

**Frequency selectivity in noise-exposed chinchillas\*** Robert I. Davis, Ph.D., Roger P. Hamernik, Ph.D., George A. Turrentine and William A. Ahroon, Ph.D., Auditory Research Laboratory, SUNY - Plattsburgh, 107 Beaumont Hall, Plattsburgh, NY 12901

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*Noise-induced-hearing-loss*

## INTRODUCTION:

Over the past few years, in the course of our noise research, we have had the opportunity to collect auditory evoked potential (AEP) tuning curves (TC) on over 300 noise exposed chinchillas for which sensory cell loss data as well as threshold shift data were available. Recently, we published a paper on the normative data acquired from approximately 150 chinchillas in which we related TC variables to the amount of noise-induced PTS and sensory cell loss along the cochlea. This analysis was performed in discrete octave bands along the entire length of the cochlea. Implicit in this analysis was a complete neglect of the influence of pathology in adjacent regions of the cochlea on the TC characteristics measured at a specific audiometric test frequency.

### Slide I:

This slide illustrates an example of some of this data. The AEP turning curve was recorded from the inferior colliculus using a simultaneous tone-on-tone masking paradigm. The percent change in the mean TC variables ( $Q_{10\text{ dB}}$  and the low and high frequency slopes) measured at the audiometric test frequencies were compared with the extent of sensory cell loss for various amounts of PTS induced by a variety of noise exposures. These results show a systematic relation between the degree of PTS, abnormal OHC populations and changes in tuning.

There is relatively little information in the literature relating various patterns of sensory cell damage to changes in tuning. We have therefore continued the analysis of our large experimental population in an attempt to evaluate the quality of tuning in subjects with certain specific configurations of noise-induced cochlear sensory cell damage.

### Slide II:

Sixty-seven (67) animals out of a population of over 300, were divided into 5 reasonably homogeneous groups as defined in this slide. Groups I and II had less than 15 dB PTS at all test frequencies. Group I, however, was restricted to animals that had less than 10% OHC loss within each of the octave band lengths of the cochlea centered at .25, .5, 1, 2, 4, 8 and 16 kHz; (i.e., a population which, in a clinical setting, would be considered within normal limits). Group II had thresholds similar to those of Group I, but more than 10% OHC loss within the octave bands centered at .5, 1, 2 and 4 kHz. The remaining three groups had restricted lesions of OHC that exceeded 20% within the 1 or 2 kHz octave bands (Group III); within the 4 kHz octave band (Group IV) and within the 8 and 11.2 kHz octave bands (Group V). In each of these 3 groups OHC losses were less than 10% within all the other OB lengths of the cochlea.

## METHODS:

Pre and postexposure measures of hearing threshold and masked threshold (simultaneous tone-on-tone paradigm) were obtained in each chinchilla using the AEP recorded from a chronic bipolar electrode implanted in the inferior colliculus.

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Status of the sensory cell population was also evaluated using surface preparation histology and standard cochleograms were constructed. Percent hair cell loss was calculated for octave bands along the length of the cochlea. These data were collected using a consistent set of experimental protocols which can be found in the literature.

Note: Although our original experimental population contains more than 300 subjects, the N in each of the above 5 groups is quite small, because we wanted to make the groups as homogenous as possible. The small N causes the statistical power to be low.

## RESULTS:

### Slide III:

In this and subsequent slides the mean pre and 30-day post exposure high and low frequency tuning curve slopes, the group mean PTS and the mean percent sensory cell loss within the octave band frequencies of .5, 1, 2, 4, 8 and 11.2 kHz are shown for the same group. Group I, shown in this slide, consists of 36 animals with a mean PTS of less than 5 dB at each test frequency and a corresponding mean OHC loss of less than 5% in each octave band length of the cochlea centered on that audiometric test frequency. As anticipated in this noise-exposed but relatively normal group of animals, the mean pre and postexposure values for the low and high frequency tuning curve slope are essentially unchanged across the range of frequencies tested.

### Slide IV:

In contrast to this group, 6 animals that had a mean PTS of less than 10 dB at each test frequency but had a greater than 10% loss of OHC within the OB represented by center frequencies of .5, 1, 2 and 4 kHz were analyzed. For both slopes, the mean pre and postexposure values were similar at .5, 1, and 2 kHz. At the higher test frequencies, the post exposure values were reduced except for the LFS at 11.2 kHz. This reduction was statistically significant for only the HF slope at 4 kHz.

