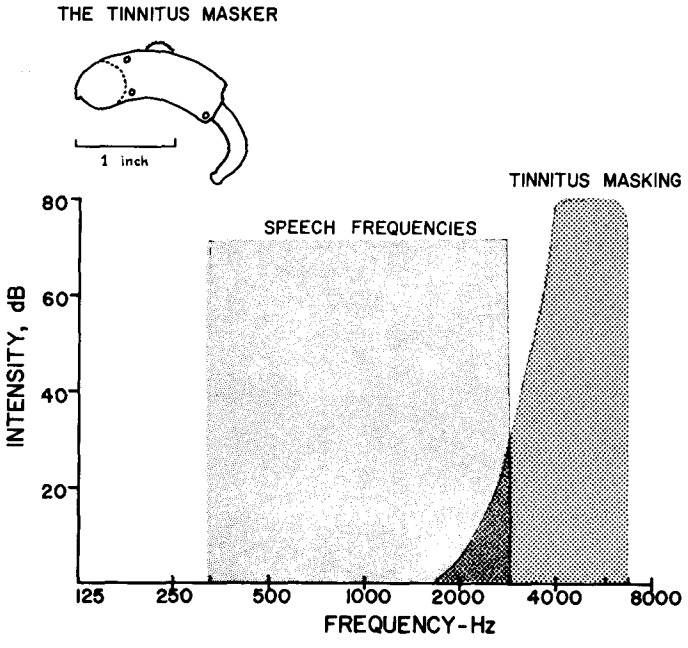

Fig. 3. Sound spectrum generated by the Tinnitus Masker. Sound generated by the Tinnitus Masker was measured in the human ear canal using a calibrated probe tube microphone. The Masker was set at full volume. Measurements were made every 100 Hz starting at 100 Hz through 10,000 Hz using a 50 Hz band width window.

FM-MASKING FOR THE RELIEF OF TINNITUS.

For some patients the major complaint about tinnitus it its disruptive effect upon sleep. Their tinnitus was such that routine daily activity could mask it. At night, in the quiet, the tinnitus becomes a problem. For these people we recommended FM-Masking, that is, detuning an FM radio so as to produce static which occurs between stations. The patient is instructed to increase the intensity of the FM static until it masks the tinnitus and to arrange a bedside radio so that it is available throughout the night.

We have recommended FM-Masking to 10 patients, 1 did not comply, 6 (67%) obtained complete relief and for 3 (37%) it did not work. FM-Masking has the disadvantage of producing wide band noise extending into the speech frequencies so that it disrupts speech reception. Some patients, however, use it for periods of concentration or work.

SUMMARY OF RELIEF PROCEDURES.

In summary, there are 82 patients who have complied with masking recommendations and who have been evaluated. Complete relief of tinnitus has been reported by 59 (72%) of these patients. The remaining 23 (28%) have displayed a great variety of results, all of which are less than complete relief.

Two patients are of particular interest. Both utilized the Tinnitus Masker and both claim now to be cured. That is, they have returned their Maskers after 6½ month's use in 1 case and 9 months in the other. One patient was available for retesting which revealed his hearing to be still

normal. We do not claim that masking tinnitus is a curative procedure but clearly this is one aspect of masking which will bear additional attention. Both of these patients had had a long standing tinnitus, 10 years in one and 6 in the other. Both displayed residual inhibition which gradually increased as they continued using the Masker. It is routine that patients using the Masker on a daily basis experience 30 to 40 minutes or more of residual inhibition upon removal of the Masker. Interestingly enough, the same thing does not happen for patients using hearing aids. The marked difference in the production of residual inhibition for Masker users vs. users of hearing aids suggests that more attention must be given to the composition of the masking sound. Random environmental noises do not seem adequate to provide maximal masking. It is also probably the case that the Masker is not as efficient as it could be. In the future it is our intent to more precisely construct the Masker according to each Patient's needs. Some cases may necessitate the use of a Masker-Hearing Aid combination, and we are currently trying this approach with two patients.

TINNITUS IN PROFOUNDLY DEAF EARS.

We have seen three patients with severe tinnitus coming from "dead" ears. Patients of this sort present a real problem in that the lack of any hearing function means that masking cannot be utilized. These are unilateral cases and contralateral masking has not as yet proven effective for them.

Patients of this sort suggest the possibility of resorting to cochlea destruction; however, one of our patients has had a labyrinthectomy which only made his tinnitus worse. It appears that the tinnitus of the profoundly deaf is different and will require a special procedure as yet unknown.

CONCLUSIONS.

Various forms of masking have been demonstrated to be effective for the relief of tinnitus in 72% of the cases. It is our conviction that with improved precision of customizing the masking sound to the patients' tinnitus the incidence of relief will increase.

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