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Evaluation of Early Oto - Acoustic Emission Changes Following Radiotherapy

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Abstract

Oto-acoustic emission is known to be a sensitive test detecting the integrity of outer hair cell population. In this study, pre-and post radiotherapy assessment of 15 patients using oto-acoustic emission showed significant affection of high frequency by analysing percentage reproducebility, amount of elicited emission in dB, and power spectral analysis of the response using fast fourier transform.

Introduction

THE ingenious observation of Kemp [1] of what is called oto-acoustic emission (OAE) has led to a radically new prespective in cochlear mechanics. He noticed release of audiofrequency energy into the ear canal from the cochlea, transmitted through the ossicular chain and tympanum, in response to an adequate auditory stimulus.

The transmission of emission to the ear canal is highly unlikely to be a functional part of the hearing mechanism, so emissions must be considered as an energy leakage from the cochlear travelling wave [2]. This energy leakage is an inevitable biomechanical property of the healthy functioning cochlea. So, OAEs offer a mean of examining certain functional aspects of the cochlea, from the ear canal, using acoustic probe.

On the other hand, permanent hearing loss secondary to radiation therapy was described by Leach [3]. He attributed its cause to conductive and/or sensory neural abnormalities and rarely ossicular necrosis. He found permanent changes in approximately 30% of patients studied. The degree of hearing loss was on the average of 20 to 30 dB and its configuration at the high frequency.

A report by Stell [4] showed that the inner ear is radioresistant at the usual clinical radiation dose with conventional fractionation.

Material and Methods

The present study included 15 patients (7 males and 8 females) with malignancies requiring treatment by radiation, where the radiation portals included the aural region.

Five patients had brain tumours for which they received a total dose of 50 Gy over 5 weeks, while the other 10 patients had advanced tumours of the head and neck for which they received hyperfractionated radiotherapy for a total dose of 7200 cGy/48 treatment 6-7 wks which is equivalent radiobiologically to a total dose of 6000 Gy by conventional fractionation. The click evoked oto-acoustic emissions were examined in all 15 cases twice, pre-and immediately post-irradiation.

All the study group showed bilateral normal peripheral hearing (less than 25 dB HL) and bilateral excellent speech discrimination. Immittance-metry showed bilateral type A tympanogram with preserved acoustic reflex at normal sensation levels. Pure-tone audiometry and immittance-metry were performed using an audiometer (Amplaid 309) and immittancemeter (amplaid 702), respectively. A cone shaped acoustic probe composed of a pair of plastic tubes was employed for the recording the OAE.

The probe composed of two miniature microphones (Knowles, EA-1843). It is connected to Otodynamic (ILO88) stimulator, which in turn is connected to IBM XT computer for data storage, analysis, and control. The stimulus used was non filtered click 100us, given in a train of four clicks three condensation and one rarefaction and their sum is zero. This technique is called non-linear recording [2], to insure cochlear response. Usually 256 sweeps between 3 and 20 ms after the beginning of sound stimulation were averaged. The measurement of the OAE was performed with subject lying down, but awake in order to prevent contamination of waveform with the noise of snoring.

Results

Table (I): Mean and S.D. of the Hearing Threshold Levels at Different Frequencies before and after Radiotherapy.

		250	500	1000	2000	4000	8000 Hz
Before	M	10.9	7.3	4	5	8.5	8
	SD	+ 4.4	+ 3.7	+ 1.3	+ 1.5	+ 9.6	+ 2.2
After	M	11	7.9	5	5.8	9.9	9.1
	S.D	+ 4.3	+ 3.5	+ 3	+ 1.6	+ 4.8	+ 4.2

No significant difference between both conditions ($P > 0.05$)

Table (2): The Percentage Reporducebility of Otoacoustic Emission Waveforms both before and after Radiotherapy.

		1000	2000	8000 Hz	4000
Before	M	47.9	57.1	59	38
	SD	+ 34.2	+ 40.7	+ 41.9	+ 41.1
After	M	29.2	37.8	16.4*	22.1
	S.D	+ 37.1	+ 42.1	+ 28	+ 27.1

* significant difference between conditions ($P < 0.05$)

Table (3): The Amount of Emission in DB and the Accompanied Noise before and after Radiotherapy.