### Slide V:

The 15 animals in Group III had a mean OHC loss of up to 40% within the 1-2 kHz OB region of the cochlea and 5 to 15 dB PTS between 0.5 and 2 kHz. The mean postexposure TC slopes are reduced at all probe frequencies. This reduction in slope was statistically significant at the .05 level, at .5 and 1 kHz for the LFS and at 1 and 2 kHz for the HFS where sensory cell damage appeared. Thus, although there is minimal PTS in regions of the cochlea which appear normal, there is still some reduction in tuning, although these reductions in normal regions are not statistically significant.

### Slide VI:

In this group of 6 animals, damage is restricted to the region of the cochlea encompassed by the OB with a center frequency of 4 kHz. Although the mean pre and postexposure HFS values remain essentially the same, except at 11.2 kHz, the mean postexposure LFS is significantly reduced at all probe frequencies except at 11.2 kHz. Thus, for this group, statistically significant effects on tuning appear in regions of the cochlea with near normal (<10% loss) cell populations and relatively small (5-10 dB) amounts of PTS.

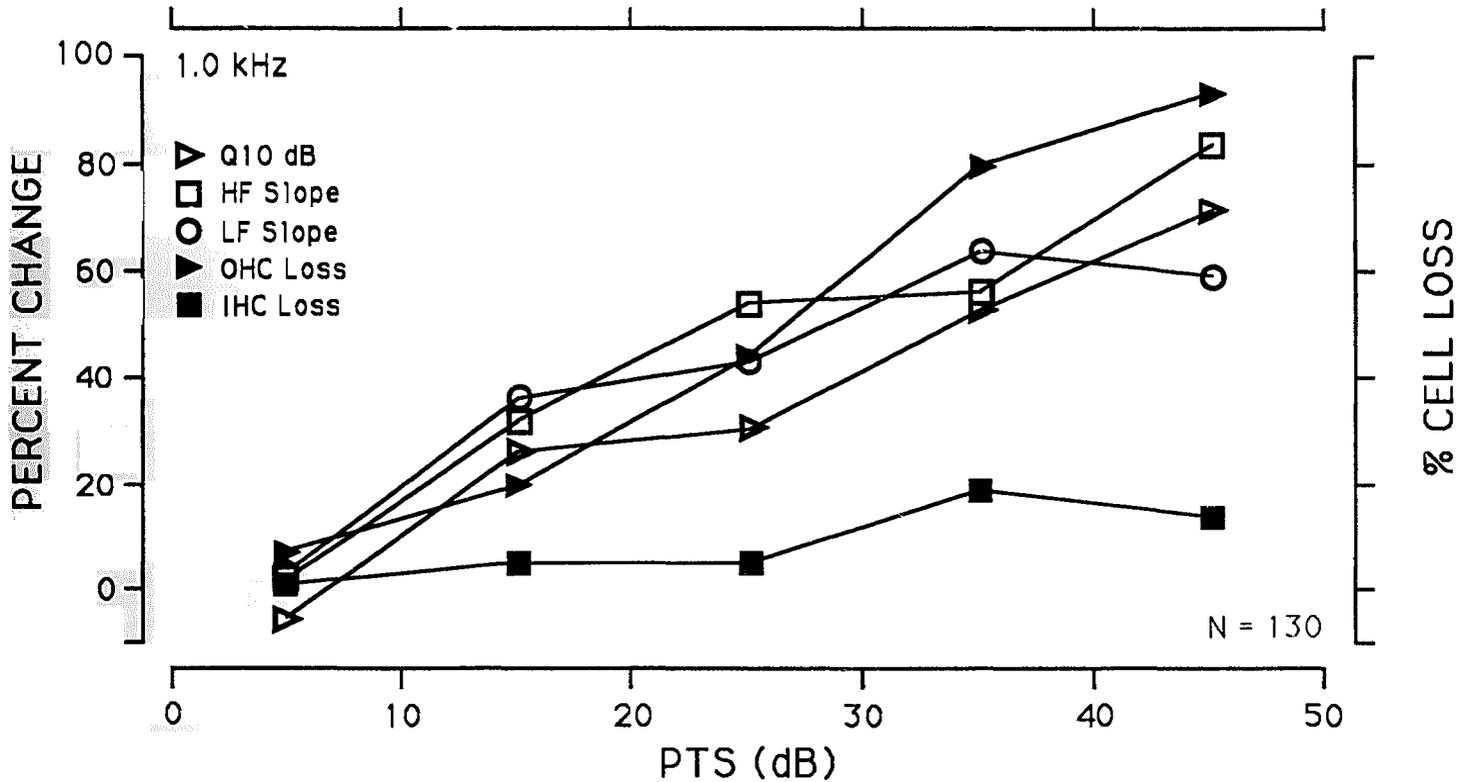
### Slide VII:

