MOBILE PHONES EFFECTS ON COCHLEAR FUNCTION

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ABSTRACT:
Twenty healthy mobile phone users were examined for changes in cochlear function during and after exposure to electromagnetic radiation emitted from mobile phones. All subjects were examined using click evoked Otoacoustic emission testing. The other ear was taken as an intrasubject control. Cochlear responses and wave reproducibility were recorded before, during, and after exposure to mobile phone radiation. Results showed no statistically significant difference between the three test conditions. Accordingly, there is no scientific basis for concluding that mobile phones have or have no effects on cochlear function.

KEY WORDS:
Otoacoustic emissions
Cochlear function
Mobile phones
Electromagnetic waves.

INTRODUCTION:
The widespread use of mobile telephones raises the concern about the potential influences of electromagnetic fields (EMFs) on human health. Headache and other neuropsychological symptoms occur in users of cellular telephones, and controversy exists concerning risks for brain cancer. Anatomically, the ear is in close proximity to the mobile telephone during use. Hearing loss due to mobile telephone use has not been described in the medical literature; however, if there is a subtle cochlear involvement, it might be detected by means of changes in evoked otoacoustic emissions (OAEs).

The radiofrequency radiation emitted from cellular telephones during transmission is absorbed superficially on the skin and bones surrounding the ear, and intracranially behind the ear.1 Radiofrequency radiation does not possess sufficient energy to remove electrons from molecules, and causes little increase in the temperature of facial or brain tissue. Despite the lack of a known carcinogenic effect of radiofrequency radiation from cellular telephones, there are public health concerns about their safety. Electromagnetic radiation at certain radio frequencies has been reported to cause sleep disturbances, headaches, and electroencephalographic changes2,3.

Headache and other neuropsychological symptoms occur in users of cellular telephones, and controversy exists concerning risks for brain cancer. The frequencies for transmission and reception by cellular telephones, about 900 MHz for analog and 1800 MHz for digital transmission, have wavelengths of 33-35 and 16-17 cm, respectively. Human heads are oval in shape with a short axis about 16 to 17 cm in length. Near the ear there will be a cross-section in the head.
with an axis half the wavelength of 900 MHz and equal to the wavelength of transmissions at 1800 MHz. Therefore, the human head can serve as a resonator for the electromagnetic radiation emitted by the cellular telephone, absorbing much of the energy specifically from these wavelengths. Brain cells and tissues demodulate the cell-phone's audio frequencies from the radio frequency carrier. Low audio frequencies in the ranges of alpha and beta waves affect these waves and thereby influence brain function. These effects state the case for a precautionary policy.

Transient Evoked Otoacoustic Emissions (TEOAEs), follow a brief stimulus. The time delay between the stimulus and the response allows the examiner to isolate the response. TEOAEs detected from normal ears mirror the spectral properties of the stimulus (Glattke & Robinette, 2002). TEOAE measures have been widely reported for clinical studies ranging from newborn screening to ongoing monitoring of audiologic status, as might be used with chemotherapy patients. Technical details regarding the derivation of the numerical measures displayed in the results have been provided by Glattke, Pafitis, Cummiskey and Herer (1995). Although no universal standard exists, the measures involved in the determination of whether or not a TEOAE is present are reproducibility and signal to noise ratio. The two types of results are related to each other and both have been employed to establish "pass" criteria for individuals undergoing screening. OAEs provide us with sensitive peeks into the function of the auditory periphery. Thus far, only a small portion of OAE potential has been tapped, primarily by efforts to use OAEs to screen for hearing loss.

Kizilay et al., (2003) concluded that chronic exposure of EMF, as long as 30 days 1h per day, emitting from a mobile phone did not cause any hearing deterioration in adult and developing rats, at least at outer and middle ear and cochlear levels.

As Kemp (2002) has noted, OAEs continue to attract the keen interest of many researchers and, as a consequence, the clinical applications of OAEs are bound to prosper.

The purpose of this study was to examine the instantaneous effects of electromagnetic waves emitted from the mobile phones on normal cochlear physiology through analyzing the outer hair cells function via measuring the otoacoustic emissions.

METHODS:
Twenty healthy mobile phone users (age range 21-45 years) were enrolled in this study. All participants were subjected to the following:
- Thorough medical history, including history of any previous ear disease, noise exposure, trauma, or ototoxic drug intake. All subjects were not complaining of any chronic systemic diseases
- Ear, nose, and throat examination including Otoscopic examination.
- Pure-tone and speech audiometry
- Immittance, including tympanometry and stapedial reflexes recording
- Transient click evoked otoacoustic emissions. Recording of cochlear echo was done before, during, and after exposure to electromagnetic waves emitted from a cellular phone for
complete three minutes. The otoacoustic emission was also recorded from the contralateral ear as intrasubject control.