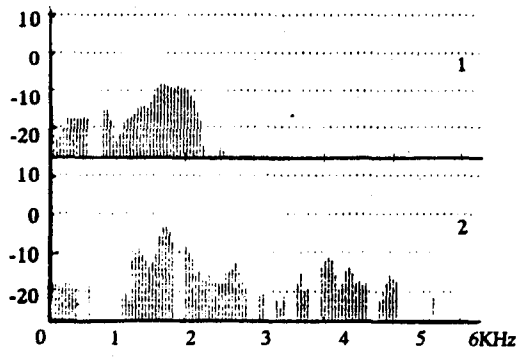
Condition	Emossion	Noise
Before	* 8.17 + 5.19	5.72 + 2.9
After	* 6.6 + 5.1	3.11 + 10.6

* significant difference between conditions ($P < 0.05$)

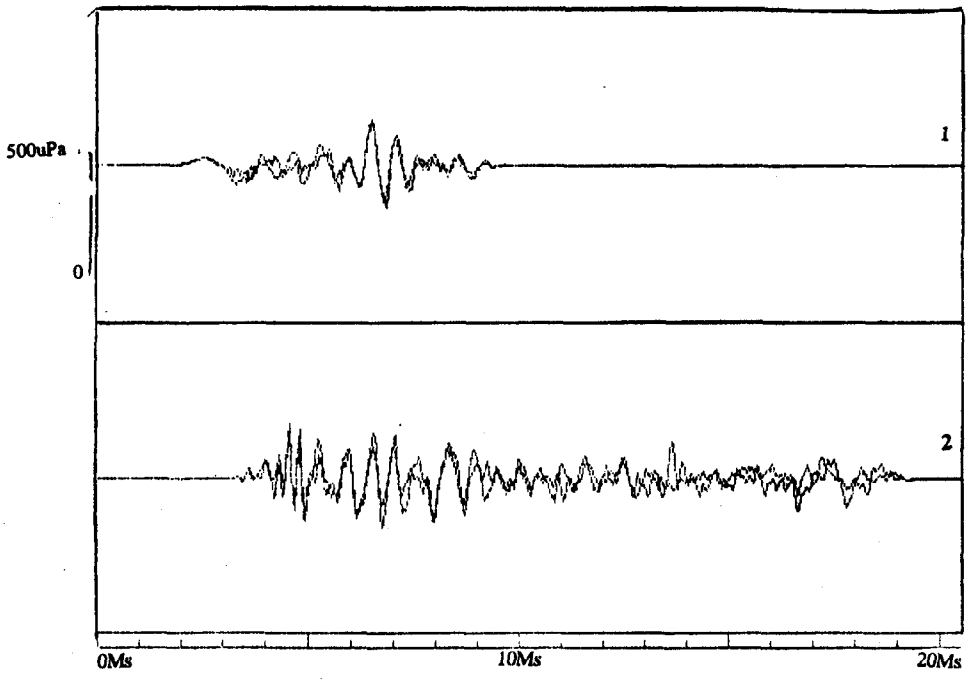
Table (4): The Power Spectral Analysis of Oto-Acoustic Emission before & after Radiotherapy.

Cond.	500	1000	1000	1500	2000	2500 Hz	3KHz
Before	- 12.1	- 15	- 13	- 15	-15	- 18	-20
	+ 9.1	+ 11.1	+ 9.5	+ 11.6	+ 11.6	+ 10.2	+ 11
After	- 17	- 18	- 17	- 21.1	- 24*	- 26.2*	- 29*
	+ 12.2	+ 13	+ 11	+ 8.6	+ 8.8	+ 4.2	+ 12

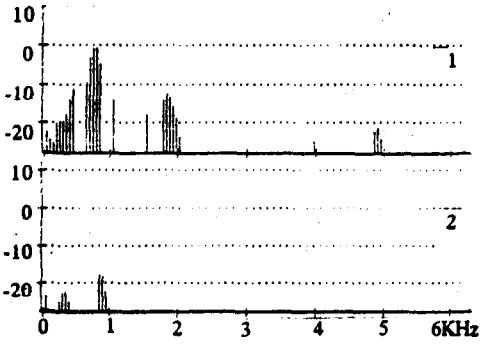
No significant difference ($P > 0.05$)



KARIMA
C/C hyper fractionation



(Fig. 1)