In this group of 4 animals with sensory cell loss restricted to the 8 and 11.2 kHz regions of the cochlea, the mean postexposure high and low frequency slope closely approximate the pre-exposure

values up to the region where damage appears. At 8 and 11.2 kHz, the postexposure slopes are clearly reduced with a statistically significant effect occurring for the LFS at 11.2 kHz.

#### **CONCLUSIONS: Slide VIII**

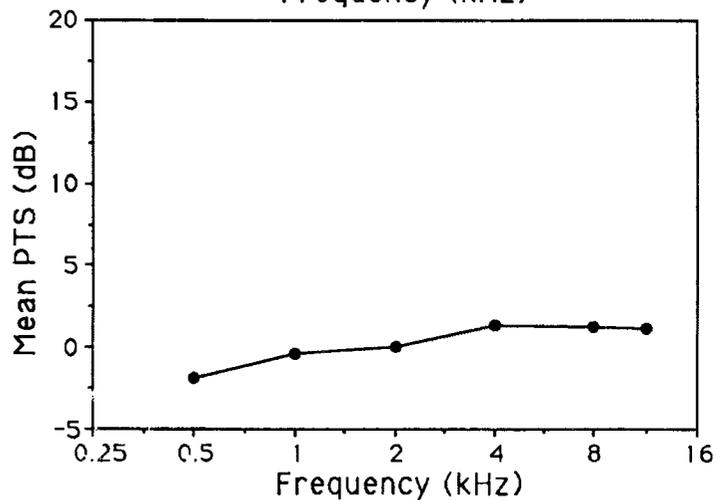
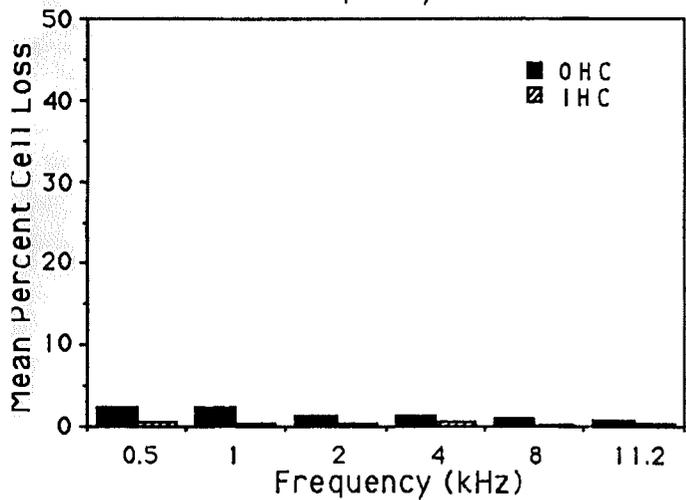
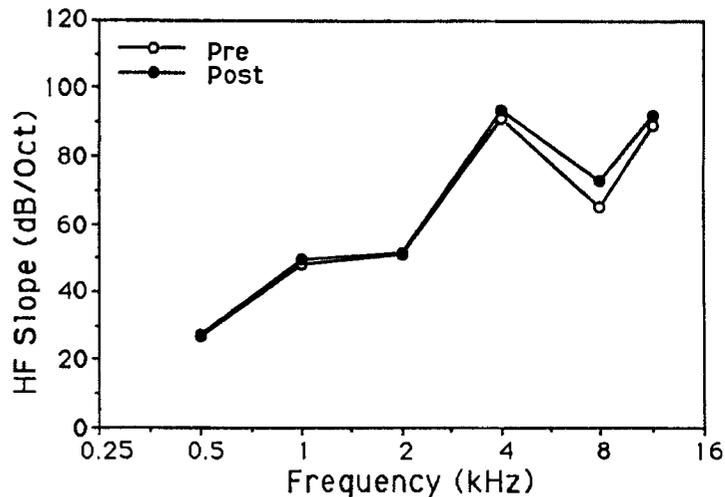
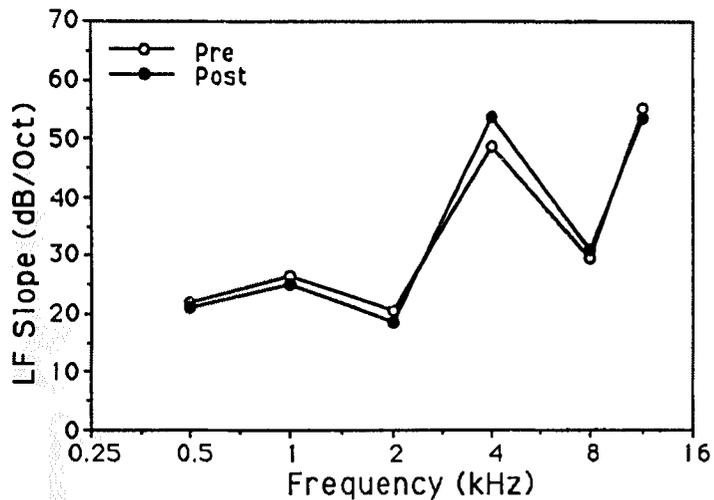
1. Tuning is not altered in noise-exposed cochleas having less than 5 dB PTS and less than 5% sensory cell damage.
2. The tuning curve is not a sensitive measure of the condition of the cochlea when considerable sensory cell damage is present with a concomitant small amount (<10 dB) of PTS.
3. Tuning is reduced in both normal and damaged regions of the cochlea when the damage is restricted to the apical and mid-portion of the cochlea. These changes in tuning at normal frequency regions are most pronounced for the group with the 4 kHz focal lesion.
4. For a high frequency lesion the changes in tuning are limited to the region of PTS and outer hair cell loss.
5. The low frequency slope would appear to be a more sensitive indicator of a noise-induced cochlear lesion than is the high frequency slope.