- Statistical analysis of cochlear responses and waveform reproducibility was done from the results obtained from the four test conditions using analysis of variance test.

RESULTS:

Five males and 15 healthy females participated in this study (age: 21-45 years). All of them were right-handed, so the left ear was used as an intrasubject control. All of them showed normal results in basic audiological evaluations. All participants were using their cellular phones on a daily basis. This time ranges from 10 to 120 minutes each day. Some subjects who participated in this study experienced temporary dull pain or discomfort related to cellular phone use.

Transient click evoked otoacoustic emission results were analyzed based on cochlear response, waveform reproducibility, and signal to noise ratio per frequency.

Multivariate analysis of variance was used for statistical analysis of the data in the four test conditions. Although test results showed a trend for reduced cochlear response (Figure 1) and waveform reproducibility (Figure 2), these differences did not reach statistically significant values at the 0.05 criterion.

**Table 1:** ANOVA test for cochlear response.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>30.8365</td>
<td>3</td>
<td>10.27883333</td>
<td>0.829692678</td>
<td>0.481619</td>
<td>2.724946</td>
</tr>
<tr>
<td>Within Groups</td>
<td>941.543</td>
<td>76</td>
<td>12.38872368</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>972.3795</td>
<td>79</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Table 2:** ANOVA test for waveform reproducibility.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>1898.45</td>
<td>3</td>
<td>632.8166667</td>
<td>1.869102629</td>
<td>0.141948</td>
<td>2.724946</td>
</tr>
<tr>
<td>Within Groups</td>
<td>25731.1</td>
<td>76</td>
<td>338.5671053</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>27629.55</td>
<td>79</td>
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These results showed that although the cochlear response emitted from the cochlea showed decrease in the amount of cochlear echo emitted during exposure and the post-test condition compared to the control and the pre-test condition, this differences did not reach the significance levels.
Also no correlation was found between the daily average use and the cochlear response in the different test conditions.

Furthermore, auditory brainstem response was done on few subjects to examine the effects of the emitted electromagnetic waves on neural synchronization and integrity though the lower brainstem. Results showed that the waveform morphology was greatly affected specially in the early waves (Figure 3). Contrary to otoacoustic emission recordings which are acoustic responses, evoked potentials recordings should be interpreted cautiously as placing an electromagnetic waves source in the vicinity of recording electrodes may affect the quality of the recorded waves.

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**Figure 1: Cochlear response recorded in dB SPL in the four test conditions.**
Figure 2: Waveform reproducibility in percentage in the four test conditions.

Figure 3: Auditory Brainstem responses recorded before, during, and immediately after cellular phone use.
DISCUSSION:
The study did not support the hypothesis that use of handheld cellular telephones affects normal cochlear physiology. No association was observed between use of cellular phones and outer haircells function.

The current study was conducted few years after the usage of cellular telephone became common, and did not measure the risks associated with long-term cellular telephone use. The main aim of this study was to assess the immediate changes of cellular phone use on normal cochlear physiology, mainly outer haircells function, which is responsible for cochlear echo production. Although the results pointed to a decrease in the emitted cochlear echo and waveform reproducibility during exposure to the cellular phone electromagnetic waves, these effects did not reach the preset criterion for significance. Further studies are needed to explain the relation of exposure to handheld cellular telephones and cochlear physiology, auditory brainstem function, and central auditory processing. An apparent decrease in the cochlear response and waveform reproducibility, although statistically insignificant, necessitate pursuing further research on greater population and using different recording paradigms.

REFERENCES:
تأثير التليفون المحمول على وظائف قوقعة الأذن

هشام محمود سامي
قسم الأنف والأذن والحنجرة – كلية طب المنيا

تم فحص 20 شخص سليم من مستخدمي التليفون المحمول للتغيرات التي قد تحدث في وظائف القوقعة خلال وبعد التعرض للإشعاع الكهرومغناطيسي الذي ينبعث من التليفونات المحمولة. وتم فحص جميع الأشخاص باستخدام اختبار الانبعاث الصوتي المثار من قوقعة الأذن. وقد تم استخدام الأذن التي لا يستخدم فيها التليفون المحمول للمقارنة. وقد تم قياس استجابات قوقعة الأذن قبل وخلال وبعد استخدام التليفون المحمول. وقد أوضحت النتائج أنه ليس هناك فرقا له دالة إحصائية قبل وخلال وبعد استخدام التليفون المحمول. ولذلك ليس هناك قاعدة علمية للحكم بأن التليفونات المحمولة لها تأثير أو ليس لها تأثير على قوقعة الأذن.