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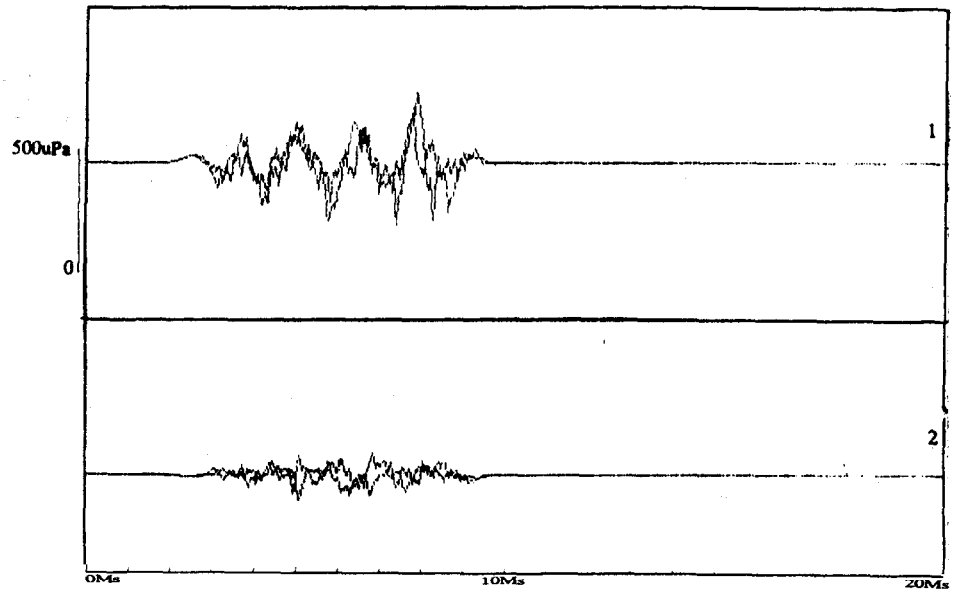

(Fig. 2)

Discussion

Studies of oto-acoustic emissions in the ears of normally hearing persons support the proposition that specific properties of these responses can serve as indicators of the status of outer hair cell function in a given ear. Oto-acoustic emission represents the only measure of cochlear function that specifically tests the condition of the preneural components of the auditory pathway [5]. Emissions are charaterized by being stable over time. Thus, they may be used eventually as a long-term monitor of any progressive hearing loss [6].

In this study, OAE has been used as a detector of any changes in the intactness of outer hair cell population following radiotherapy.

In previous studies, pure-tone audiometry (subjective hearing threshold) was used to monitor any deviation in hearing sensitivity, which in one hand had the pitfall of being subjective test and on the other it is specific in detecting inner ear pathologies.

Stell [4] was concerned about the effect of radiothrapy on hearing. They found 8 ears with sensory neural hearing loss out of 28 ears (14 subjects) underwent radiotherapy, 4000 Hz frequency showed the greatest deficit. In another study done by Leach [3], a total of fifty six patients had been investigated, eight of them showed hearing affection immediately after treatment.

Dias [7] examined 19 patients (38 ears) before and after radiotherapy, 19 ears showed affection in their hearing on an average of 9.9 dB.

Zaret [8] described a case of occupatoinal hearing loss attributable to radiation exposure, and when examined, it showed profound hearing loss and loss of vestibular function using caloric test.

In our work, 15 patient were examined audiologically before and after radiotherapy. Otoscopic examination and immitancemetry were done to exclude the possibility of middle ear disease either before or after treatment.

Pure-tone audiometry of the study group showed no significant difference before and immediately after treatment in all the tested frequencies.

Click evoked oto-acoustic emission was done and its results were compared before and after radiotherapy. The percentage reproducebility of the emission waveform was analysed at each frequency (at 1, 2, 3, & 4 kHz).

Reproducebility at 3 and 4 KHz showed considerable reduction at post radiation session with no significant difference at lower frequencies (see table 2). The amount of the elicited emission in dB together with the recorded noise in dB were recorded showing significant difference of the emission, being reduced after treatment,

however, with no significant difference of the accompanied noise (see table 3).

The spectral analysis of the otoacoustic emission waveform using fast fourier transformer (fft) was used. The fft at frequencies 0.5, 1, 1.5, 2, 2.5 & 3 kHz were calculated in dB and compared before and after treatment. fft at 2.5 & 3 kHz showed significant reduction following radiotherapy (Figs 1 & 2).

Despite the results of previous studies, showing no effect of radiation on hearing sensitivity using pure-tone audiometry, oto-acoustic emission showed affection of high frequency part of hair cell population i. e. oto-acoustic emission detects the insult induced by radiotherapy, however minute it is. indicating high sensitivity of that test.

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