Relationship between tuning curve variables, sensory cell loss and the amount of permanent threshold shift (PTS) at the 1 kHz audiometric test frequency. Davis et al. (1989) Hearing Research. 41:1-14.

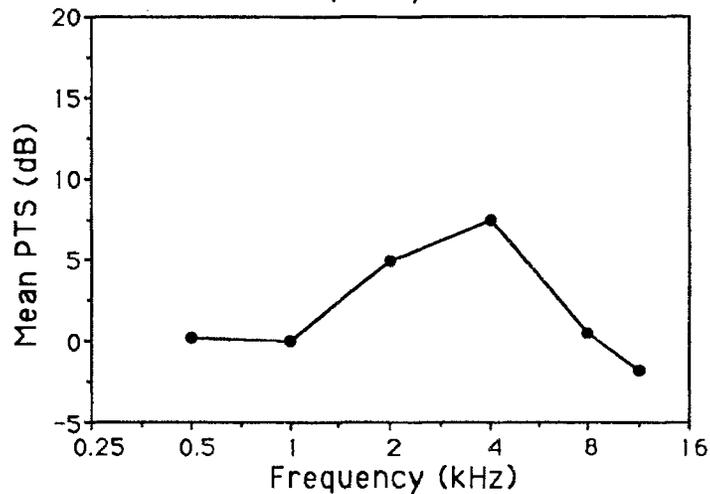
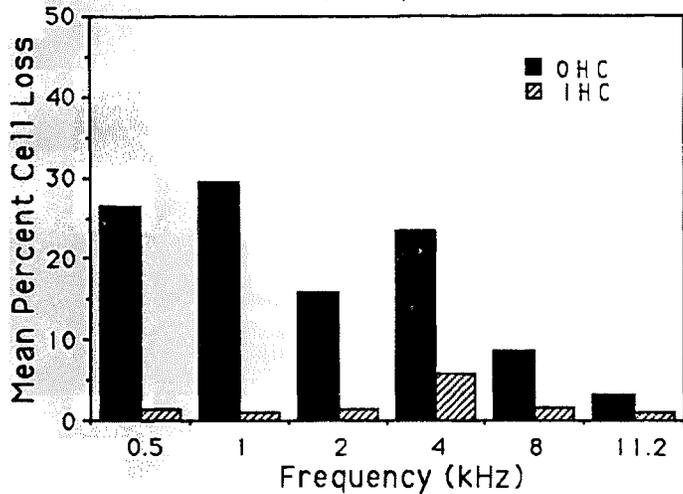
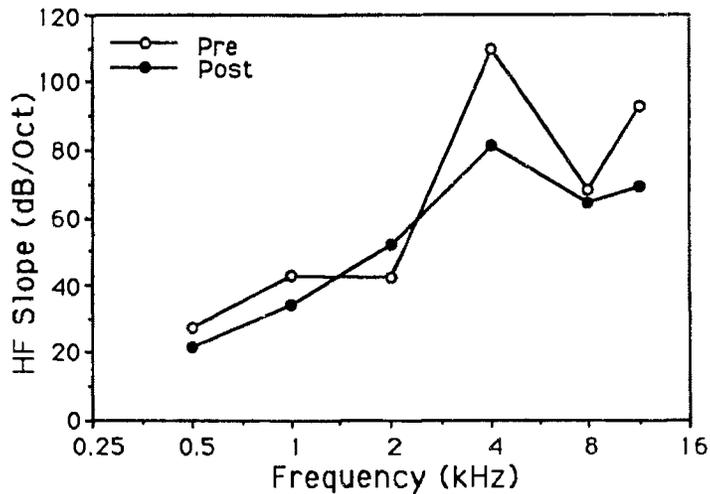
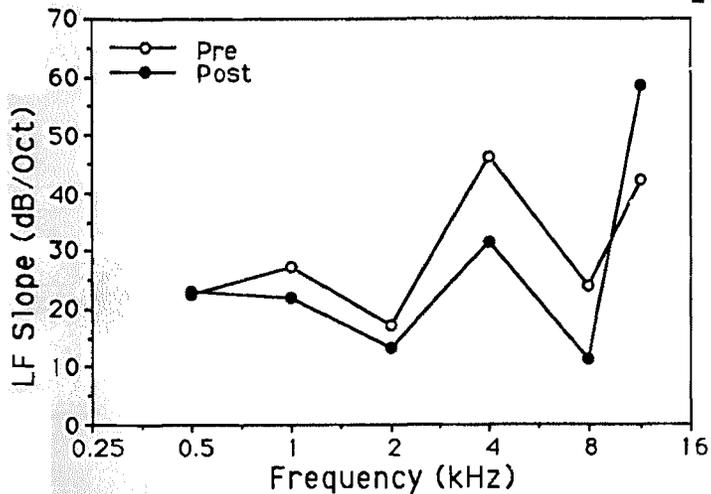
Group	N	Criteria		
		PTS	OHC Loss	
1	36	<15 dB at all f's	<10% within each octave band	essentially "normal" postexposure cochlea
2	6	<15 dB at all f's	≥10% at 0.5, 1, 2 and 4 kHz & normal (<10%) at all other f's	apical lesion with "normal" thresholds
3	15		>20% at 1 or 2 kHz & ≤ 10% at all other f's	low frequency focal lesion
4	6		>20% at 4 kHz & ≤ 10% at all other f's	mid frequency focal lesion
5	4		> 20% at 8 and 11.2 kHz & ≤10% at all other f's	high frequency focal lesion

