A novel method of evaluating miners at risk for noise-induced hearing loss

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INTRODUCTION

Noise-induced hearing loss (NIHL) negatively affects the quality of life of mine employees and costs mining companies large amounts in compensation claims. The prevention of NIHL requires early identification and recent evidence about the ability of otoacoustic emissions to identify inner ear damage before the conventional tests are able to, requires an investigation of the feasibility of using this method of testing on a large workforce in an annual medical surveillance settings.

DISTORTION PRODUCT OTOACOUSTIC EMISSIONS

Distortion-product otoacoustic emission (DPOAE) testing uses two tones as an input into the ear and measures the 'echo' that returns from the interacting waves elicited from the outer hair cells of the cochlea and the fluids in the inner ear.

The DPOAE test has been shown to be a clinically feasible and sensitive tool for assessing the part of the ear that is damaged by noise exposure.[1-4,11] The benefits of the DPOAE test are:

- no active response is required from the person being tested[1,2]
- they reliably identify early cochlear damage due to noise[5-8]
- speed and cost-effectiveness of testing[2,7,9]
- no requirement for a sound-proof booth, only a relatively quiet test room.

However, these findings have all been shown in a diagnostic audiology or clinical environment where the tester is skilled in audiological testing.[10] There is a need to show the same reliability and validity of the test results when tests are conducted in a non-clinical environment, such as that of an annual medical surveillance environment, where the ambient noise levels in the testing area are not as easily controlled due to large numbers of people needing to be accommodated for testing. Furthermore, the same reliability and validity of test results has not as yet been shown when tests are conducted by a less skilled tester such as an audiometrist or technician. Another aspect that requires investigation is whether the use of the DPOAE test in a population that has pre-existing hearing loss, such as is found in the mining population, can provide reliable and valid test results. This is due to the fact that DPOAEs are absent when the hearing loss exceeds a moderate range; this may reduce the feasibility of using this test. Finally, because NIHL is an irreversible condition, it is important to identify early NIHL in order to facilitate effective prevention strategies. The ability of DPOAEs to identify early cochlear damage has been shown in military environments but has not been clearly shown in an industrial environment such as in the mining industry.[2]

This pilot study was aimed at evaluating the feasibility of using DPOAE testing as an adjunct to audiometry in annual medical surveillance in the mining environment. It focussed specifically on the correlation between screening audiometry results and DPOAE results in an annual medical surveillance where ambient noise levels are not easily controlled and the testing is performed by a technician.

The objectives of the study were:

- To evaluate the signal-to-noise ratio of the DPOAE test results when the tests were conducted in different venues in an Occupational Health Centre by a technician
- To evaluate the viability of DPOAE testing in a population that has been exposed to noise and therefore may have existing hearing loss
- To investigate the correlation between screening audiometry HTLs and DPOAE levels
- To evaluate the ability of DPOAE test results to identify early NIHL.

DPOAE testing does not require a response form the testee nor a sound-proof booth and can be performed in less than 5 minutes

RESULTS

Signal-to-noise ratio

Table 1: Comparison of signal-to-noise ratio between emission levels and noise floor at the two testing venues

DPOAE f_2 Frequency	633 Hz	797 Hz	996 Hz	1266 Hz	1605 Hz	2027 Hz	2555 Hz	3234 Hz	4055 Hz	5133 Hz	6434 Hz
Clinic	8.9	11.3	13.3	14.6	15.6	14.6	12.6	13.7	19.9	15.2	7.9
Mine	10.0	12.8	13.4	15.9	15.2	14.9	12.5	14.2	20.3	17.1	6.4