# Group I (N=36)



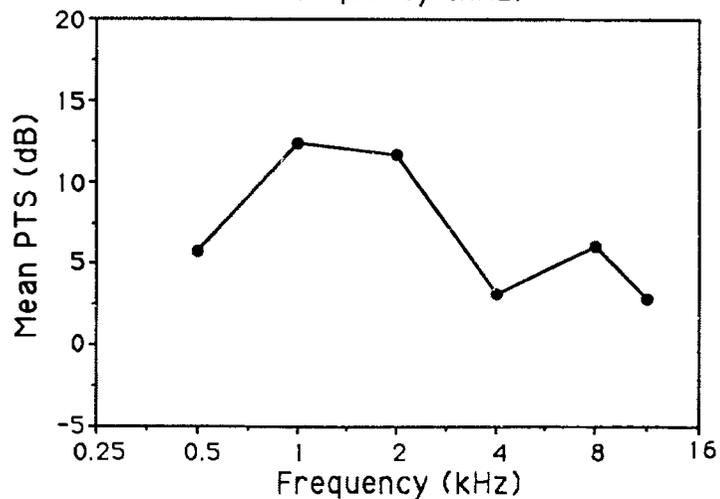
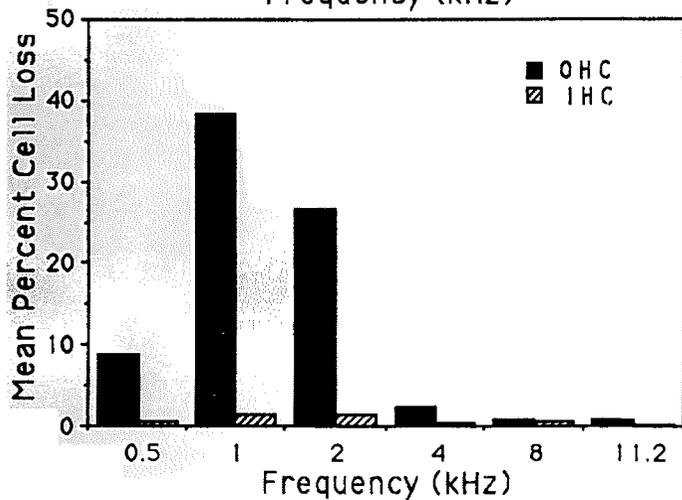
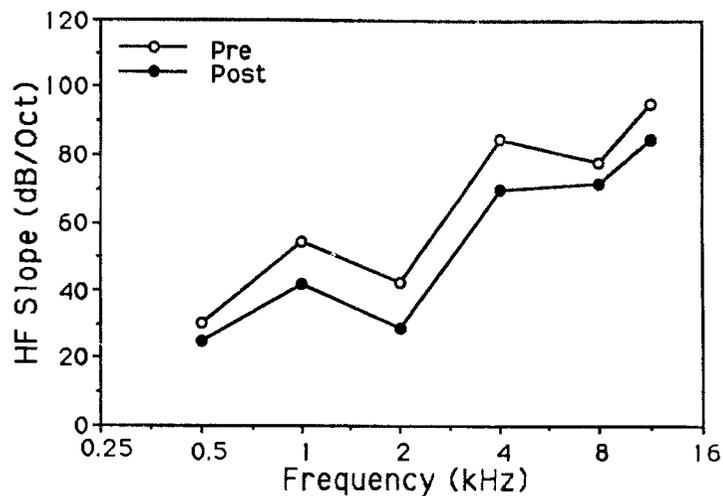
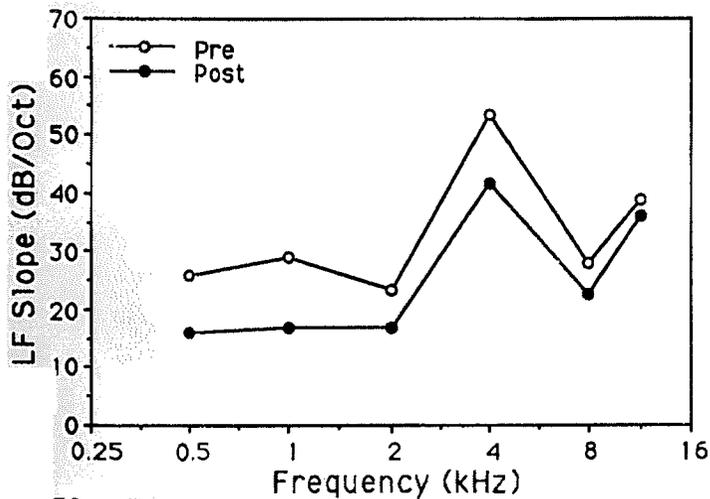
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# Group II (N=6)



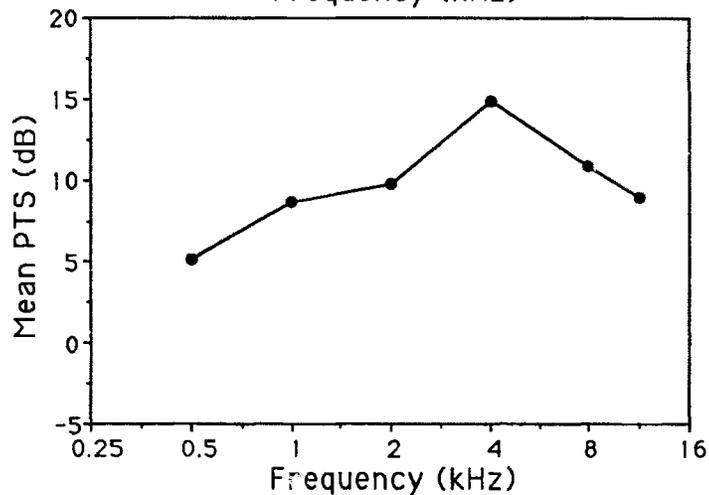
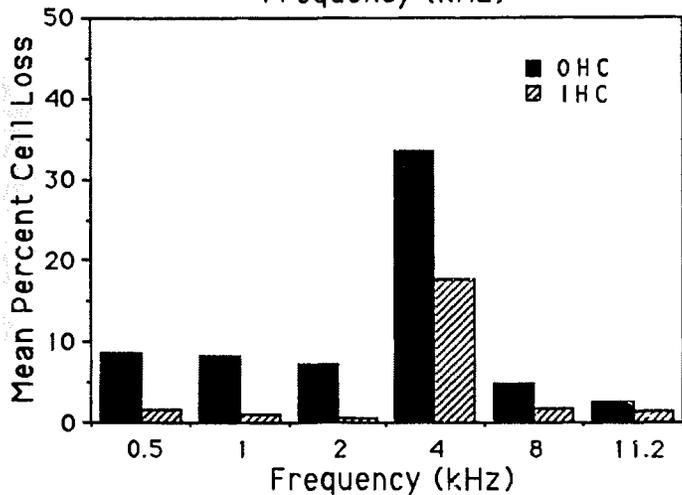
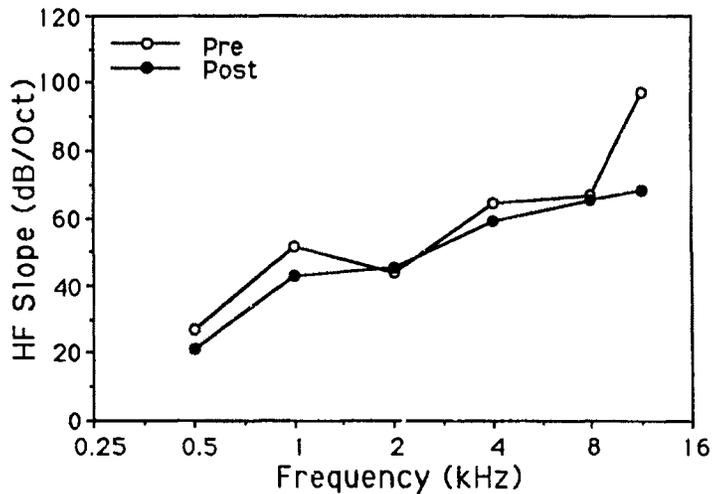
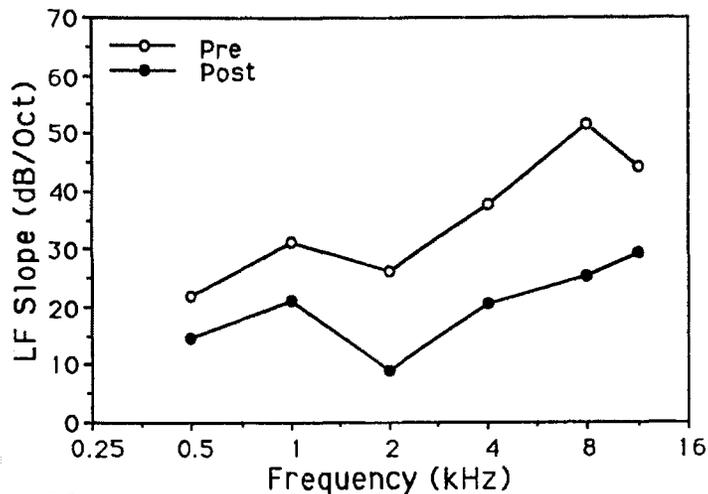
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# Group III (N=15)