Hearing levels

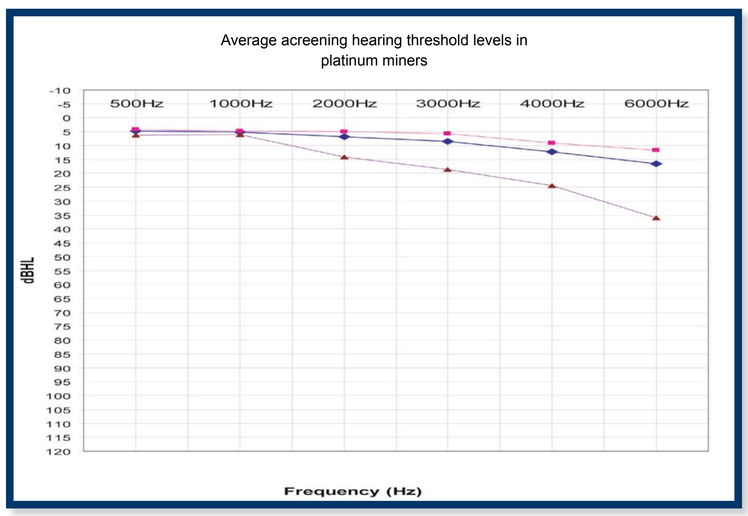

Figure 1: Average Audiogram threshold levels in platinum miners

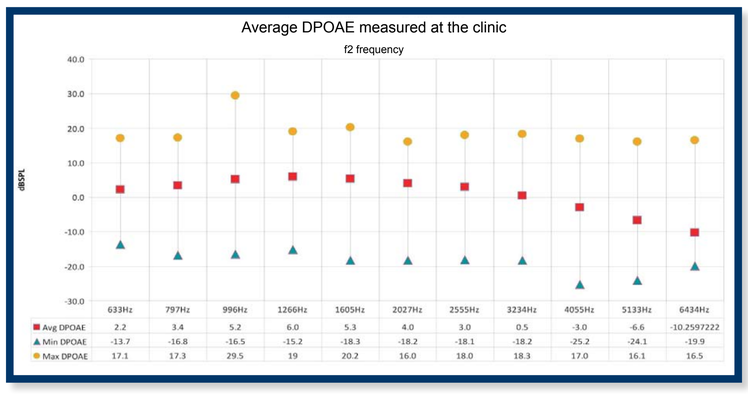

Figure 2: Average DPOAE levels of subjects tested at the clinic

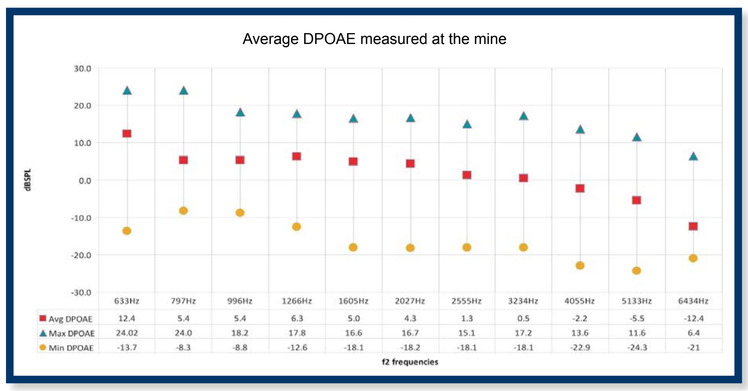

Figure 3: Average DPOAE levels of subjects tested at the mine

Correlations between audiogram and DPOAE results

Table 2: Correlations between screening audiogram thresholds and DPOAE levels

Test venue: Clinic											
DPOAE f_2 frequency (HZ)	633	797	996	1266	1605	2027	2555	3234	4055	5133	6434
Audiogram frequency	Correlation Coefficient										
500Hz	-0.3	-0.26	-0.32	-0.18	-0.15	-0.14	-0.28	-0.18	-0.22	-0.06	-0.24
1000Hz	-0.13	-0.13	-0.2	-0.14	-0.03	0.02	-0.09	-0.12	-0.18	-0.13	-0.27
2000Hz	-0.11	-0.11	-0.2	-0.24	-0.37	-0.47	-0.54	-0.6	-0.48	-0.59	-0.48
3000Hz	-0.2	-0.18	-0.19	-0.25	-0.3	-0.4	-0.53	-0.71	-0.69	-0.67	-0.58
4000Hz	-0.09	-0.08	-0.14	-0.1	-0.25	-0.3	-0.35	-0.58	-0.6	-0.66	-0.5
6000Hz	-0.19	-0.2	-0.2	-0.3	-0.35	-0.43	-0.36	-0.5	-0.5	-0.58	-0.59
Test venue: Mine											
500Hz	-0.37	-0.28	-0.04	-0.06	0.00	-0.02	-0.11	-0.25	0.19	-0.02	-0.37
1000Hz	-0.29	-0.15	-0.23	-0.25	-0.28	-0.41	-0.41	-0.43	-0.18	-0.33	-0.36
2000Hz	-0.15	-0.09	-0.05	-0.11	-0.06	-0.25	-0.2	-0.41	-0.13	-0.27	-0.4
3000Hz	-0.07	-0.08	0.11	0.13	0.14	0.08	-0.06	-0.38	-0.24	-0.28	-0.11
4000Hz	-0.13	-0.05	0.1	0.11	0.1	0.06	0.05	-0.29	-0.49	-0.24	-0.08
6000Hz	-0.37	-0.31	-0.1	-0.08	-0.03	-0.06	-0.17	-0.22	0.24	-0.03	-0.24

Yellow = Correlation coefficient is significant (2-tailed) $p<0.05$

Early indication of NIHL

Table 3: Indication of cochlea damage by DPOAE results

Degree of HL	Number of subjects	Early Identification	Identified	Not identified
Normal hearing	73	53	4	16
Early NIHL	26	11	15	0
NIHL	1	0	1	0

CONCLUSION AND RECOMMENDATIONS

The results of the current study provide evidence that DPOAE testing is feasible in a screening audiometry setting because the hearing levels of platinum miners are within the range that valid results can be obtained. The results also indicate that if attention is given to the ambient noise levels reliable results can be obtained when tests are conducted by a technician. DPOAE testing can also identify early NIHL in 73 % of the miners before pure-tone audiometry does.

If DPOAE testing was a routine part of annual medical surveillance testing more information about the actual damage that is occurring in the cochlea would be available and would provide evidence for counsellors of noise-exposed miners that will motivate them to protect their hearing and prevent NIHL.

The CSIR investigates a method for early identification of noise-induced hearing loss in order to improve the success of prevention strategies amongst South African miners.

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