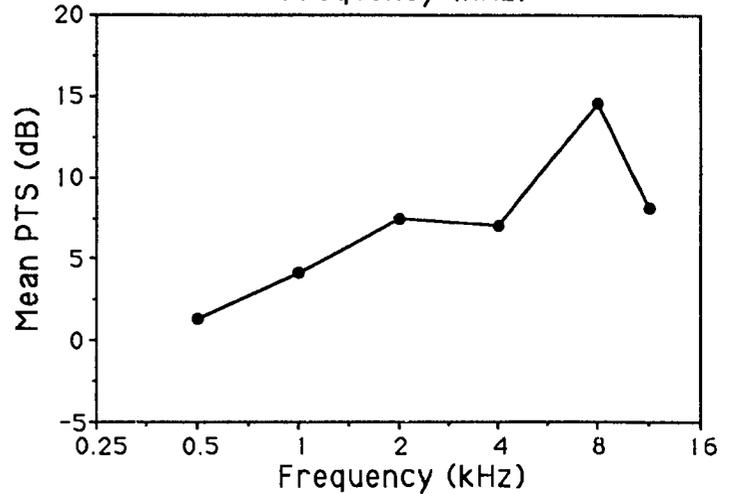
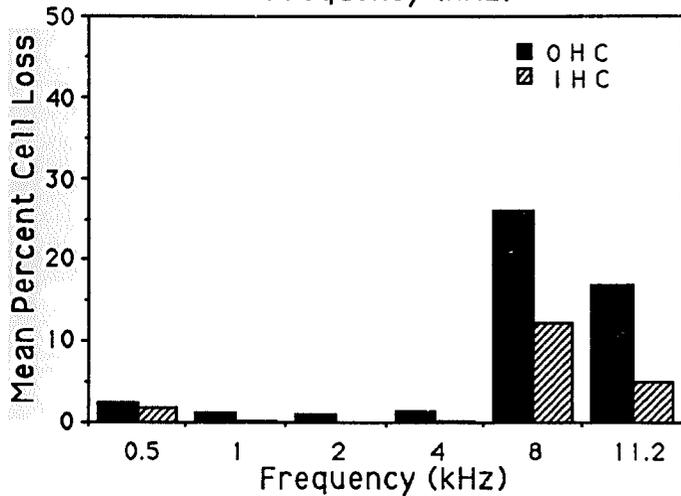
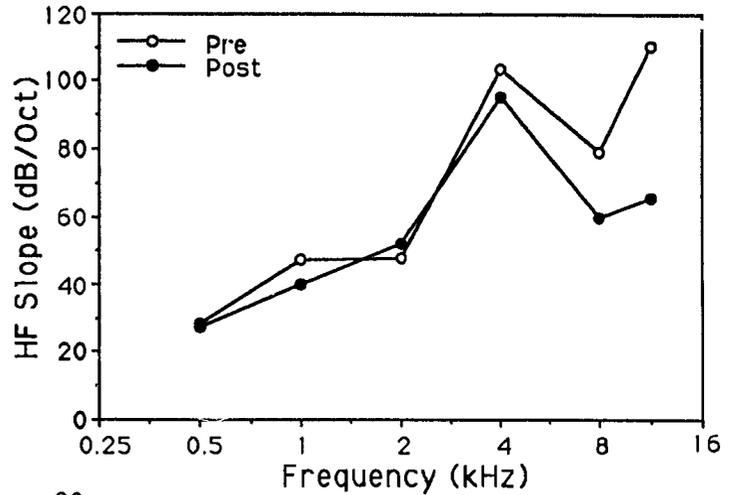
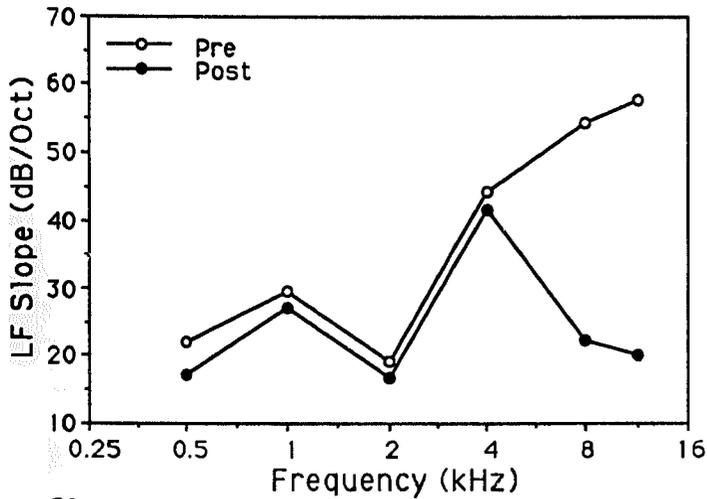
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# Group IV (N=6)



-122-

# Group V (N=4)



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## Conclusions:

1. Tuning is not altered in "normal" post-noise-exposed cochleas.
2. The tuning curve is not sensitive to the condition of the cochlea when sensory cell damage is coupled with "normal" pure tone thresholds.
3. Tuning is reduced in both normal and damaged regions of the cochlea when cell loss is restricted to the mid-portion of the cochlea.
4. For a high frequency lesion the changes in tuning are limited to the region of outer hair cell loss.
5. The low frequency slope appears to be a more sensitive indicator of a cochlear lesion than is the high frequency slope.

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